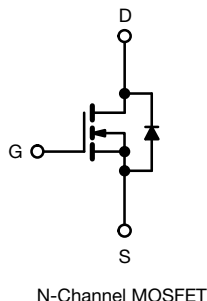
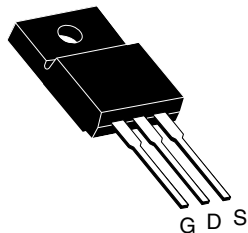


## E Series Power MOSFET

**TO-220 FULLPAK**


### FEATURES

- Low figure-of-merit (FOM)  $R_{DS(on)} \times Q_g$
- Low input capacitance ( $C_{iss}$ )
- Reduced switching and conduction losses
- Ultra low gate charge ( $Q_g$ )
- Avalanche energy rated (UIS)
- Material categorization: for definitions of compliance please see [www.vishay.com/doc?99912](http://www.vishay.com/doc?99912)



**RoHS**  
COMPLIANT  
HALOGEN  
**FREE**  
Available

### APPLICATIONS

- Server and telecom power supplies
- Switch mode power supplies (SMPS)
- Power factor correction power supplies (PFC)
- Lighting
  - High-intensity discharge (HID)
  - Fluorescent ballast lighting
- Industrial
  - Welding
  - Induction heating
  - Motor drives
  - Battery chargers
  - Renewable energy
  - Solar (PV inverters)

### PRODUCT SUMMARY

|                                         |                 |      |
|-----------------------------------------|-----------------|------|
| $V_{DS}$ (V) at $T_J$ max.              | 650             |      |
| $R_{DS(on)}$ max. ( $\Omega$ ) at 25 °C | $V_{GS} = 10$ V | 0.28 |
| $Q_g$ max. (nC)                         | 78              |      |
| $Q_{gs}$ (nC)                           | 9               |      |
| $Q_{gd}$ (nC)                           | 17              |      |
| Configuration                           | Single          |      |

### ORDERING INFORMATION

|                                 |                |
|---------------------------------|----------------|
| Package                         | TO-220 FULLPAK |
| Lead (Pb)-free                  | SiHF15N60E-E3  |
| Lead (Pb)-free and Halogen-free | SiHF15N60E-GE3 |

### ABSOLUTE MAXIMUM RATINGS ( $T_C = 25$ °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 ( $T_J = 150$ °C) <sup>e</sup>   | $V_{GS}$ at 10 V | $T_C = 25$ °C                   | A    |
|                                                           |                  | $T_C = 100$ °C                  |      |
| Pulsed Drain Current <sup>a</sup>                         | $I_{DM}$         | 39                              |      |
| Linear Derating Factor                                    |                  | 0.27                            | W/°C |
| Single Pulse Avalanche Energy <sup>b</sup>                | $E_{AS}$         | 102                             | mJ   |
| Maximum Power Dissipation                                 | $P_D$            | 34                              | W    |
| Operating Junction and Storage Temperature Range          | $T_J, T_{stg}$   | -55 to +150                     | °C   |
| Drain-Source Voltage Slope                                | $dV/dt$          | $V_{DS} = 0$ V to 80 % $V_{DS}$ | V/ns |
| Reverse Diode $dV/dt$ <sup>d</sup>                        |                  |                                 |      |
| Soldering Recommendations (Peak temperature) <sup>c</sup> | For 10 s         | 300                             | °C   |
| Mounting Torque                                           | M3 screw         | 0.6                             | Nm   |

#### Notes

- Repetitive rating; pulse width limited by maximum junction temperature.
- $V_{DS} = 50$  V, starting  $T_J = 25$  °C,  $L = 11.6$  mH,  $R_g = 25$   $\Omega$ ,  $I_{AS} = 4.2$  A.
- 1.6 mm from case.
- $I_{SD} \leq I_D$ ,  $dI/dt = 100$  A/ $\mu$ s, starting  $T_J = 25$  °C.
- 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) | $R_{thJC}$ | -    | 3.7  |      |

