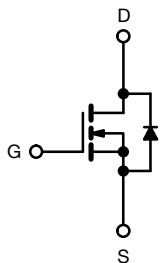
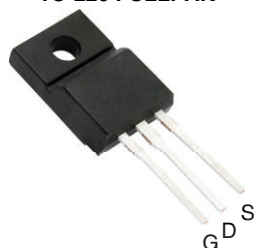


## Power MOSFET

**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>a</sup>                     | $I_D$          | 5.1         | A                   |
| Continuous drain current                                  |                | 3.2         |                     |
| Pulsed drain current <sup>a</sup>                         | $I_{DM}$       | 21          |                     |
| Linear derating factor                                    |                | 0.48        | 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>                  | $E_{AR}$       | 6           | mJ                  |
| Maximum power dissipation                                 | $P_D$          | 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 | $^\circ\text{C}$    |
| Soldering recommendations (peak temperature) <sup>d</sup> | For 10 s       | 300         |                     |
| Mounting torque                                           | M3 screw       | 0.6         | Nm                  |

#### 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**  $T_J = 25\text{ °C}$ , unless otherwise noted

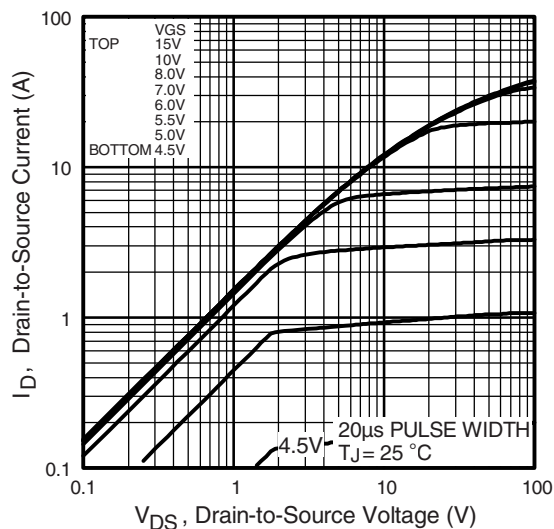
| PARAMETER                                 | SYMBOL                           | TEST CONDITIONS                                                                                                                                          |                                                                                   | MIN. | TYP. | MAX.  | UNIT  |
|-------------------------------------------|----------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|------|------|-------|-------|
| Static                                    |                                  |                                                                                                                                                          |                                                                                   |      |      |       |       |
| Drain-ssource breakdown voltage           | V <sub>DS</sub>                  | V <sub>GS</sub> = 0 V, I <sub>D</sub> = 250 μA                                                                                                           |                                                                                   | 650  | -    | -     | V     |
| V <sub>DS</sub> temperature coefficient   | ΔV <sub>DS</sub> /T <sub>J</sub> | Reference to 25 °C, I <sub>D</sub> = 1 mA <sup>d</sup>                                                                                                   |                                                                                   | -    | 670  | -     | mV/°C |
| Gate-source threshold voltage             | V <sub>GS(th)</sub>              | V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 250 μA                                                                                              |                                                                                   | 2.0  | -    | 4.0   | V     |
| Gate-source leakage                       | I <sub>GSS</sub>                 | V <sub>GS</sub> = ± 30 V                                                                                                                                 |                                                                                   | -    | -    | ± 100 | nA    |
| Zero gate voltage drain current           | I <sub>DSS</sub>                 | V <sub>DS</sub> = 650 V, V <sub>GS</sub> = 0 V                                                                                                           |                                                                                   | -    | -    | 25    | μA    |
|                                           |                                  | V <sub>DS</sub> = 520 V, V <sub>GS</sub> = 0 V, T <sub>J</sub> = 125 °C                                                                                  |                                                                                   | -    | -    | 250   |       |
| Drain-source on-state resistance          | R <sub>DS(on)</sub>              | V <sub>GS</sub> = 10 V                                                                                                                                   | I <sub>D</sub> = 3.1 A <sup>b</sup>                                               | -    | -    | 0.93  | Ω     |
| Forward transconductance                  | g <sub>fs</sub>                  | V <sub>DS</sub> = 50 V, I <sub>D</sub> = 3.1 A                                                                                                           |                                                                                   | 3.9  | -    | -     | S     |
| Dynamic                                   |                                  |                                                                                                                                                          |                                                                                   |      |      |       |       |
| Input capacitance                         | C <sub>iss</sub>                 | V <sub>GS</sub> = 0 V,<br>V <sub>DS</sub> = 25 V,<br>f = 1.0 MHz, see fig. 5                                                                             |                                                                                   | -    | 1417 | -     | pF    |
| Output capacitance                        | C <sub>oss</sub>                 |                                                                                                                                                          |                                                                                   | -    | 177  | -     |       |
