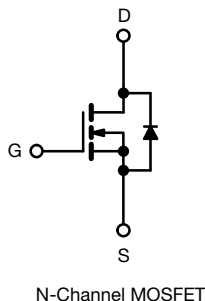


## E Series Power MOSFET

Thin-Lead 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

- Switch mode power supplies (SMPS)
- Power factor correction power supplies (PFC)
- Lighting
  - High-Intensity discharge (HID)
  - Fluorescent ballast lighting
- Consumer
  - Adaptors
  - Televisions
  - Game console
- Computing
  - Adaptors
  - ATX power supply

### PRODUCT SUMMARY

|                                         |                 |      |
|-----------------------------------------|-----------------|------|
| $V_{DS}$ (V) at $T_J$ max.              | 650             |      |
| $R_{DS(on)}$ max ( $\Omega$ ). at 25 °C | $V_{GS} = 10$ V | 0.18 |
| $Q_g$ max. (nC)                         | 86              |      |
| $Q_{gs}$ (nC)                           | 11              |      |
| $Q_{gd}$ (nC)                           | 24              |      |
| Configuration                           | Single          |      |

### ORDERING INFORMATION

|                                 |                          |
|---------------------------------|--------------------------|
| Package                         | Thin-Lead TO-220 FULLPAK |
| Lead (Pb)-free                  | SiHA22N60E-E3            |
| Lead (Pb)-free and halogen-free | SiHA22N60E-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>                         | $I_{DM}$         | 56             |      |
| Linear derating factor                                    |                  | 0.28           | W/°C |
| Single pulse avalanche energy <sup>b</sup>                | $E_{AS}$         | 367            | mJ   |
| Maximum power dissipation                                 | $P_D$            | 35             | W    |
| Operating junction and storage temperature range          | $T_J, T_{stg}$   | -55 to +150    | °C   |
| Drain-source voltage slope                                | $dV/dt$          | $T_J = 125$ °C | V/ns |
| Reverse diode $dV/dt$ <sup>d</sup>                        |                  |                |      |
| Soldering recommendations (peak temperature) <sup>c</sup> |                  | for 10 s       | °C   |
| Mounting torque                                           |                  | M3 screw       | Nm   |

#### Notes

- Repetitive rating; pulse width limited by maximum junction temperature
- $V_{DS} = 50$  V, starting  $T_J = 25$  °C,  $L = 28.2$  mH,  $R_g = 25$   $\Omega$ ,  $I_{AS} = 5.1$  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**