**SPECIFICATIONS** ( $T_J = 25\text{ °C}$ , unless otherwise noted)

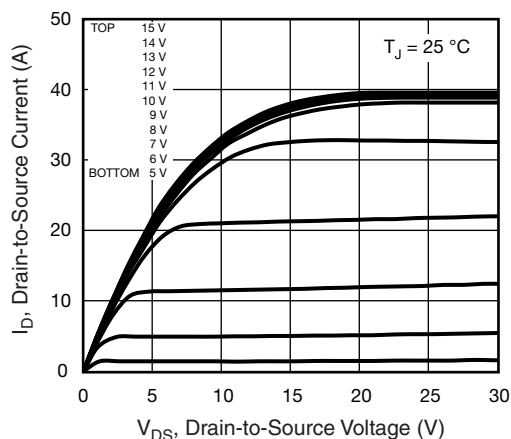
| PARAMETER                                                 | SYMBOL                           | TEST CONDITIONS                                                                                                                                          |                                               | MIN. | TYP. | MAX.  | UNIT |
|-----------------------------------------------------------|----------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------|------|------|-------|------|
| Static                                                    |                                  |                                                                                                                                                          |                                               |      |      |       |      |
| Drain-Source Breakdown Voltage                            | V <sub>DS</sub>                  | V <sub>GS</sub> = 0 V, I <sub>D</sub> = 250 μA                                                                                                           |                                               | 600  | -    | -     | 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                                                                                                                |                                               | -    | 0.71 | -     | V/°C |
| Gate-Source Threshold Voltage (N)                         | V <sub>GS(th)</sub>              | V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 250 μA                                                                                              |                                               | 2    | -    | 4     | V    |
| Gate-Source Leakage                                       | I <sub>GSS</sub>                 | V <sub>GS</sub> = ± 20 V                                                                                                                                 |                                               | -    | -    | ± 100 | nA   |
|                                                           |                                  | V <sub>GS</sub> = ± 30 V                                                                                                                                 |                                               | -    | -    | ± 1   | μA   |
| Zero Gate Voltage Drain Current                           | I <sub>DSS</sub>                 | V <sub>DS</sub> = 600 V, V <sub>GS</sub> = 0 V                                                                                                           |                                               | -    | -    | 1     | μA   |
|                                                           |                                  | V <sub>DS</sub> = 480 V, V <sub>GS</sub> = 0 V, T <sub>J</sub> = 125 °C                                                                                  |                                               | -    | -    | 10    |      |
| Drain-Source On-State Resistance                          | R <sub>DS(on)</sub>              | V <sub>GS</sub> = 10 V                                                                                                                                   | I <sub>D</sub> = 8 A                          | -    | 0.23 | 0.28  | Ω    |
| Forward Transconductance                                  | g <sub>fs</sub>                  | V <sub>DS</sub> = 30 V, I <sub>D</sub> = 8 A                                                                                                             |                                               | -    | 4.6  | -     | S    |
| Dynamic                                                   |                                  |                                                                                                                                                          |                                               |      |      |       |      |
| Input Capacitance                                         | C <sub>iss</sub>                 | V <sub>GS</sub> = 0 V,<br>V <sub>DS</sub> = 100 V,<br>f = 1 MHz                                                                                          |                                               | -    | 1350 | -     | pF   |
| Output Capacitance                                        | C <sub>oss</sub>                 |                                                                                                                                                          |                                               | -    | 70   | -     |      |
| Reverse Transfer Capacitance                              | C <sub>rss</sub>                 |                                                                                                                                                          |                                               | -    | 5    | -     |      |
