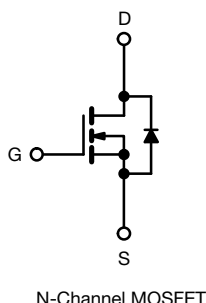


## E Series Power MOSFET with Fast Body Diode

Thin-Lead TO-220 FULLPAK



### FEATURES

- Fast body diode MOSFET using E series technology
- Reduced  $t_{rr}$ ,  $Q_{rr}$ , and  $I_{RRM}$
- Low figure-of-merit (FOM)  $R_{DS(on)} \times Q_g$
- Low input capacitance ( $C_{iss}$ )
- Low switching losses due to reduced  $Q_{rr}$
- 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

- Telecommunications
  - Server and telecom power supplies
- Lighting
  - High-intensity discharge (HID)
  - Fluorescent ballast lighting
- Consumer and computing
  - ATX power supplies
- Industrial
  - Welding
  - Battery chargers
- Renewable energy
  - Solar (PV inverters)
- Switch mode power supplies (SMPS)
- Applications using the following topologies
  - LCC
  - Phase shifted bridge (ZVS)
  - 3-level inverter
  - AC/DC bridge

### PRODUCT SUMMARY

|                                         |                 |      |
|-----------------------------------------|-----------------|------|
| $V_{DS}$ (V) at $T_J$ max.              | 700             |      |
| $R_{DS(on)}$ max. ( $\Omega$ ) at 25 °C | $V_{GS} = 10$ V | 0.18 |
| $Q_g$ max. (nC)                         | 106             |      |
| $Q_{gs}$ (nC)                           | 14              |      |
| $Q_{gd}$ (nC)                           | 33              |      |
| Configuration                           | Single          |      |

### ORDERING INFORMATION

|                                 |                          |
|---------------------------------|--------------------------|
| Package                         | Thin-Lead TO-220 FULLPAK |
| Lead (Pb)-free                  | SiHA21N65EF-E3           |
| Lead (Pb)-free and halogen-free | SiHA21N65EF-GE3          |

### ABSOLUTE MAXIMUM RATINGS ( $T_C = 25$ °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 ( $T_J = 150$ °C) <sup>e</sup>   | $V_{GS}$ at 10 V | $T_C = 25$ °C  | A    |
|                                                           |                  | $T_C = 100$ °C |      |
| Pulsed drain current <sup>a</sup>                         | $I_{DM}$         | 53             |      |
| 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
- $V_{DD} = 50$  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**