| Reverse transfer capacitance              | C <sub>rss</sub>                 |                                                                                                                                                          |                                                                                   | -    | 7.0  | -     |       |
| Output capacitance                        | C <sub>oss</sub>                 | V <sub>GS</sub> = 0 V                                                                                                                                    | V <sub>DS</sub> = 1.0 V, f = 1.0 MHz                                              | -    | 1912 | -     | pF    |
|                                           |                                  |                                                                                                                                                          | V <sub>DS</sub> = 520 V, f = 1.0 MHz                                              | -    | 48   | -     |       |
| Effective output capacitance              | C <sub>oss eff.</sub>            |                                                                                                                                                          | V <sub>DS</sub> = 0 V to 520 V <sup>c</sup>                                       | -    | 84   | -     |       |
| Total gate charge                         | Q <sub>g</sub>                   | V <sub>GS</sub> = 10 V                                                                                                                                   | I <sub>D</sub> = 5.2 A, V <sub>DS</sub> = 400 V<br>see fig. 6 and 13 <sup>b</sup> | -    | -    | 48    | nC    |
| Gate-source charge                        | Q <sub>gs</sub>                  |                                                                                                                                                          |                                                                                   | -    | -    | 12    |       |
| Gate-drain charge                         | Q <sub>gd</sub>                  |                                                                                                                                                          |                                                                                   | -    | -    | 19    |       |
| Turn-on delay time                        | t <sub>d(on)</sub>               | V <sub>DD</sub> = 325 V, I <sub>D</sub> = 5.2 A<br>R <sub>G</sub> = 9.1 Ω, R <sub>D</sub> = 62 Ω,<br>see fig. 10 <sup>b</sup>                            |                                                                                   | -    | 14   | -     | ns    |
| Rise time                                 | t <sub>r</sub>                   |                                                                                                                                                          |                                                                                   | -    | 20   | -     |       |
| Turn-off delay time                       | t <sub>d(off)</sub>              |                                                                                                                                                          |                                                                                   | -    | 34   | -     |       |
| Fall time                                 | t <sub>f</sub>                   |                                                                                                                                                          |                                                                                   | -    | 18   | -     |       |
| Drain-Source Body Diode Characteristics   |                                  |                                                                                                                                                          |                                                                                   |      |      |       |       |
| Continuous source-drain diode current     | I <sub>S</sub>                   | MOSFET symbol showing the integral reverse p - n junction diode<br> |                                                                                   | -    | -    | 5.2   | A     |
| Pulsed diode forward current <sup>a</sup> | I <sub>SM</sub>                  |                                                                                                                                                          |                                                                                   | -    | -    | 21    |       |
| Body diode voltage                        | V <sub>SD</sub>                  | T <sub>J</sub> = 25 °C, I <sub>S</sub> = 5.2 A, V <sub>GS</sub> = 0 V <sup>b</sup>                                                                       |                                                                                   | -    | -    | 1.5   | V     |
| Body diode reverse recovery time          | t <sub>rr</sub>                  | T <sub>J</sub> = 25 °C, I <sub>F</sub> = 5.2 A, dI/dt = 100 A/μs <sup>b</sup>                                                                            |                                                                                   | -    | 493  | 739   | ns    |
| Body diode reverse recovery charge        | Q <sub>rr</sub>                  |                                                                                                                                                          |                                                                                   | -    | 2.1  | 3.2   | μC    |
| Forward turn-on time                      | t <sub>on</sub>                  | Intrinsic turn-on time is negligible (turn-on is dominated by L <sub>S</sub> and L <sub>D</sub> )                                                        |                                                                                   |      |      |       |       |