| Effective Output Capacitance, Energy Related <sup>a</sup> | C <sub>o(er)</sub>               | V <sub>DS</sub> = 0 V to 480 V, V <sub>GS</sub> = 0 V                                                                                                    |                                               | -    | 53   | -     |      |
| Effective Output Capacitance, Time Related <sup>b</sup>   | C <sub>o(tr)</sub>               |                                                                                                                                                          |                                               | -    | 177  | -     |      |
| Total Gate Charge                                         | Q <sub>g</sub>                   | V <sub>GS</sub> = 10 V                                                                                                                                   | I <sub>D</sub> = 8 A, V <sub>DS</sub> = 480 V | -    | 39   | 78    | nC   |
| Gate-Source Charge                                        | Q <sub>gs</sub>                  |                                                                                                                                                          |                                               | -    | 11   | -     |      |
| Gate-Drain Charge                                         | Q <sub>gd</sub>                  |                                                                                                                                                          |                                               | -    | 17   | -     |      |
| Turn-On Delay Time                                        | t <sub>d(on)</sub>               | V <sub>DD</sub> = 480 V, I <sub>D</sub> = 8 A,<br>V <sub>GS</sub> = 10 V, R <sub>g</sub> = 9.1 Ω                                                         |                                               | -    | 16   | 32    | ns   |
| Rise Time                                                 | t <sub>r</sub>                   |                                                                                                                                                          |                                               | -    | 26   | 52    |      |
| Turn-Off Delay Time                                       | t <sub>d(off)</sub>              |                                                                                                                                                          |                                               | -    | 41   | 82    |      |
| Fall Time                                                 | t <sub>f</sub>                   |                                                                                                                                                          |                                               | -    | 22   | 44    |      |
| Gate Input Resistance                                     | R <sub>g</sub>                   | f = 1 MHz, open drain                                                                                                                                    |                                               | 0.3  | 0.86 | 1.7   | Ω    |
| 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> |                                               | -    | -    | 15    | A    |
| Pulsed Diode Forward Current                              | I <sub>SM</sub>                  |                                                                                                                                                          |                                               | -    | -    | 60    |      |
| Diode Forward Voltage                                     | V <sub>SD</sub>                  | T <sub>J</sub> = 25 °C, I <sub>S</sub> = 8 A, V <sub>GS</sub> = 0 V                                                                                      |                                               | -    | 1.0  | 1.2   | V    |
| Reverse Recovery Time                                     | t <sub>rr</sub>                  | T <sub>J</sub> = 25 °C, I <sub>F</sub> = I <sub>S</sub> = 8 A,<br>dI/dt = 100 A/μs, V <sub>R</sub> = 25 V                                                |                                               | -    | 302  | 604   | ns   |
| Reverse Recovery Charge                                   | Q <sub>rr</sub>                  |                                                                                                                                                          |                                               | -    | 4.0  | 8     | μC   |
| Reverse Recovery Current                                  | I <sub>RRM</sub>                 |                                                                                                                                                          |                                               | -    | 24   | -     | A    |