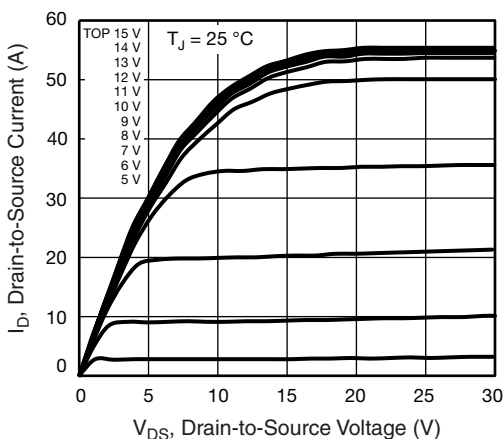
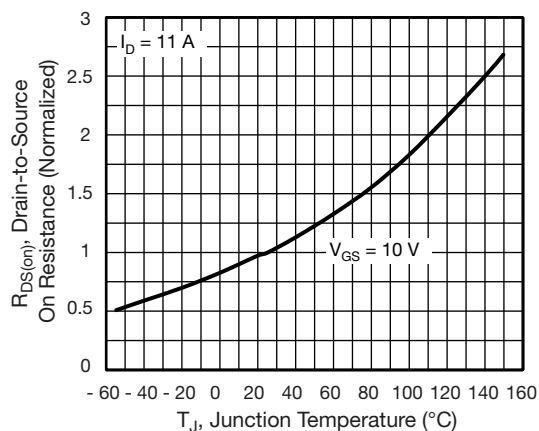
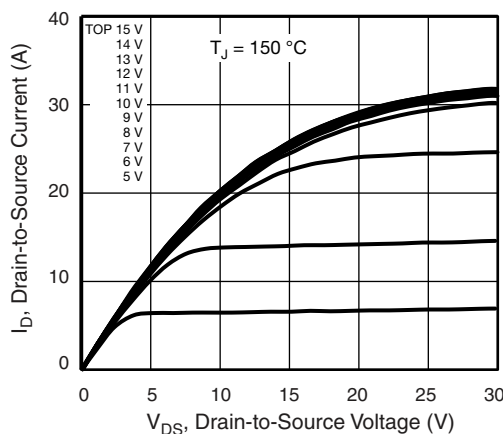
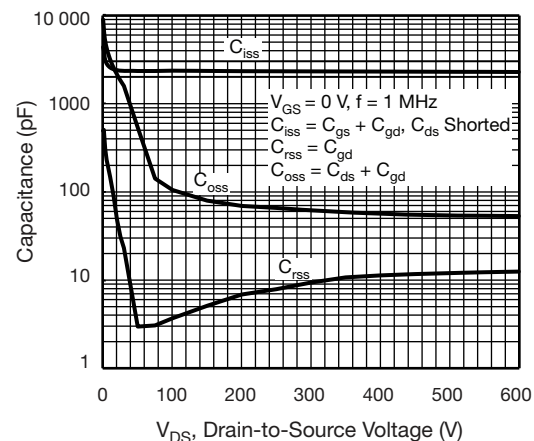
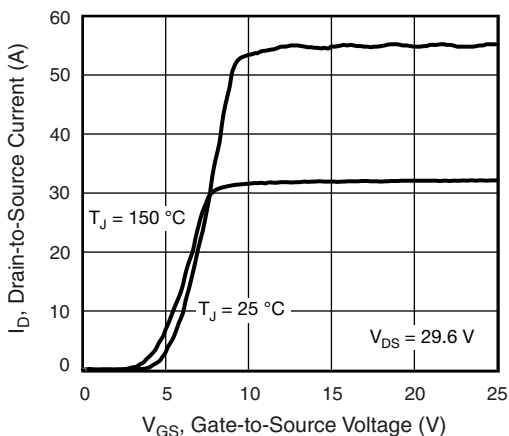
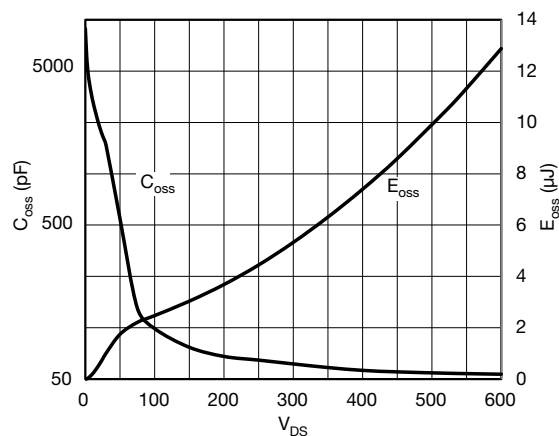
| PARAMETER                        | SYMBOL     | TYP. | MAX. | UNIT |
|----------------------------------|------------|------|------|------|
| Maximum junction-to-ambient      | $R_{thJA}$ | -    | 65   | °C/W |
| Maximum junction-to-case (drain) | $R_{thJC}$ | -    | 3.6  |      |