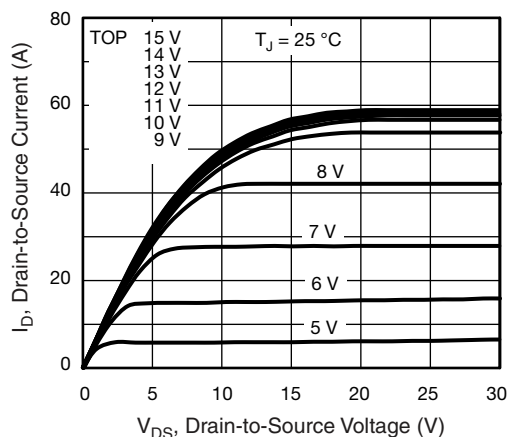
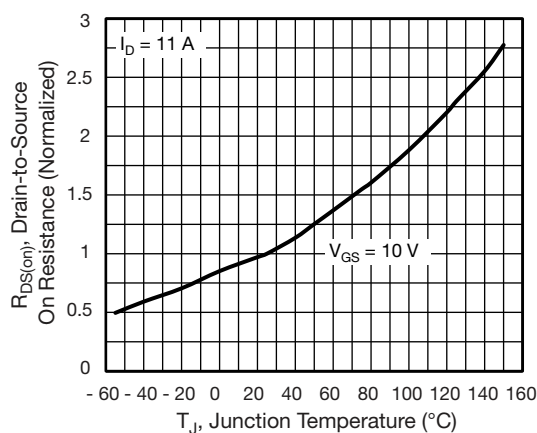
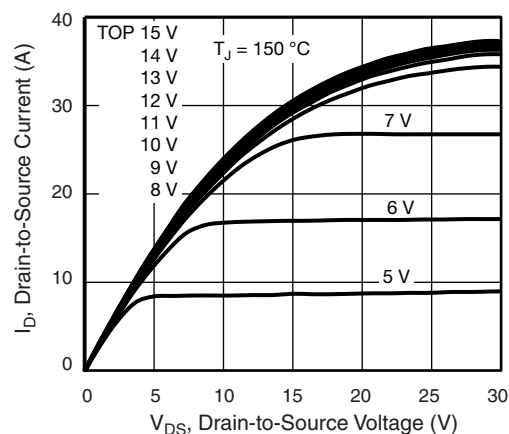
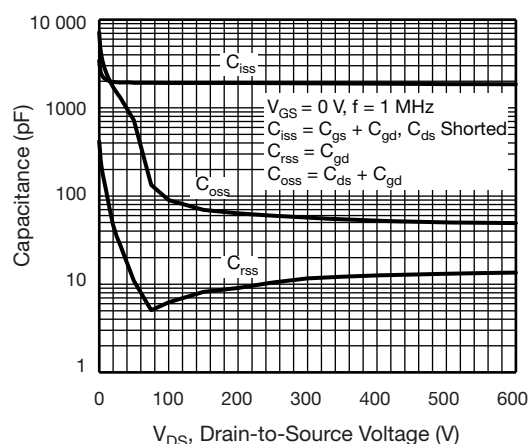
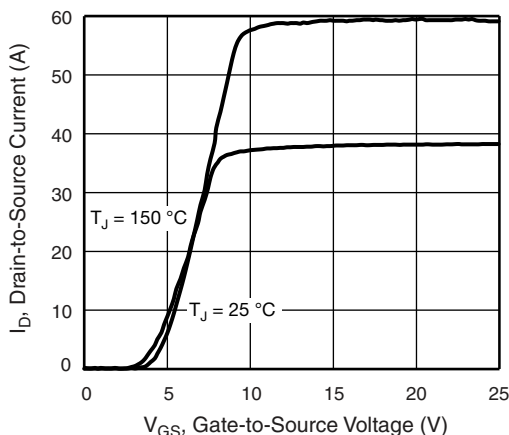
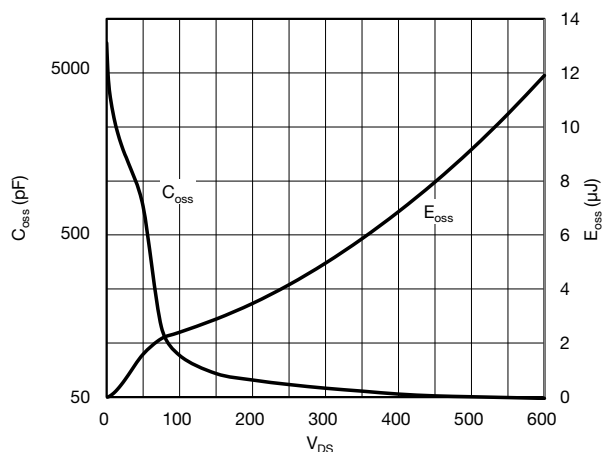
| PARAMETER                        | SYMBOL     | TYP. | MAX. | UNIT |
|----------------------------------|------------|------|------|------|
| Maximum junction-to-ambient      | $R_{thJA}$ | -    | 65   | °C/W |
| Maximum junction-to-case (drain) | $R_{thJC}$ | -    | 3.6  |      |