**Notes**

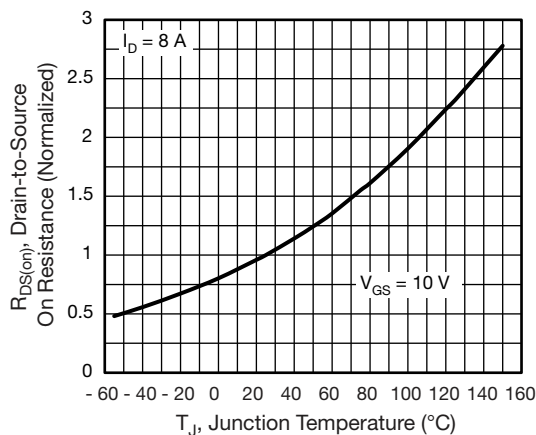
- a.  $C_{oss(er)}$  is a fixed capacitance that gives the same energy as  $C_{oss}$  while  $V_{DS}$  is rising from 0 % to 80 %  $V_{DSS}$ .  
b.  $C_{oss(tr)}$  is a fixed capacitance that gives the same charging time as  $C_{oss}$  while  $V_{DS}$  is rising from 0 % to 80 %  $V_{DSS}$ .



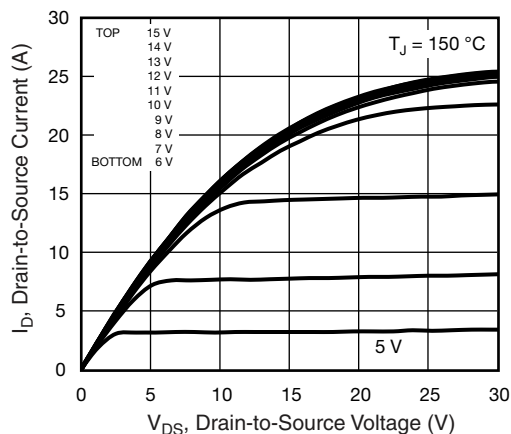
**TYPICAL CHARACTERISTICS** (25 °C, unless otherwise noted)



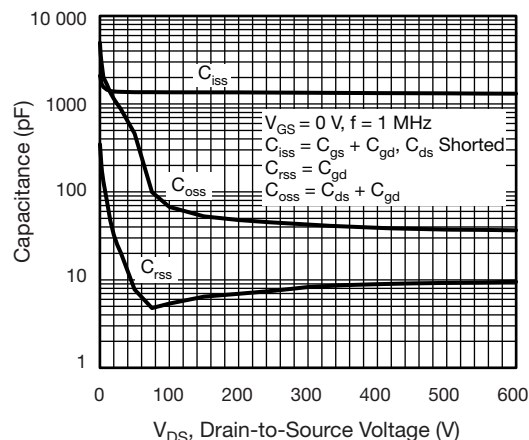
**Fig. 1 - Typical Output Characteristics**



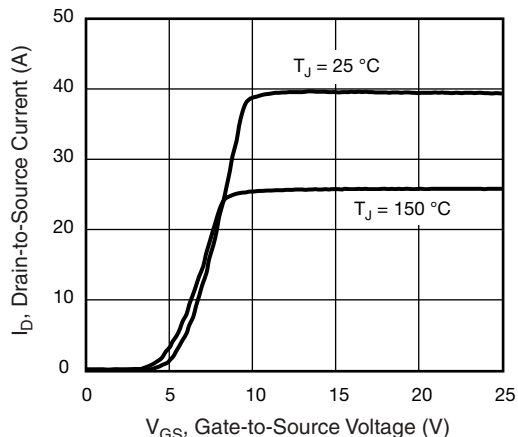
**Fig. 4 - Normalized On-Resistance vs. Temperature**



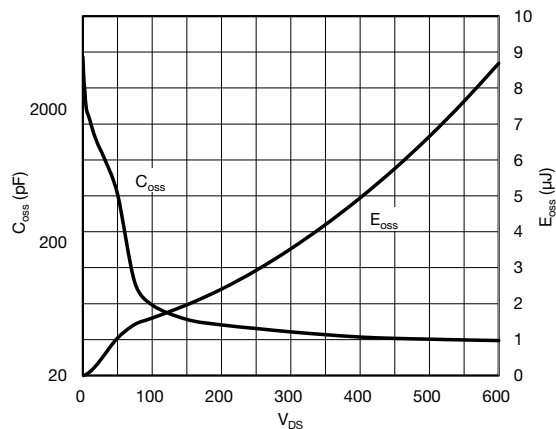
**Fig. 2 - Typical Output Characteristics**