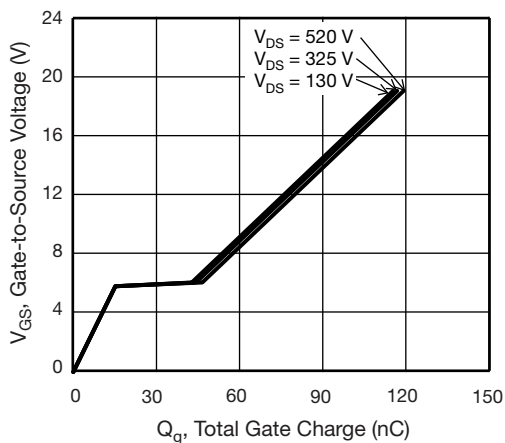
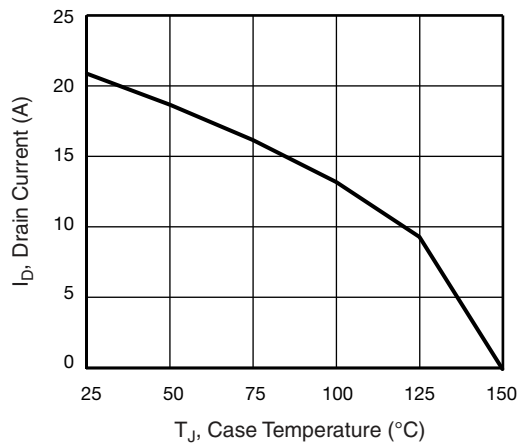
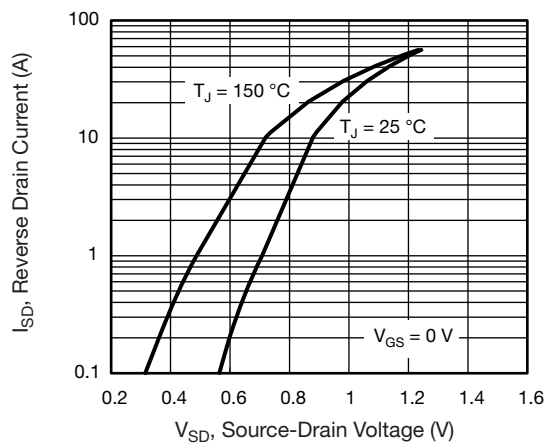
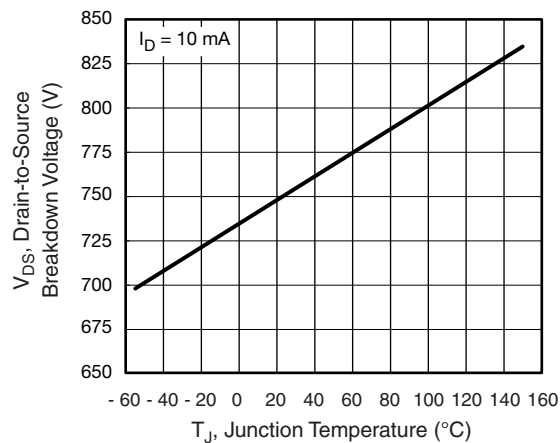
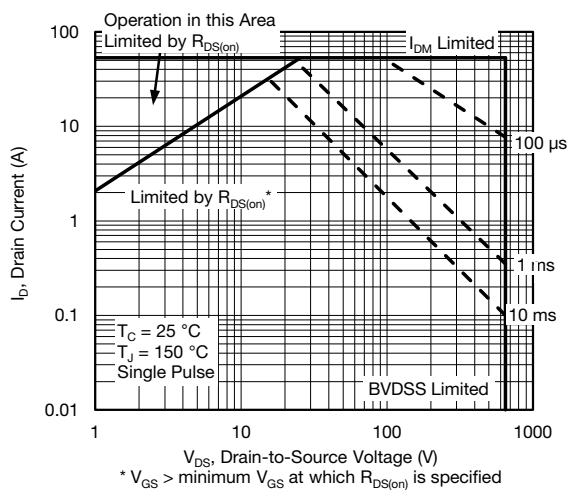
**SPECIFICATIONS** ( $T_J = 25\text{ }^{\circ}\text{C}$ , unless otherwise noted)

