

## Power MOSFET

**TO-220 FULLPAK**


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)


**RoHS**  
COMPLIANT

### APPLICATIONS

- Switch mode power supply (SMPS)
- Uninterruptible power supply
- High speed power switching
- High voltage isolation = 2.5 kV<sub>RMS</sub> (t = 60 s, f = 60 Hz)

### TYPICAL SMPS TOPOLOGIES

- Single transistor flyback
- Single transistor forward

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


| ORDERING INFORMATION |                |
|----------------------|----------------|
| Package              | TO-220 FULLPAK |
| Lead (Pb)-free       | IRFIB5N65APbF  |

| ABSOLUTE MAXIMUM RATINGS $T_C = 25^\circ\text{C}$ , unless otherwise noted |                          |                           |                |             |
|--|--------------------------|---------------------------|----------------|-------------|
| PARAMETER  | SYMBOL                   |                           | LIMIT          | UNIT        |
| Drain-source voltage   | $V_{DS}$                 |                           | 650            | V           |
| Gate-source voltage  | $V_{GS}$                 |                           | $\pm 30$       |             |
| Continuous drain current <sup>e</sup>                                      | $V_{GS}$ at 10 V         | $T_C = 25^\circ\text{C}$  | 5.1            | A           |
| Continuous drain current   |                          | $T_C = 100^\circ\text{C}$ | 3.2            |             |
| Pulsed drain current <sup>a</sup>  |                          |                           | $I_{DM}$       | 21          |
| Linear derating factor   |                          |                           |                | 0.48        |
| Single pulse avalanche energy <sup>b</sup>                                 |                          |                           | $E_{AS}$       | 325         |
| Repetitive avalanche current <sup>a</sup>                                  |                          |                           | $I_{AR}$       | 5.2         |
| Repetitive avalanche energy <sup>a</sup>                                   |                          |                           | $E_{AR}$       | 6           |
| Maximum power dissipation  | $T_C = 25^\circ\text{C}$ |                           | $P_D$          | 60          |
| Peak diode recovery $dV/dt$ <sup>c</sup>                                   |                          |                           | $dV/dt$        | 2.8         |
| Operating junction and storage temperature range                           |                          |                           | $T_J, T_{stg}$ | -55 to +150 |
| Soldering recommendations (peak temperature) <sup>d</sup>                  | For 10 s                 |                           |                | 300         |
| Mounting torque  | M3 screw                 |                           |                | 0.6         |

#### Notes

- Repetitive rating; pulse width limited by maximum junction temperature (see fig. 11)
- Starting  $T_J = 25^\circ\text{C}$ ,  $L = 24$  mH,  $R_G = 25 \Omega$ ,  $I_{AS} = 5.2$  A (see fig. 12)
- $I_{SD} \leq 5.2$  A,  $dI/dt \leq 90$  A/ $\mu\text{s}$ ,  $V_{DD} \leq V_{DS}$ ,  $T_J \leq 150^\circ\text{C}$
- 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   | $R_{DS(on)}$          | $V_{GS} = 10\text{ V}$  | $I_D = 3.1\text{ A}^b$  | -    | -    | 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%  $V_{DS}$
- $t = 60\text{ s}, f = 60\text{ Hz}$