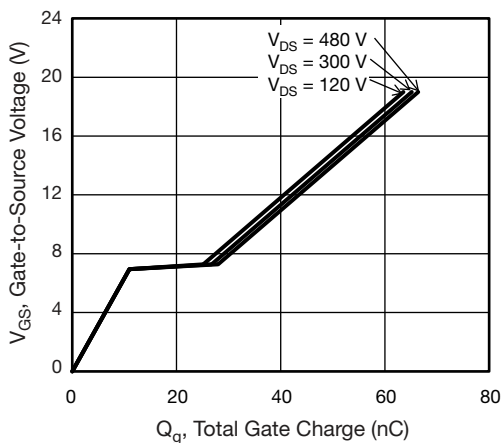
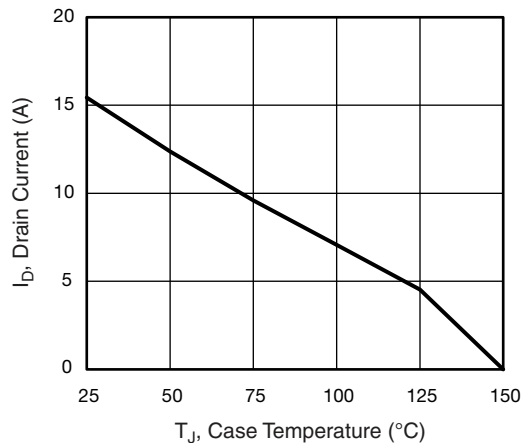
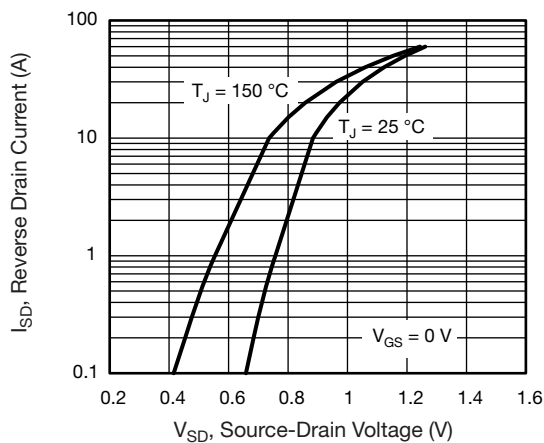
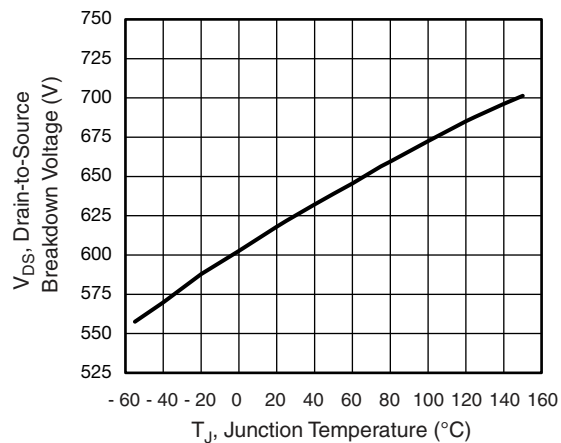
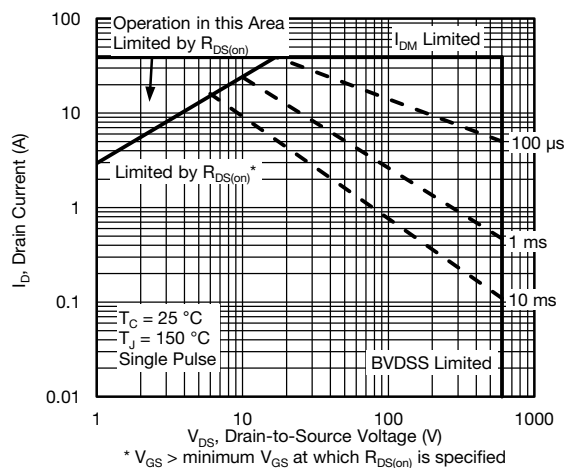
**Fig. 5 - Typical Capacitance vs. Drain-to-Source Voltage**