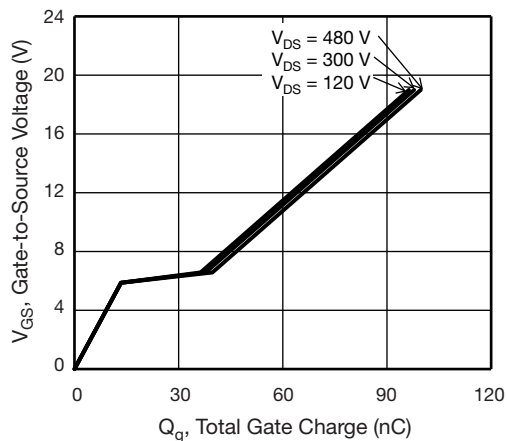
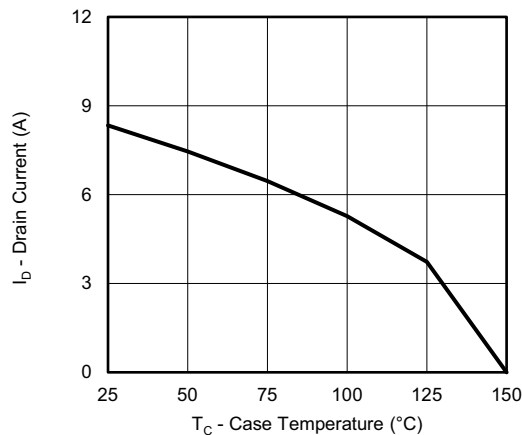
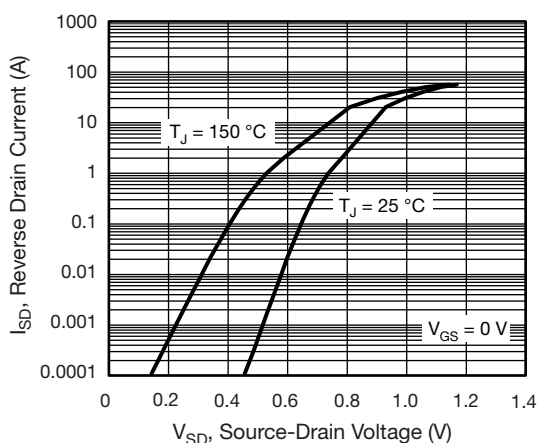
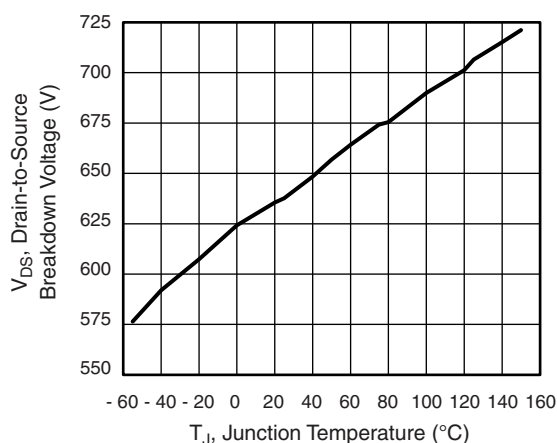
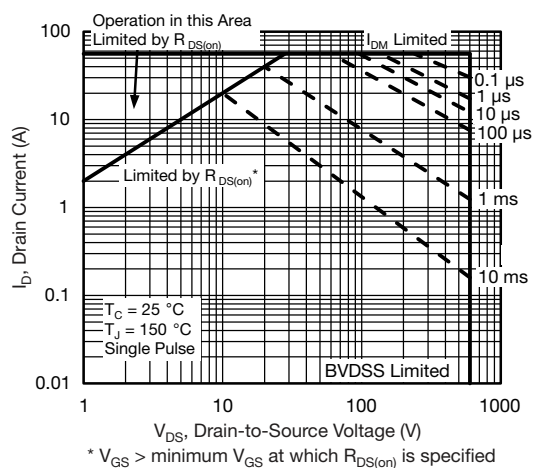
**SPECIFICATIONS** ( $T_J = 25\text{ }^{\circ}\text{C}$ , unless otherwise noted)