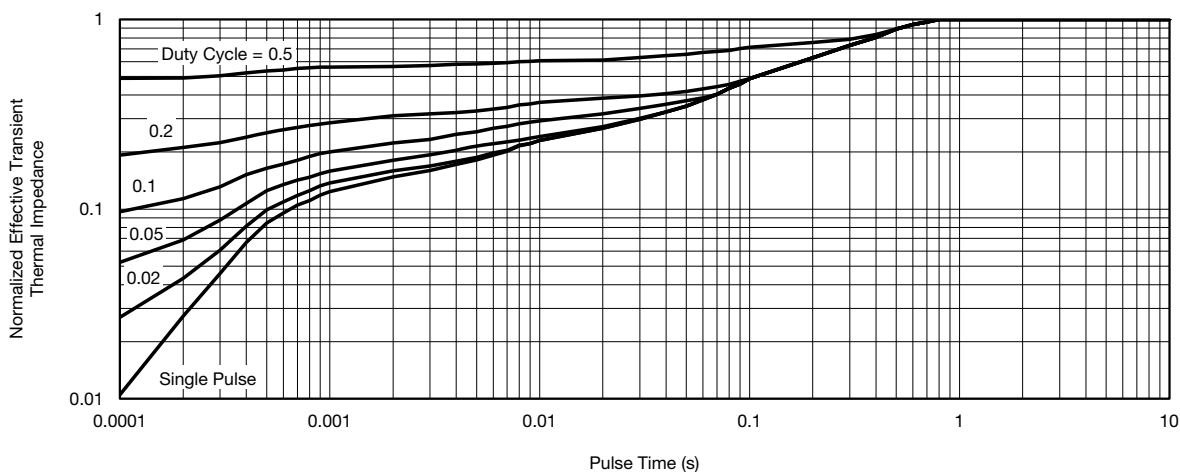
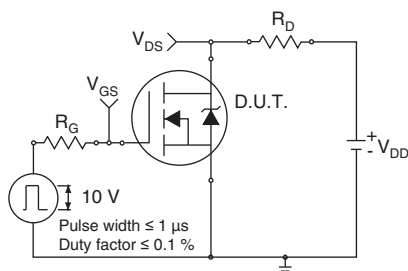
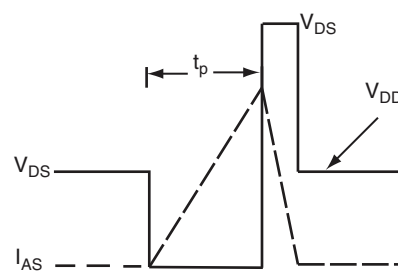
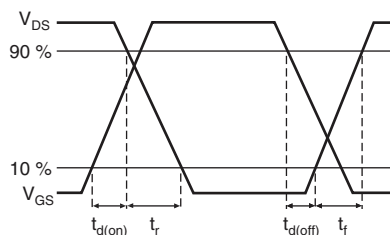
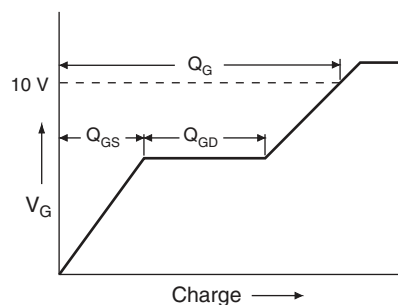
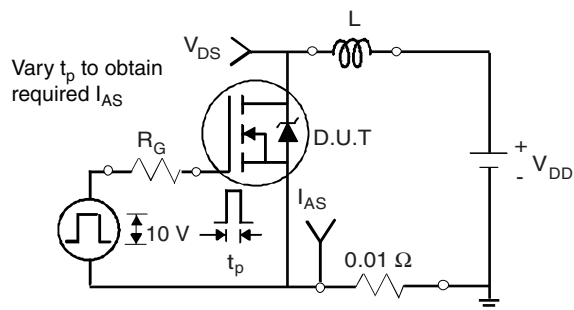
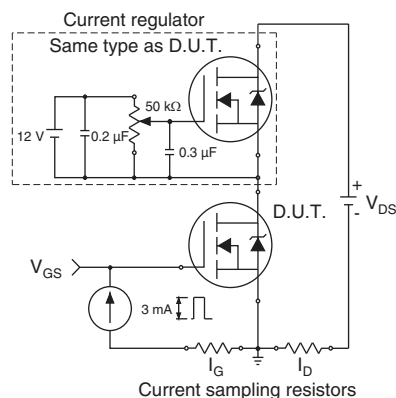
| PARAMETER                                                 | SYMBOL              | TEST CONDITIONS                                                                                                                                          |                                               | MIN. | TYP. | MAX.      | UNIT                  |
|-----------------------------------------------------------|---------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------|------|------|-----------|-----------------------|
| Static                                                    |                     |                                                                                                                                                          |                                               |      |      |           |                       |
| Drain-source breakdown voltage                            | $V_{DS}$            | $V_{GS} = 0\text{ V}$ , $I_D = 250\text{ }\mu\text{A}$                                                                                                   |                                               | 650  | -    | -         | V                     |
| $V_{DS}$ temperature coefficient                          | $\Delta V_{DS}/T_J$ | Reference to $25\text{ }^{\circ}\text{C}$ , $I_D = 1\text{ mA}$                                                                                          |                                               | -    | 0.67 | -         | V/ $^{\circ}\text{C}$ |
| Gate-source threshold voltage (N)                         | $V_{GS(th)}$        | $V_{DS} = V_{GS}$ , $I_D = 250\text{ }\mu\text{A}$                                                                                                       |                                               | 2    | -    | 4         | V                     |
| Gate-source leakage                                       | $I_{GSS}$           | $V_{GS} = \pm 20\text{ V}$                                                                                                                               |                                               | -    | -    | $\pm 100$ | nA                    |
|                                                           |                     | $V_{GS} = \pm 30\text{ V}$                                                                                                                               |                                               | -    | -    | $\pm 1$   | $\mu\text{A}$         |
| Zero gate voltage drain current                           | $I_{DSS}$           | $V_{DS} = 520\text{ V}$ , $V_{GS} = 0\text{ V}$                                                                                                          |                                               | -    | -    | 1         | $\mu\text{A}$         |
|                                                           |                     | $V_{DS} = 520\text{ V}$ , $V_{GS} = 0\text{ V}$ , $T_J = 125\text{ }^{\circ}\text{C}$                                                                    |                                               | -    | -    | 500       |                       |
| Drain-source on-state resistance                          | $R_{DS(on)}$        | $V_{GS} = 10\text{ V}$                                                                                                                                   | $I_D = 11\text{ A}$                           | -    | 0.15 | 0.18      | $\Omega$              |
| Forward transconductance                                  | $g_{fs}$            | $V_{DS} = 30\text{ V}$ , $I_D = 11\text{ A}$                                                                                                             |                                               | -    | 7.0  | -         | S                     |
| Dynamic                                                   |                     |                                                                                                                                                          |                                               |      |      |           |                       |
| Input capacitance                                         | $C_{iss}$           | $V_{GS} = 0\text{ V}$ ,<br>$V_{DS} = 100\text{ V}$ ,<br>$f = 1\text{ MHz}$                                                                               |                                               | -    | 2322 | -         | pF                    |
| Output capacitance                                        | $C_{oss}$           |                                                                                                                                                          |                                               | -    | 105  | -         |                       |
| Reverse transfer capacitance                              | $C_{rss}$           |                                                                                                                                                          |                                               | -    | 4    | -         |                       |