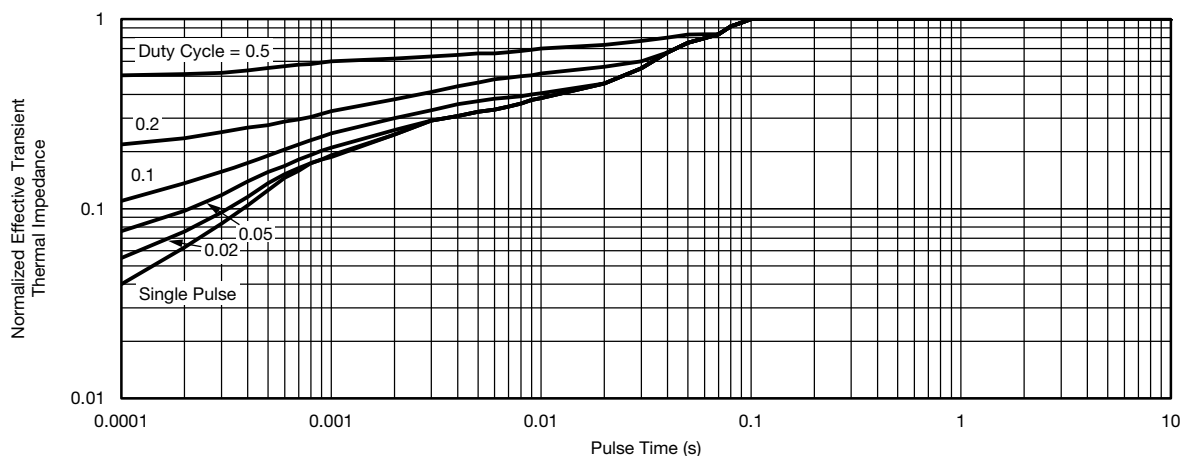


**Fig. 3 - Typical Transfer Characteristics**

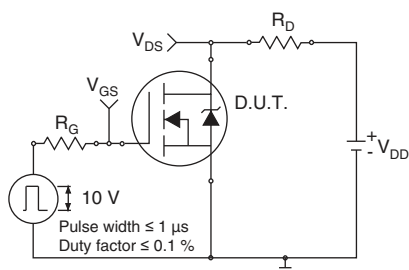


**Fig. 6 -  $C_{oss}$  and  $E_{oss}$  vs.  $V_{DS}$**

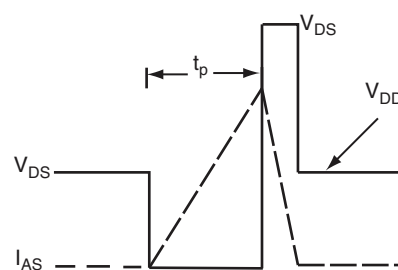

**Fig. 7 - Typical Gate Charge vs. Gate-to-Source Voltage**

**Fig. 10 - Maximum Drain Current vs. Case Temperature**

**Fig. 8 - Typical Source-Drain Diode Forward Voltage**

**Fig. 11 - Temperature vs. Drain-to-Source Voltage**

**Fig. 9 - Maximum Safe Operating Area**



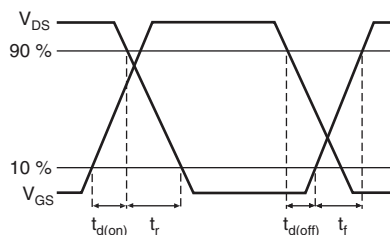
**Fig. 12 - Normalized Thermal Transient Impedance, Junction-to-Case**



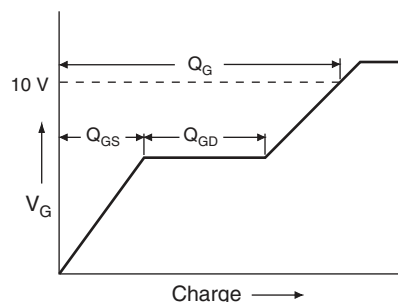
**Fig. 13 - Switching Time Test Circuit**



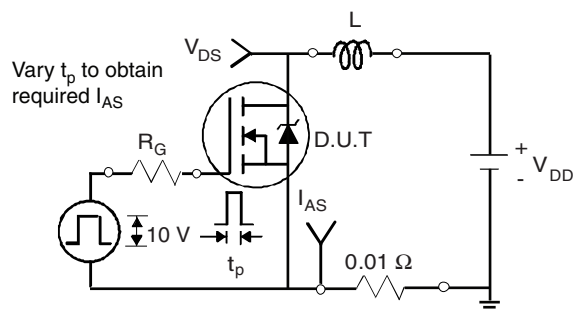
### Fig. 16 - Unclamped Inductive Waveforms