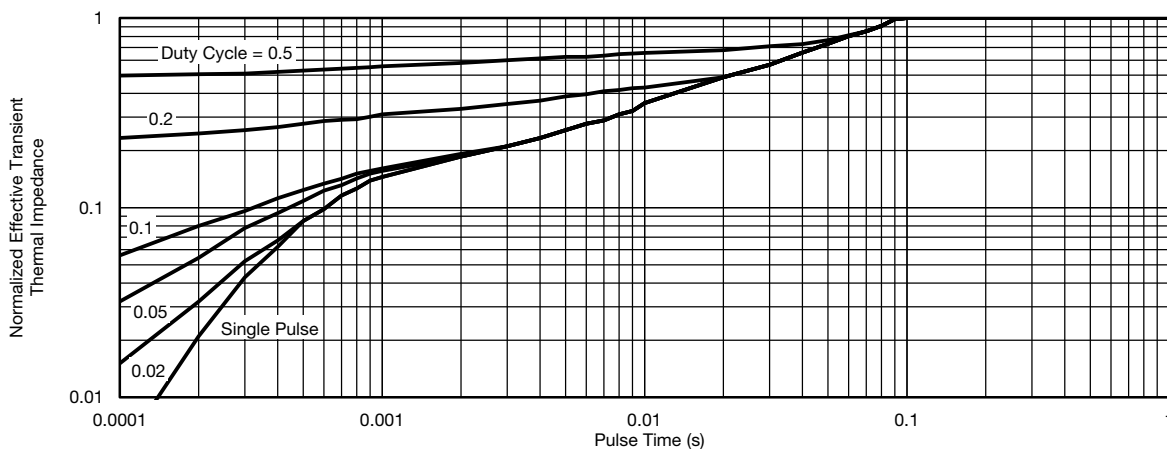
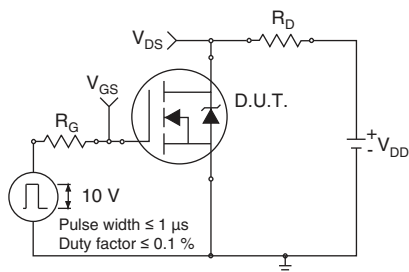
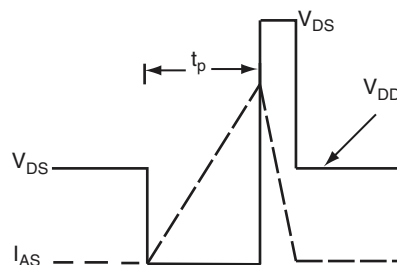
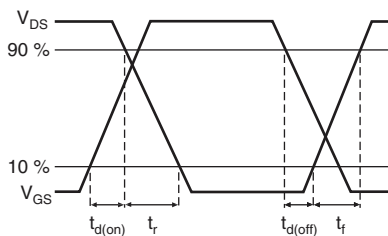
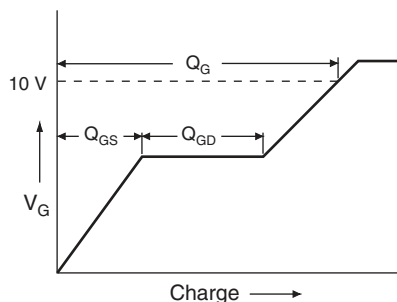
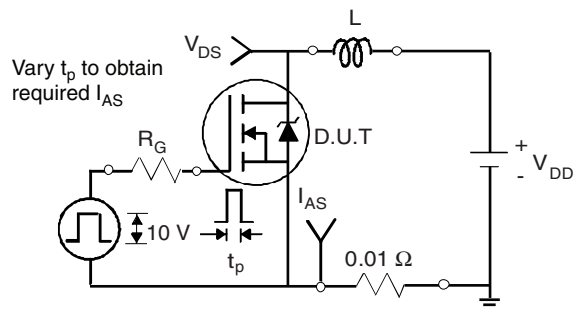
| PARAMETER                                                 | SYMBOL                           | TEST CONDITIONS                                                                                                                                          |                                                | 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> = 250 μA                                                                                                              |                                                | -    | 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> = 11 A                          | -    | 0.15 | 0.18  | Ω    |
| Forward transconductance                                  | g <sub>fs</sub>                  | V <sub>DS</sub> = 8 V, I <sub>D</sub> = 5 A                                                                                                              |                                                | -    | 6.4  | -     | 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                                                                                          |                                                | -    | 1920 | -     | pF   |
| Output capacitance                                        | C <sub>oss</sub>                 |                                                                                                                                                          |                                                | -    | 90   | -     |      |
| Reverse transfer capacitance                              | C <sub>rss</sub>                 |                                                                                                                                                          |                                                | -    | 6    | -     |      |
| 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                                                                                                    |                                                | -    | 73   | -     | pF   |
| Effective output capacitance, time related <sup>b</sup>   | C <sub>o(tr)</sub>               |                                                                                                                                                          |                                                | -    | 263  | -     |      |
| Total gate charge                                         | Q <sub>g</sub>                   | V <sub>GS</sub> = 10 V                                                                                                                                   | I <sub>D</sub> = 11 A, V <sub>DS</sub> = 480 V | -    | 57   | 86    | nC   |
| Gate-source charge                                        | Q <sub>gs</sub>                  |                                                                                                                                                          |                                                | -    | 11   | -     |      |
| Gate-drain charge                                         | Q <sub>gd</sub>                  |                                                                                                                                                          |                                                | -    | 24   | -     |      |
| Turn-on delay time                                        | t <sub>d(on)</sub>               | V <sub>DD</sub> = 380 V, I <sub>D</sub> = 11 A,<br>V <sub>GS</sub> = 10 V, R <sub>g</sub> = 4.7 Ω                                                        |                                                | -    | 18   | 36    | ns   |
| Rise time                                                 | t <sub>r</sub>                   |                                                                                                                                                          |                                                | -    | 27   | 54    |      |
| Turn-off delay time                                       | t <sub>d(off)</sub>              |                                                                                                                                                          |                                                | -    | 66   | 99    |      |
| Fall time                                                 | t <sub>f</sub>                   |                                                                                                                                                          |                                                | -    | 35   | 70    |      |
| Gate input resistance                                     | R <sub>g</sub>                   | f = 1 MHz, open drain                                                                                                                                    |                                                | 0.3  | 0.77 | 1.2   | 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> |                                                | -    | -    | 21    | A    |
| Pulsed diode forward current                              | I <sub>SM</sub>                  |                                                                                                                                                          |                                                | -    | -    | 56    |      |
| Diode forward voltage                                     | V <sub>SD</sub>                  | T <sub>J</sub> = 25 °C, I <sub>S</sub> = 11 A, V <sub>GS</sub> = 0 V                                                                                     |                                                | -    | -    | 1.2   | V    |
| Reverse recovery time                                     | t <sub>rr</sub>                  | T <sub>J</sub> = 25 °C, I <sub>F</sub> = I <sub>S</sub> = 11 A,<br>dI/dt = 100 A/μs, V <sub>R</sub> = 25 V                                               |                                                | -    | 344  | -     | ns   |
| Reverse recovery charge                                   | Q <sub>rr</sub>                  |                                                                                                                                                          |                                                | -    | 5.3  | -     | μC   |
| Reverse recovery current                                  | I <sub>RRM</sub>                 |                                                                                                                                                          |                                                | -    | 28   | -     | A    |