| Effective output capacitance, energy related <sup>a</sup> | $C_{o(er)}$         | $V_{DS} = 0\text{ V to } 520\text{ V}$ , $V_{GS} = 0\text{ V}$                                                                                           |                                               | -    | 84   | -         |                       |
| Effective output capacitance, time related <sup>b</sup>   | $C_{o(tr)}$         |                                                                                                                                                          |                                               | -    | 293  | -         |                       |
| Total gate charge                                         | $Q_g$               | $V_{GS} = 10\text{ V}$                                                                                                                                   | $I_D = 11\text{ A}$ , $V_{DS} = 520\text{ V}$ | -    | 71   | 106       | nC                    |
| Gate-source charge                                        | $Q_{gs}$            |                                                                                                                                                          |                                               | -    | 14   | -         |                       |
| Gate-drain charge                                         | $Q_{gd}$            |                                                                                                                                                          |                                               | -    | 33   | -         |                       |
| Turn-on delay time                                        | $t_{d(on)}$         | $V_{DD} = 520\text{ V}$ , $I_D = 11\text{ A}$ ,<br>$V_{GS} = 10\text{ V}$ , $R_g = 9.1\text{ }\Omega$                                                    |                                               | -    | 22   | 44        | ns                    |
| Rise time                                                 | $t_r$               |                                                                                                                                                          |                                               | -    | 34   | 68        |                       |
| Turn-off delay time                                       | $t_{d(off)}$        |                                                                                                                                                          |                                               | -    | 68   | 102       |                       |
| Fall time                                                 | $t_f$               |                                                                                                                                                          |                                               | -    | 42   | 84        |                       |
| Gate input resistance                                     | $R_g$               | $f = 1\text{ MHz}$ , open drain                                                                                                                          |                                               | -    | 0.78 | -         | $\Omega$              |
| Drain-Source Body Diode Characteristics                   |                     |                                                                                                                                                          |                                               |      |      |           |                       |
| Continuous source-drain diode current                     | $I_S$               | MOSFET symbol showing the integral reverse p - n junction diode<br> |                                               | -    | -    | 21        | A                     |
| Pulsed diode forward current                              | $I_{SM}$            |                                                                                                                                                          |                                               | -    | -    | 53        |                       |
| Diode forward voltage                                     | $V_{SD}$            | $T_J = 25\text{ }^{\circ}\text{C}$ , $I_S = 11\text{ A}$ , $V_{GS} = 0\text{ V}$                                                                         |                                               | -    | 0.9  | 1.2       | V                     |
| Reverse recovery time                                     | $t_{rr}$            | $T_J = 25\text{ }^{\circ}\text{C}$ , $I_F = I_S = 11\text{ A}$ ,<br>$di/dt = 100\text{ A}/\mu\text{s}$ , $V_R = 25\text{ V}$                             |                                               | -    | 160  | -         | ns                    |
| Reverse recovery charge                                   | $Q_{rr}$            |                                                                                                                                                          |                                               | -    | 1.2  | -         | $\mu\text{C}$         |
| Reverse recovery current                                  | $I_{RRM}$           |                                                                                                                                                          |                                               | -    | 14   | -         | A                     |