**Notes**

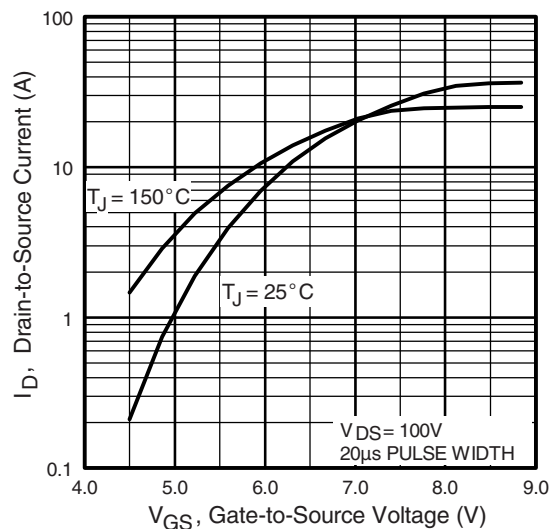
- a. Repetitive rating; pulse width limited by maximum junction temperature (see fig. 11)  
b. Pulse width  $\leq 300\text{ }\mu\text{s}$ ; duty cycle  $\leq 2\%$   
c.  $C_{oss\text{ eff.}}$  is a fixed capacitance that gives the same charging time as  $C_{oss}$  while  $V_{DS}$  is rising from 0 %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



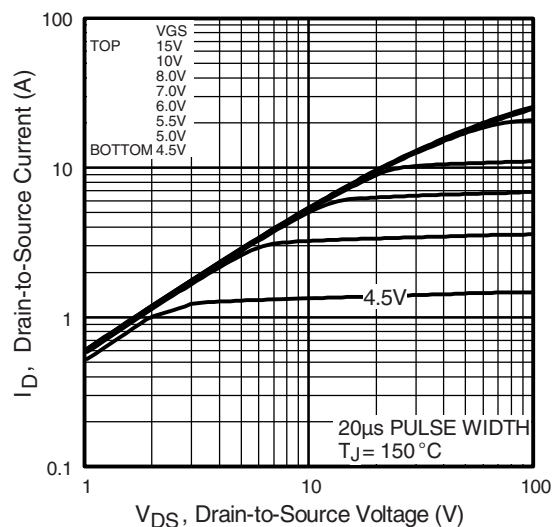
**TYPICAL CHARACTERISTICS** 25 °C, unless otherwise noted



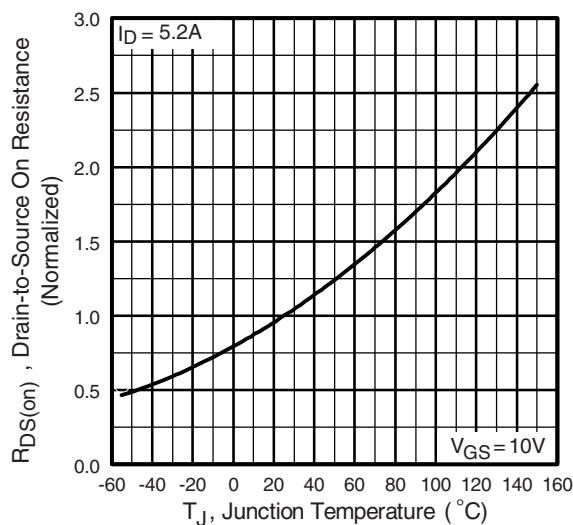
**Fig. 1 - Typical Output Characteristics**