TYPICAL CHARACTERISTICS 25 °C, unless otherwise noted

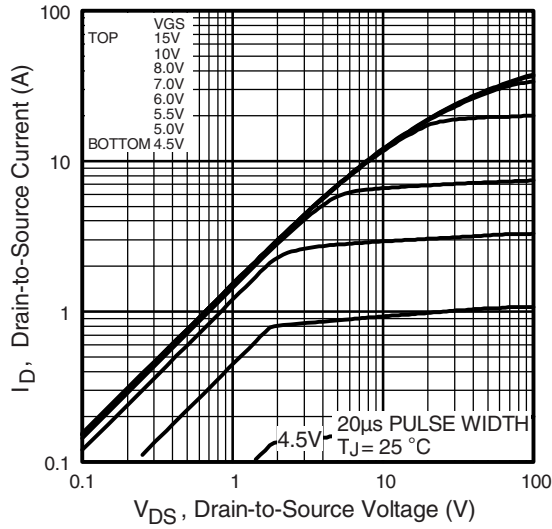


Fig. 1 - Typical Output Characteristics

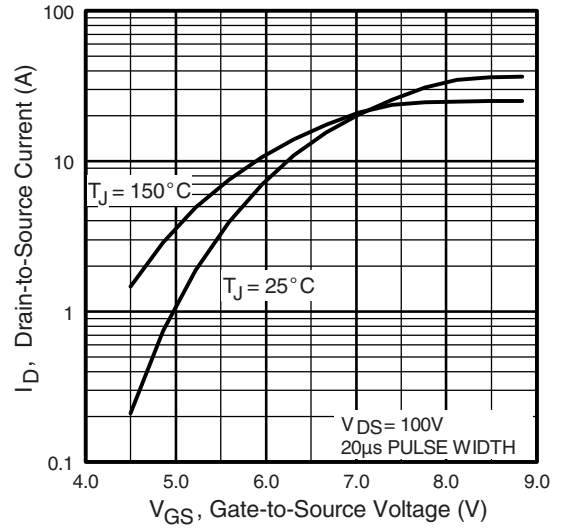


Fig. 3 - Typical Transfer Characteristics

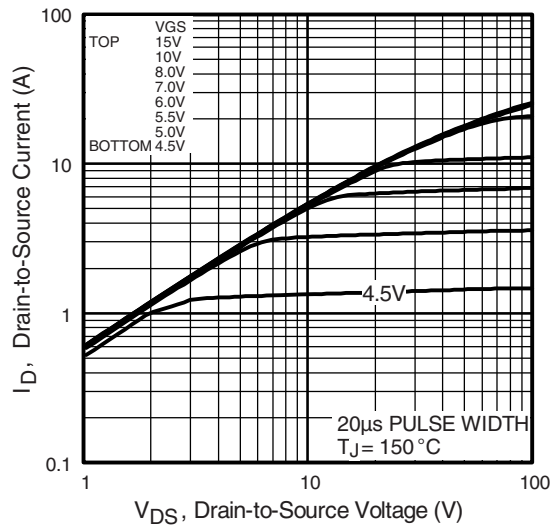


Fig. 2 - Typical Output Characteristics

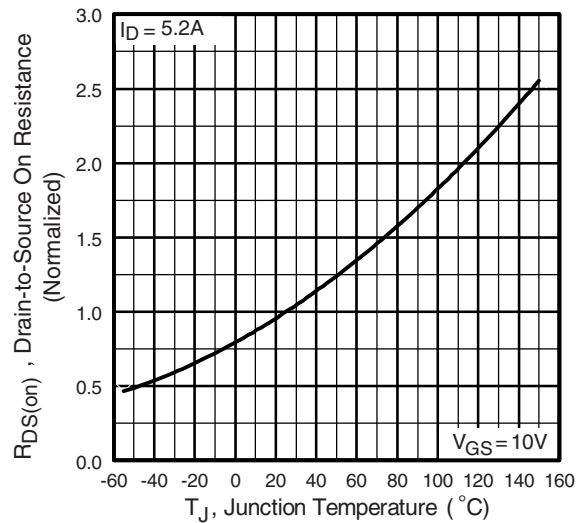