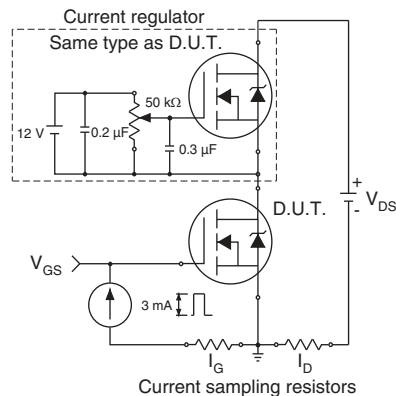
**Fig. 14 - Switching Time Waveforms**



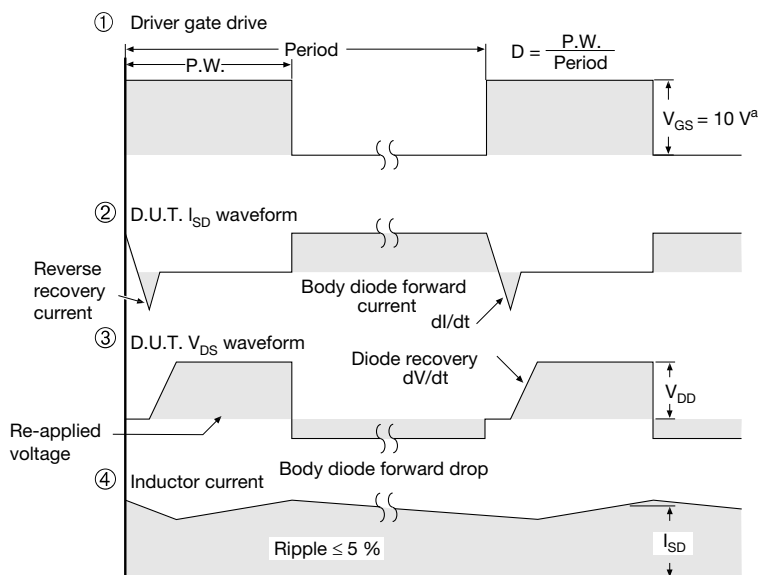
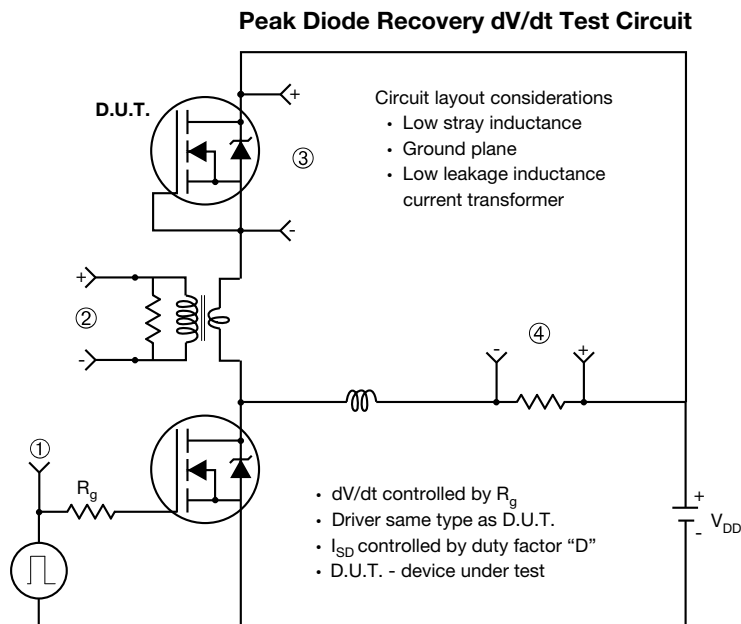
**Fig. 17 - Basic Gate Charge Waveform**