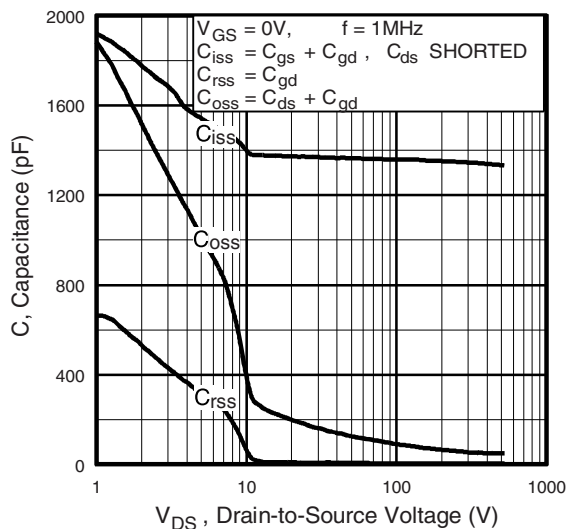
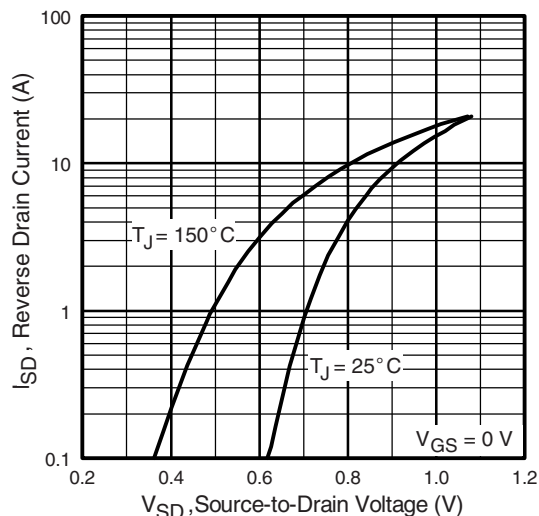
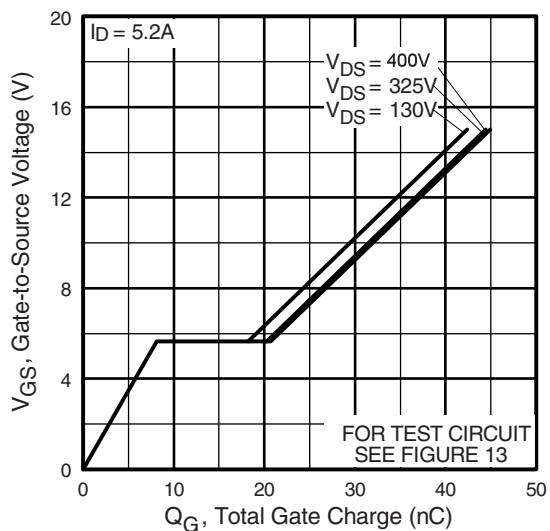
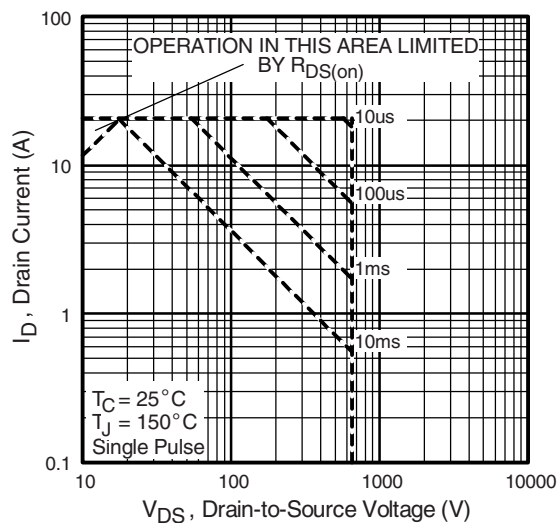
**Fig. 3 - Typical Transfer Characteristics**