Fig. 4 - Normalized On-Resistance vs. Temperature

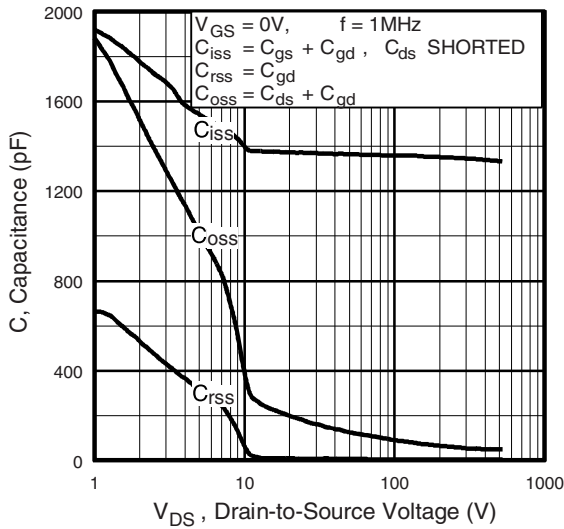


Fig. 5 - Typical Capacitance vs. Drain-to-Source Voltage

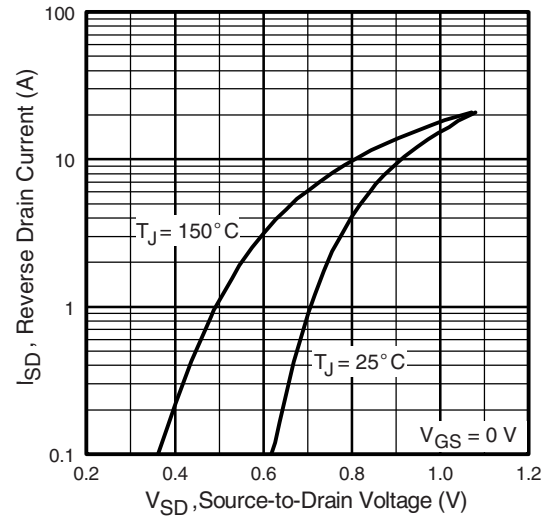


Fig. 7 - Typical Source-Drain Diode Forward Voltage

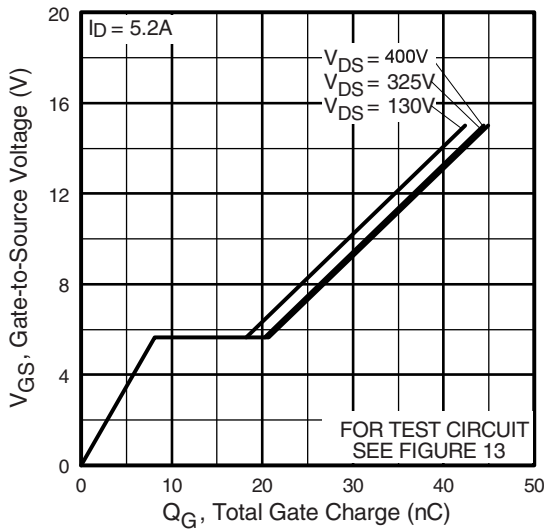


Fig. 6 - Typical Gate Charge vs. Gate-to-Source Voltage