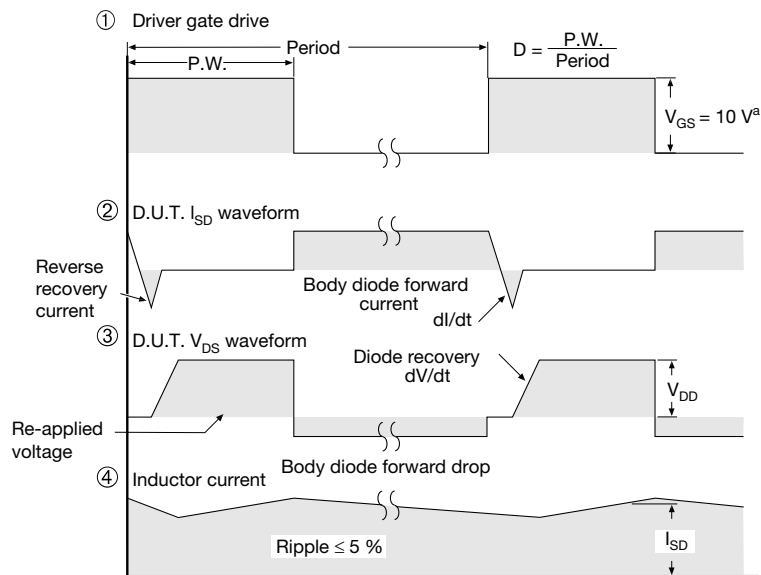
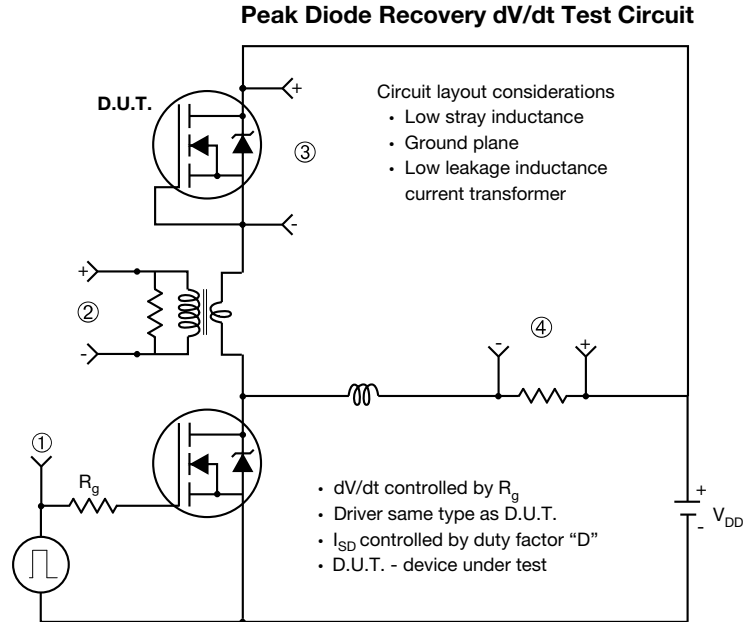
**Notes**