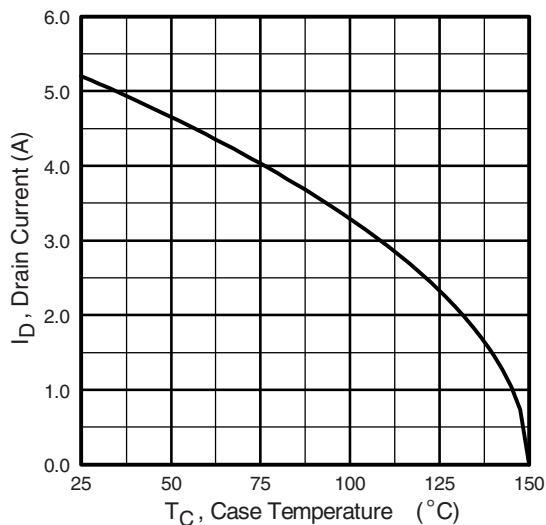
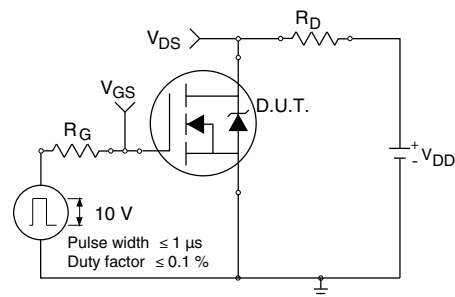
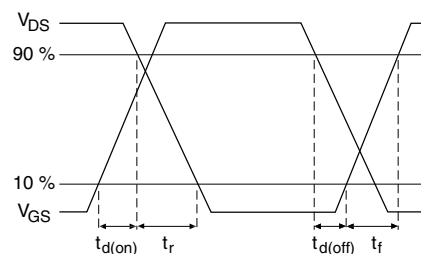
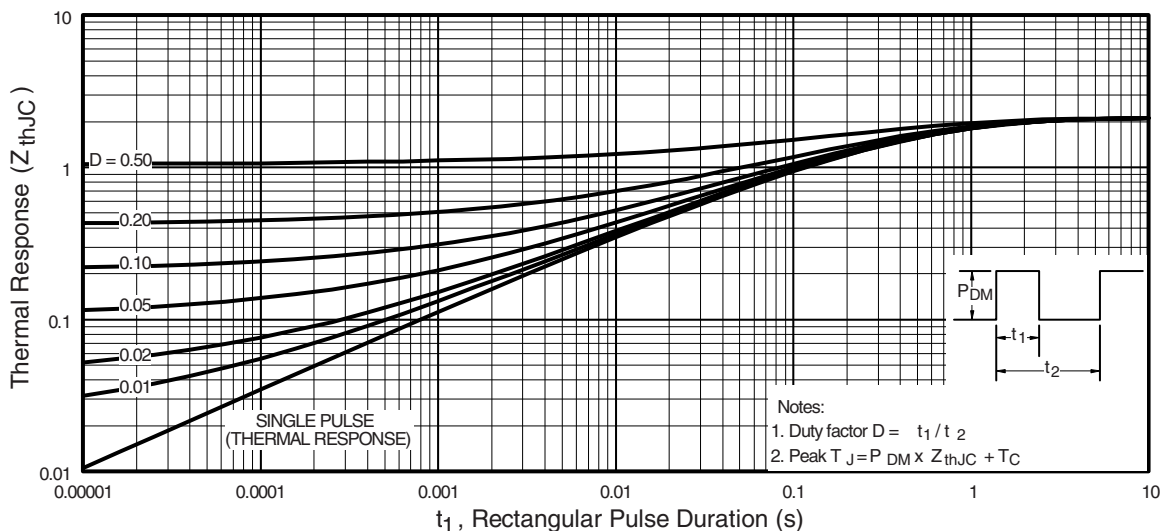