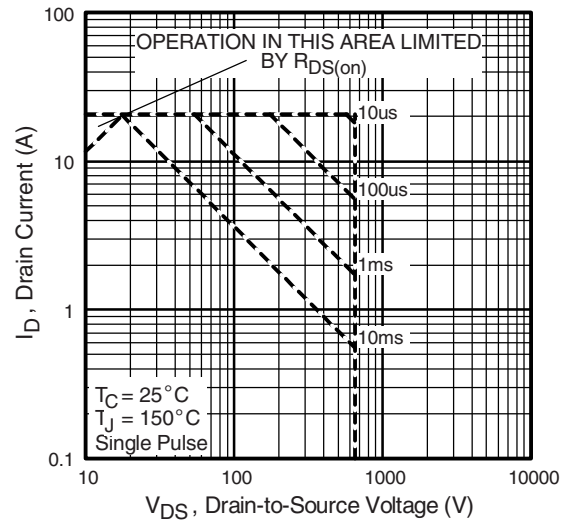


Fig. 8 - Maximum Safe Operating Area

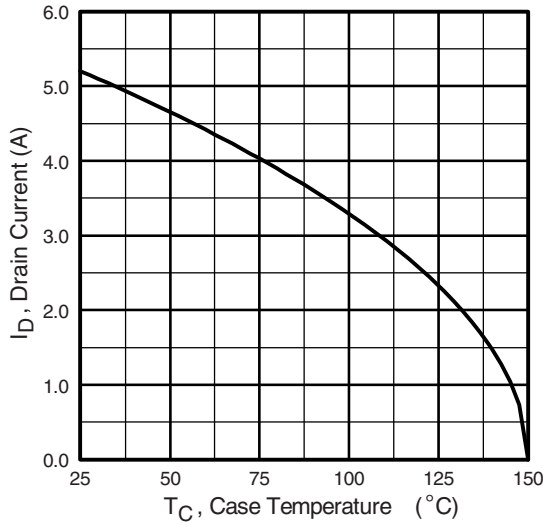


Fig. 9 - Maximum Drain Current vs. Case Temperature

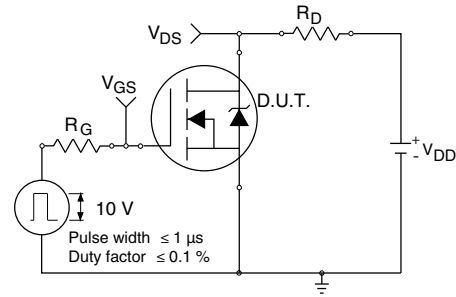


Fig. 10a - Switching Time Test Circuit

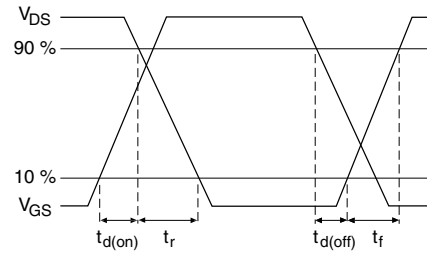


Fig. 10b - Switching Time Waveforms