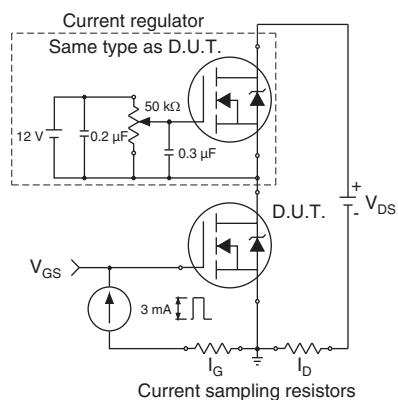
**Notes**

- 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 %  $V_{DSS}$

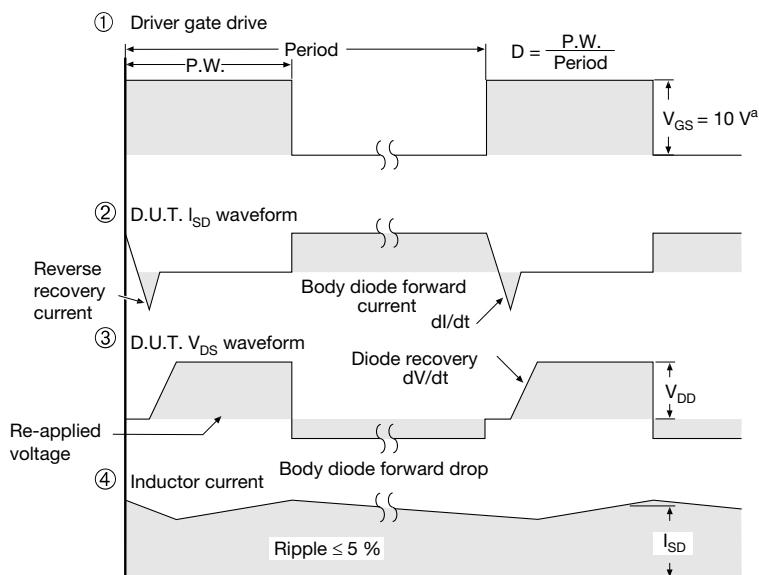
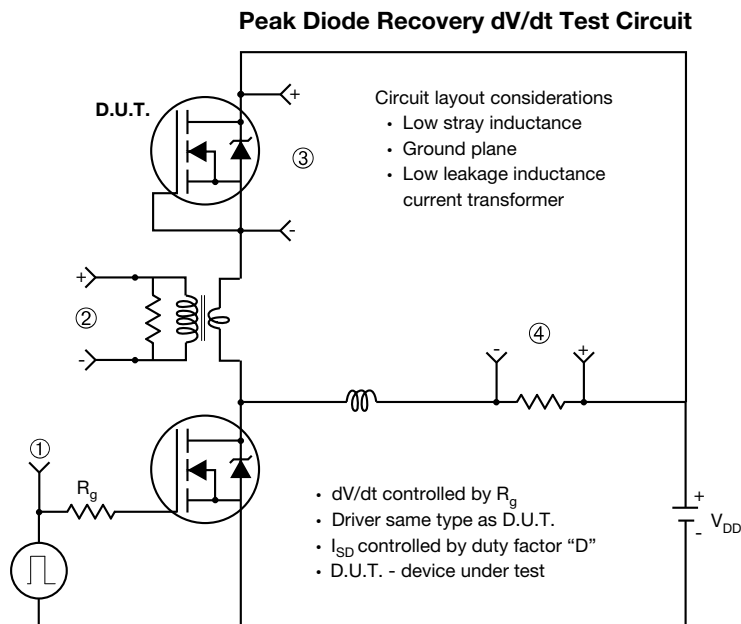
**TYPICAL CHARACTERISTICS** (25 °C, unless otherwise noted)