**Fig. 15 - Unclamped Inductive Test Circuit**



**Fig. 18 - Gate Charge Test Circuit**



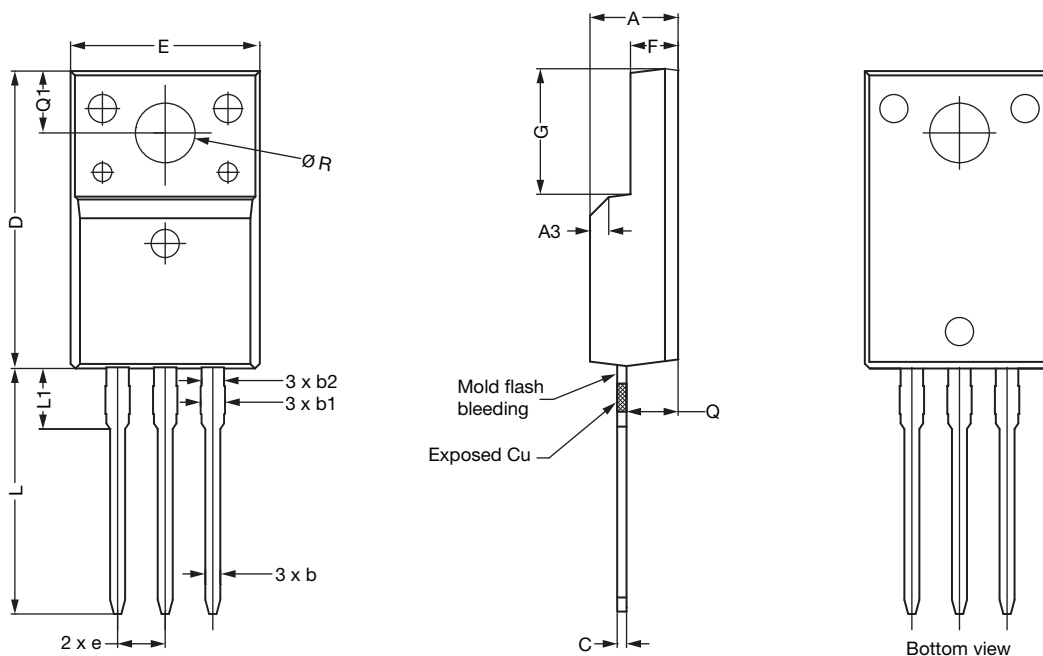
**Fig. 19 - For N-Channel**

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## TO-220 FULLPAK (High Voltage)

### OPTION 1: FACILITY CODE = 9



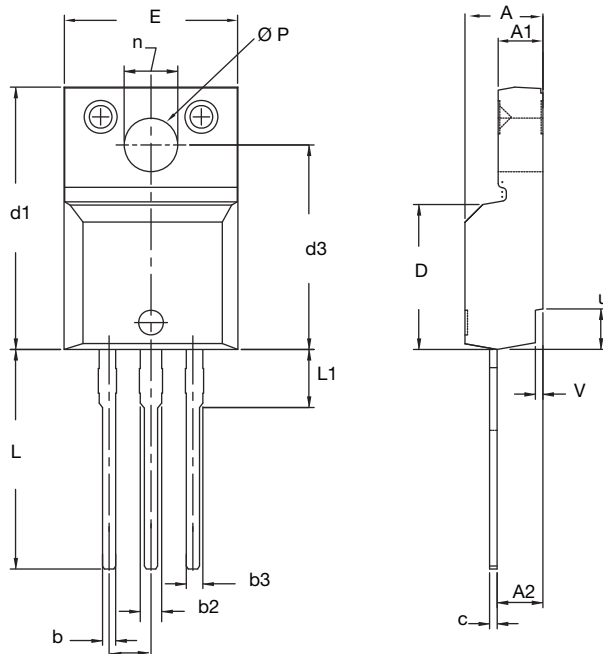
| DIM. | MILLIMETERS |       |       |
|------|-------------|-------|-------|
|      | MIN.        | NOM.  | MAX.  |
| A    | 4.60        | 4.70  | 4.80  |
| b    | 0.70        | 0.80  | 0.91  |
| b1   | 1.20        | 1.30  | 1.47  |
| b2   | 1.10        | 1.20  | 1.30  |
| C    | 0.45        | 0.50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