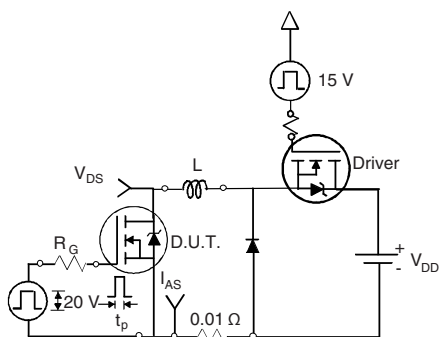
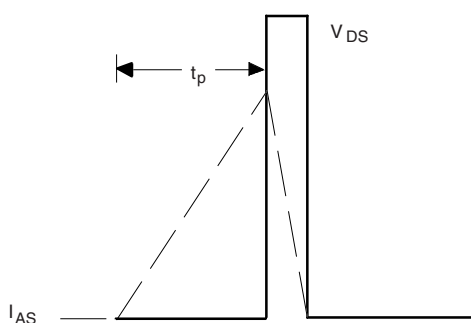
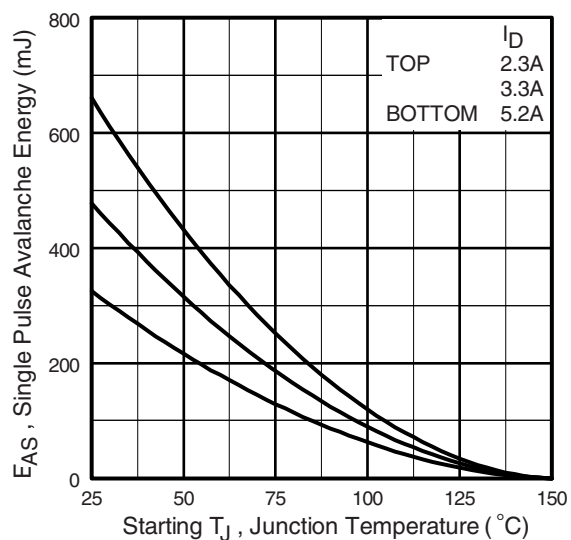
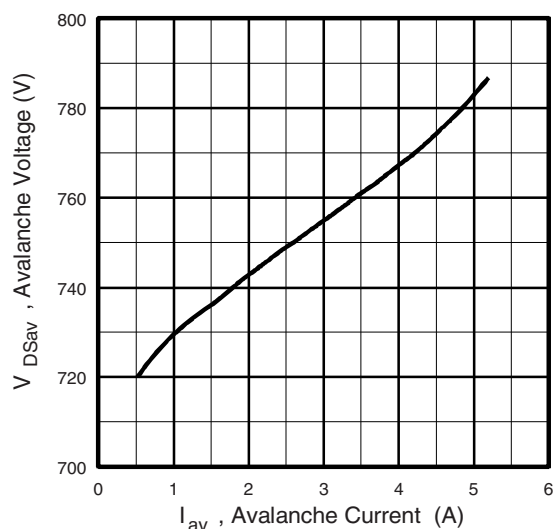
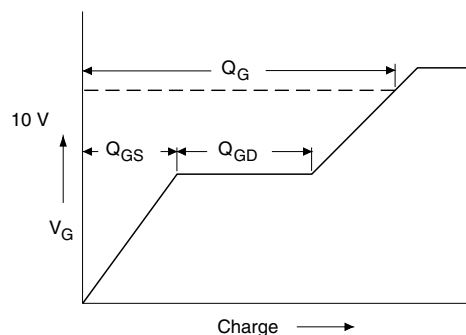
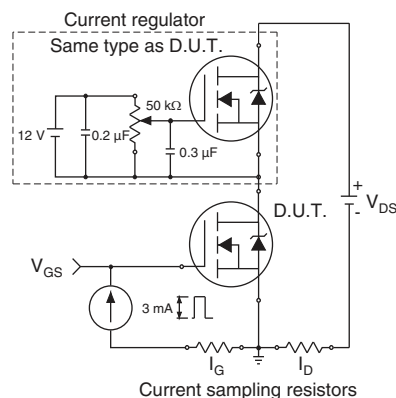
**Fig. 2 - Typical Output Characteristics**