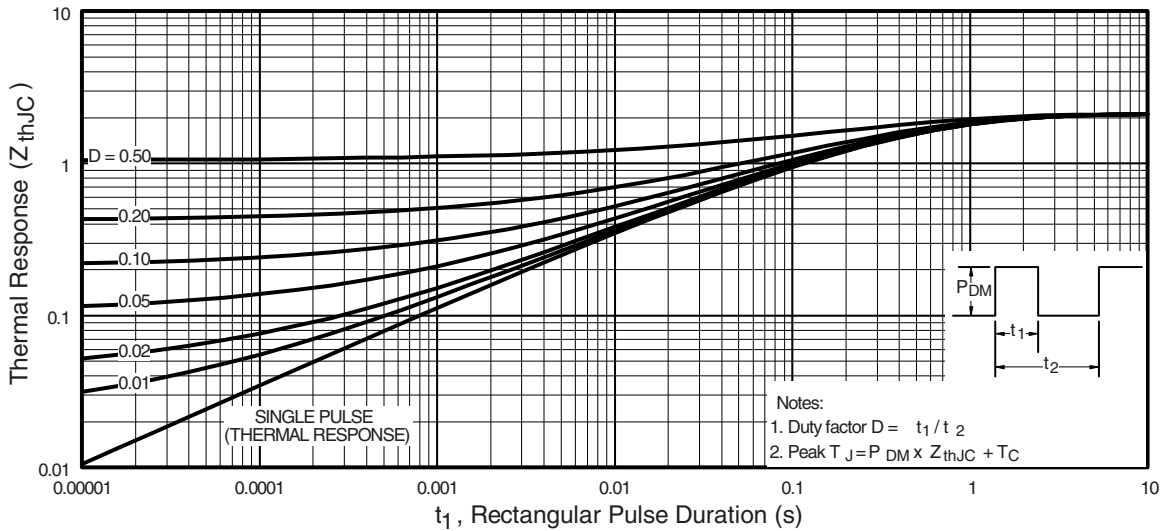


Fig. 11 - Maximum Effective Transient Thermal Impedance, Junction-to-Case

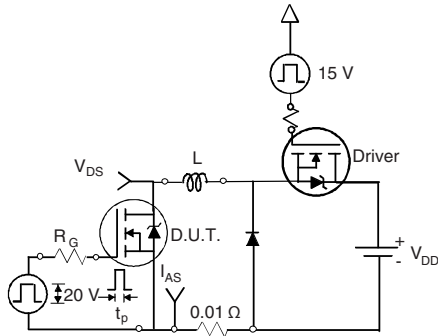


Fig. 12a - Unclamped Inductive Test Circuit

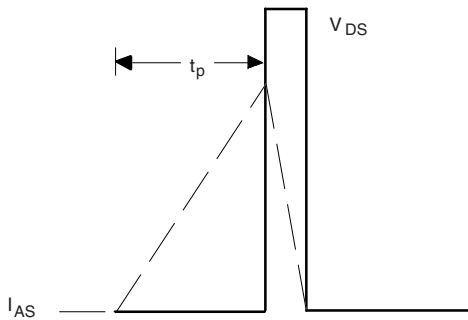


Fig. 12b - Unclamped Inductive Waveforms

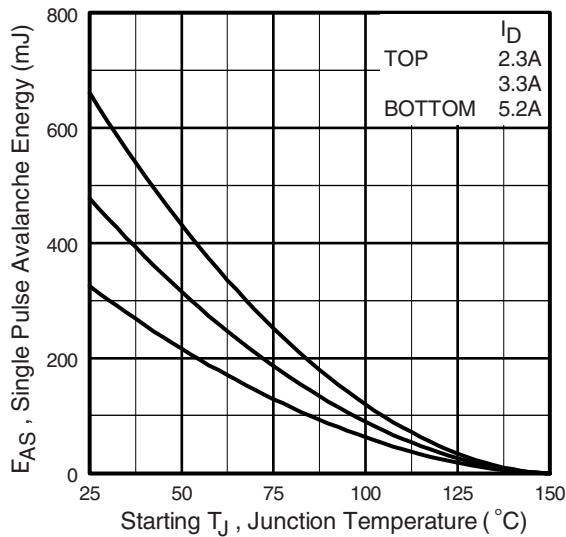