**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**



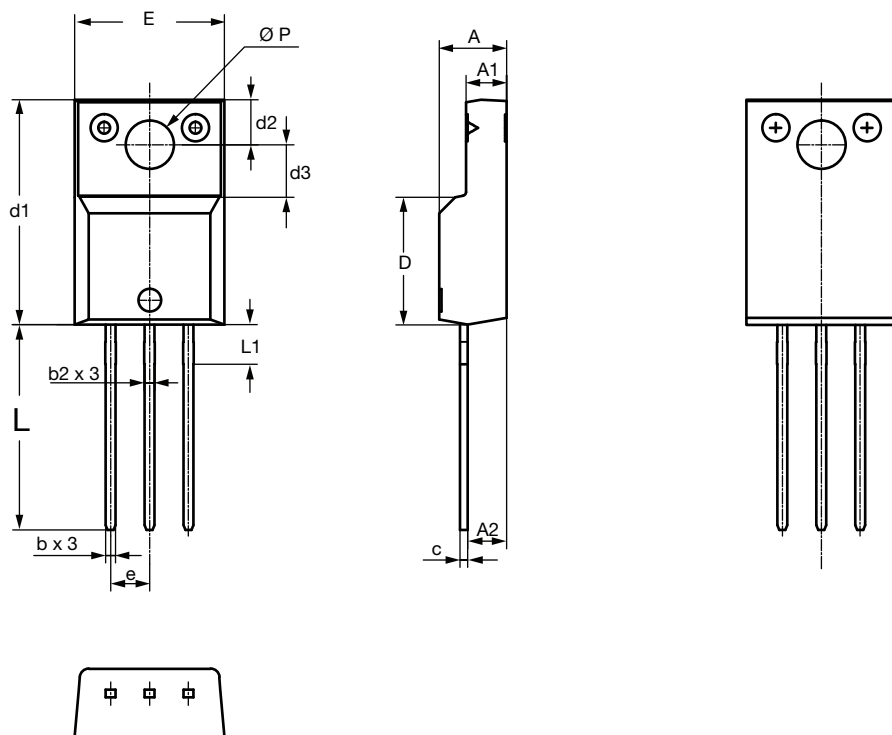
**Fig. 18 - Gate Charge Test Circuit**



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

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## TO-220 FULLPAK Thin Lead



| SYMBOL                                         | DIMENSIONS  |       |        |       |
|------------------------------------------------|-------------|-------|--------|-------|
|                                                | MILLIMETERS |       | INCHES |       |
|                                                | MIN.        | MAX.  | MIN.   | MAX.  |
| A                                              | 4.30        | 4.70  | 0.169  | 0.185 |
| A1                                             | 2.50        | 2.90  | 0.098  | 0.114 |
| A2                                             | 2.40        | 2.80  | 0.094  | 0.110 |
| b                                              | 0.60        | 0.80  | 0.024  | 0.031 |
| b2                                             | 0.60        | 0.90  | 0.024  | 0.035 |
| c                                              | -           | 0.60  | -      | 0.024 |
| D                                              | 8.30        | 8.70  | 0.327  | 0.342 |
| d1                                             | 14.70       | 15.30 | 0.579  | 0.602 |
| d2                                             | 2.90        | 3.10  | 0.114  | 0.122 |
| d3                                             | 3.30        | 3.70  | 0.130  | 0.146 |
| E                                              | 9.70        | 10.30 | 0.382  | 0.406 |
| e                                              | 2.50        | 2.70  | 0.098  | 0.106 |
| L                                              | 13.40       | 13.80 | 0.528  | 0.543 |
| L1                                             | 1.00        | 2.80  | 0.039  | 0.110 |
| Ø P                                            | 3.00        | 3.40  | 0.118  | 0.134 |
| ECN: E20-0684-Rev. D, 28-Dec-2020<br>DWG: 6021 |             |       |        |       |





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