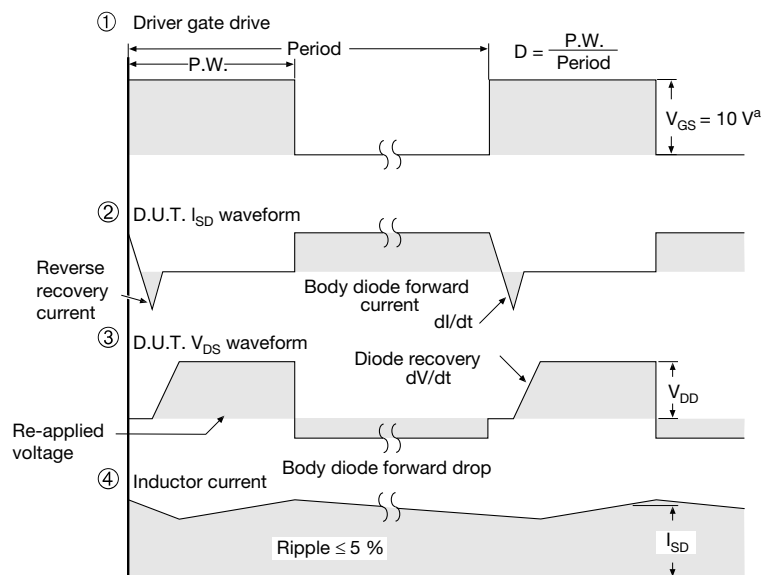
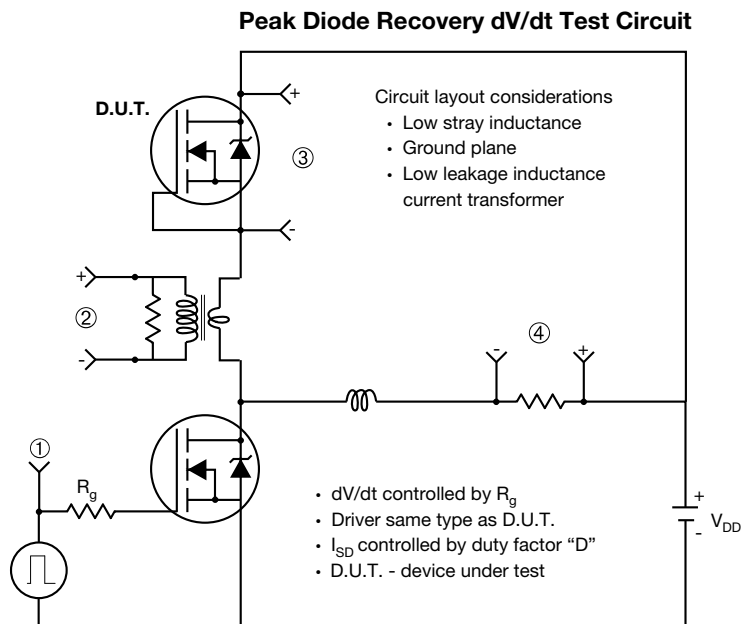