Fig. 12c - Maximum Avalanche Energy vs. Drain Current

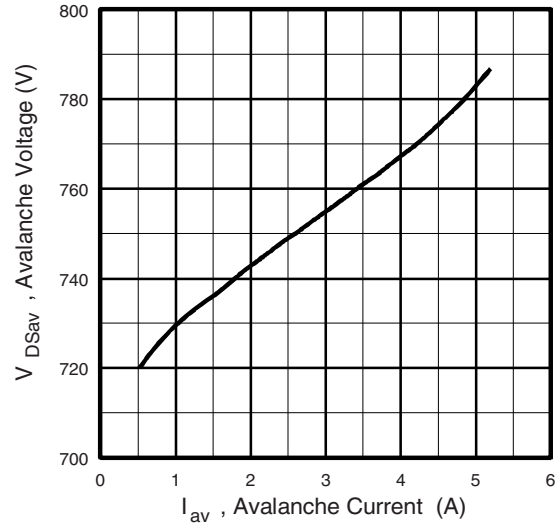


Fig. 12d - Typical Drain-to-Source Voltage vs. Avalanche Current

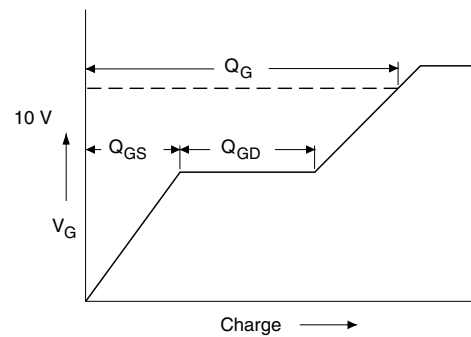


Fig. 13a - Basic Gate Charge Waveform

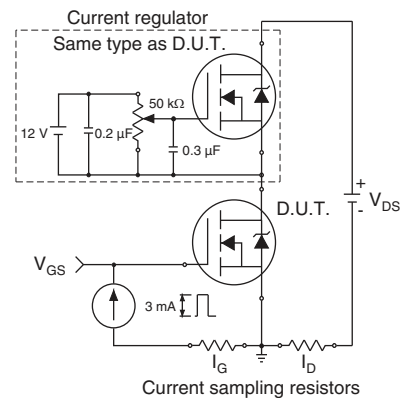
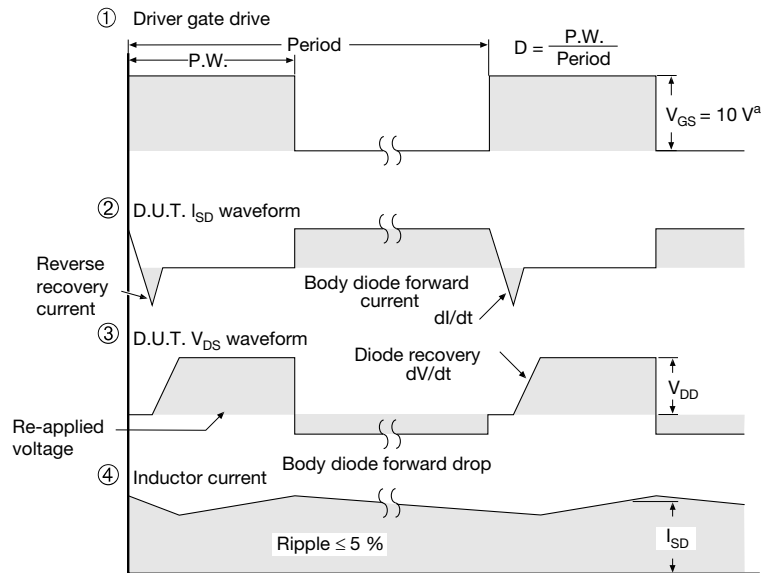
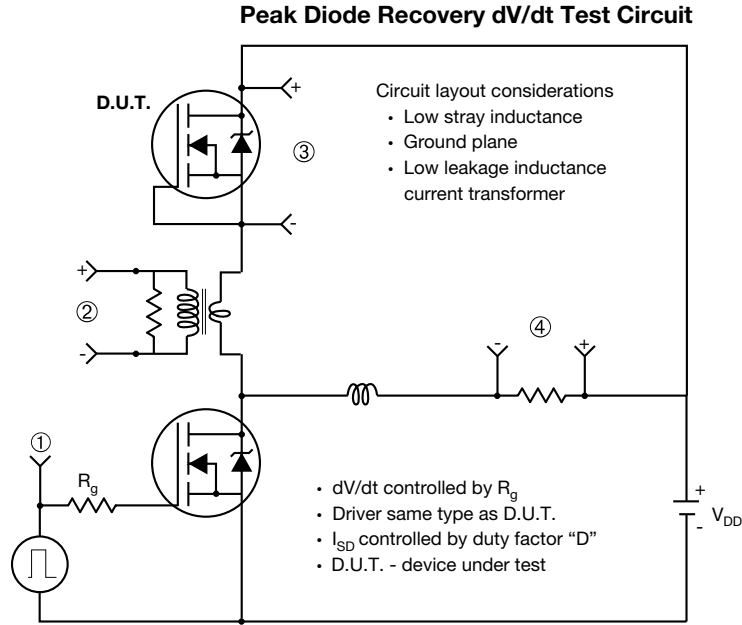