- 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**

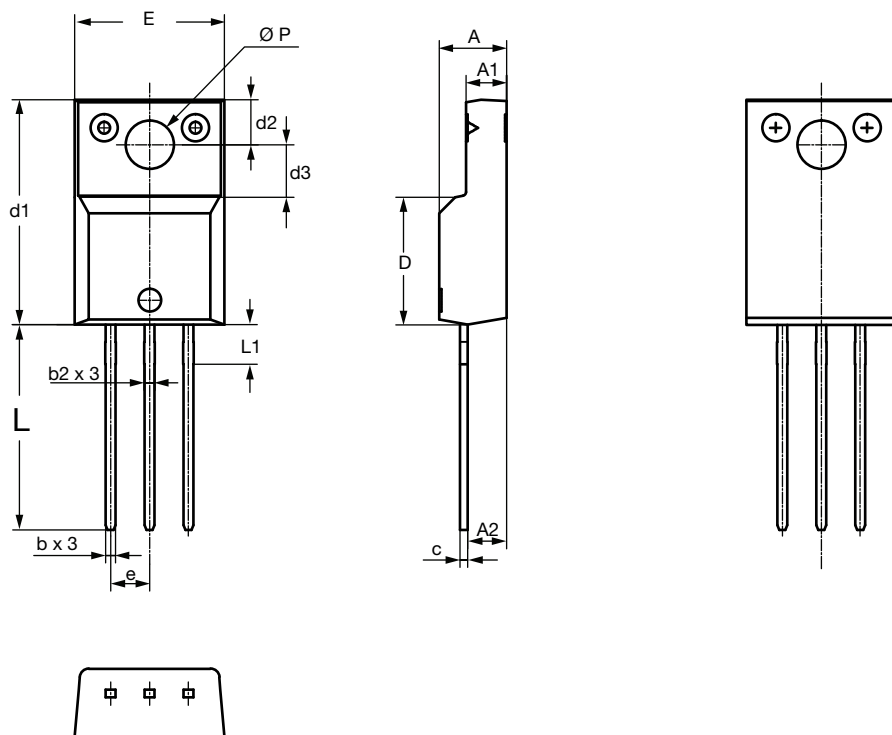

**Note**

a.  $V_{GS} = 5 V$  for logic level devices

**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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