**Fig. 4 - Normalized On-Resistance vs. Temperature**


**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

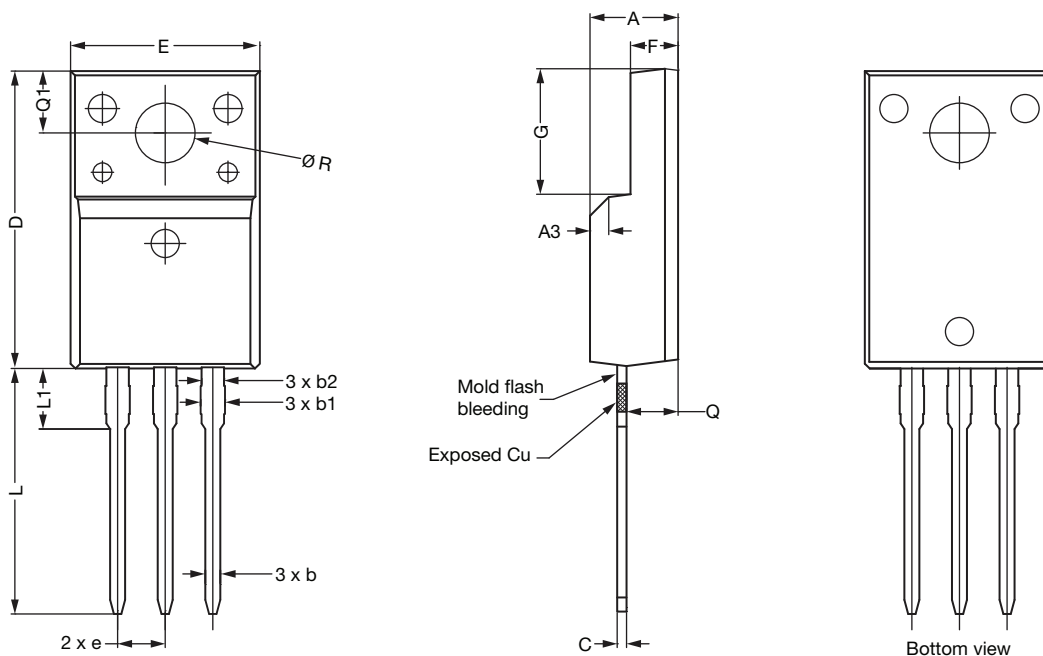
**Fig. 14 - For N-Channel**

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## TO-220 FULLPAK (High Voltage)

### OPTION 1: FACILITY CODE = 9

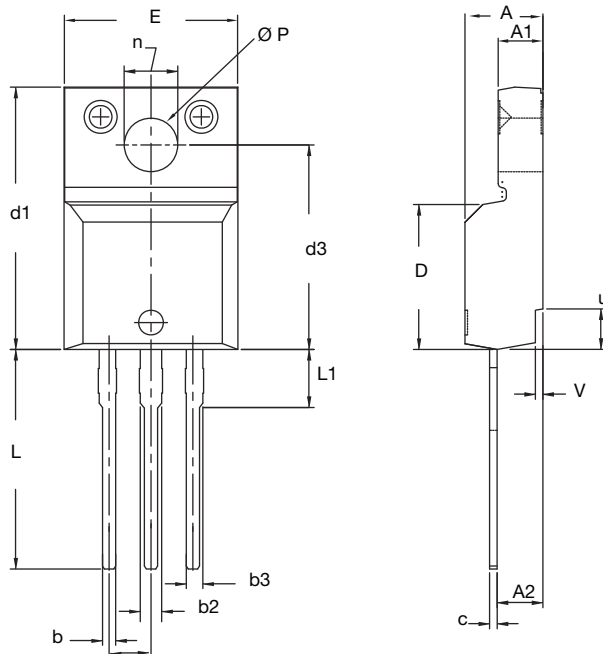


| DIM. | MILLIMETERS |       |       |
|------|-------------|-------|-------|
|      | MIN.        | NOM.  | MAX.  |
| A    | 4.60        | 4.70  | 4.80  |
| b    | 0.70        | 0.80  | 0.91  |
| b1   | 1.20        | 1.30  | 1.47  |
| b2   | 1.10        | 1.20  | 1.30  |
| C    | 0.45        | 0.50  | 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  |
| Ø 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**

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



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