Fig. 13b - Gate Charge Test Circuit



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

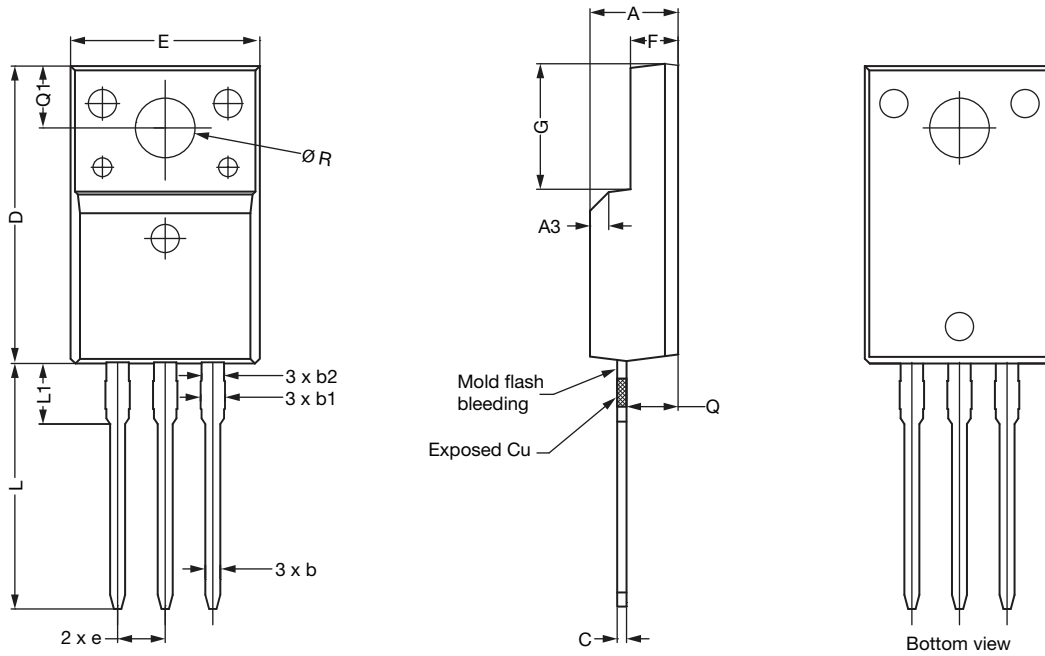
**Fig. 14 - For N-Channel**

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# TO-220 FULLPAK (High Voltage)

## OPTION 1: FACILITY CODE = 9



| DIM.            | MILLIMETERS |       |       |
|-----------------|-------------|-------|-------|
|                 | MIN.        | NOM.  | MAX.  |
| A               | 4.60        | 4.70  | 4.80  |
| b               | 0.70        | 0.80  | 0.91  |
| b1              | 1.20        | 1.30  | 1.47  |
| b2              | 1.10        | 1.20  | 1.30  |
| C               | 0.45        | 0.50  | 0.63  |
| D               | 15.80       | 15.87 | 15.97 |
| e               | 2.54 BSC    |       |       |
| E               | 10.00       | 10.10 | 10.30 |
| F               | 2.44        | 2.54  | 2.64  |
| G               | 6.50        | 6.70  | 6.90  |
| L               | 12.90       | 13.10 | 13.30 |
| L1              | 3.13        | 3.23  | 3.33  |
| Q               | 2.65        | 2.75  | 2.85  |
| Q1              | 3.20        | 3.30  | 3.40  |
| $\varnothing R$ | 3.08        | 3.18  | 3.28  |

### Notes

1. To be used only for process drawing
2. These dimensions apply to all TO-220 FULLPAK leadframe versions 3 leads
3. All critical dimensions should C meet  $C_{pk} > 1.33$
4. All dimensions include burrs and plating thickness
5. No chipping or package damage
6. Facility code will be the 1<sup>st</sup> character located at the 2<sup>nd</sup> row of the unit marking





OPTION 2: FACILITY CODE = Y



| DIM. | MILLIMETERS |        | INCHES    |       |
|------|-------------|--------|-----------|-------|
|      | MIN.        | MAX.   | MIN.      | MAX.  |
| A    | 4.570       | 4.830  | 0.180     | 0.190 |
| A1   | 2.570       | 2.830  | 0.101     | 0.111 |
| A2   | 2.510       | 2.850  | 0.099     | 0.112 |
| b    | 0.622       | 0.890  | 0.024     | 0.035 |
| b2   | 1.229       | 1.400  | 0.048     | 0.055 |
| b3   | 1.229       | 1.400  | 0.048     | 0.055 |
| c    | 0.440       | 0.629  | 0.017     | 0.025 |
| D    | 8.650       | 9.800  | 0.341     | 0.386 |
| d1   | 15.88       | 16.120 | 0.622     | 0.635 |
| d3   | 12.300      | 12.920 | 0.484     | 0.509 |
| E    | 10.360      | 10.630 | 0.408     | 0.419 |
| e    | 2.54 BSC    |        | 0.100 BSC |       |
| L    | 13.200      | 13.730 | 0.520     | 0.541 |
| L1   | 3.100       | 3.500  | 0.122     | 0.138 |
| n    | 6.050       | 6.150  | 0.238     | 0.242 |
| Ø P  | 3.050       | 3.450  | 0.120     | 0.136 |
| u    | 2.400       | 2.500  | 0.094     | 0.098 |
| V    | 0.400       | 0.500  | 0.016     | 0.020 |

ECN: E19-0180-Rev. D, 08-Apr-2019  
DWG: 5972

Notes

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4. All dimensions include burrs and plating thickness
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