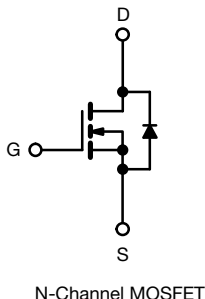
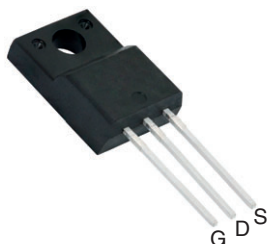


EF Series Power MOSFET with Fast Body Diode

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): $R_{on} \times Q_g$
- Low input capacitance (C_{iss})
- Increased robustness due to low 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



RoHS
COMPLIANT
HALOGEN
FREE
Available

APPLICATIONS

- Telecommunications
 - Server and telecom power supplies
- Lighting
 - High intensity discharge (HID)
 - Light emitting diodes (LEDs)
- Consumer and computing
 - ATX power supplies
- Industrial
 - Welding
 - Battery chargers
- Renewable energy
 - Solar (PV inverters)
- Switch mode power supplies (SMPS)
 - LLC
 - Phase shifted bridge (ZVS)
 - 3-level inverter
 - AC/DC bridge

PRODUCT SUMMARY

| | | |
|---|-----------------|-------|
| V_{DS} (V) at T_J max. | 650 | |
| $R_{DS(on)}$ max. (Ω) at 25 °C | $V_{GS} = 10$ V | 0.176 |
| Q_g max. (nC) | 84 | |
| Q_{gs} (nC) | 14 | |
| Q_{gd} (nC) | 24 | |
| Configuration | Single | |

ORDERING INFORMATION

| | |
|---------------------------------|--------------------------|
| Package | Thin-Lead TO-220 FULLPAK |
| Lead (Pb)-free | SiHA21N60EF-E3 |
| Lead (Pb)-free and halogen-free | SiHA21N60EF-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} | ± 30 | |
| Continuous drain current ($T_J = 150$ °C) | V_{GS} at 10 V | $T_C = 25$ °C | A |
| | | $T_C = 100$ °C | |
| Pulsed drain current ^a | I_{DM} | 53 | |
| Linear derating factor | | 0.28 | W/°C |
| Single pulse avalanche energy ^b | 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 ^d | | | |
| Soldering recommendations (peak temperature) ^c | for 10 s | 300 | °C |
| Mounting torque | M3 screw | 0.6 | Nm |


Notes

- Repetitive rating; pulse width limited by maximum junction temperature
- $V_{DD} = 50$ V, starting $T_J = 25$ °C, $L = 28.2$ mH, $R_g = 25$ Ω , $I_{AS} = 5.1$ A
- 1.6 mm from case
- $I_{SD} \leq I_D$, $dI/dt = 900$ A/ μ s, starting $T_J = 25$ °C

**THERMAL RESISTANCE RATINGS**

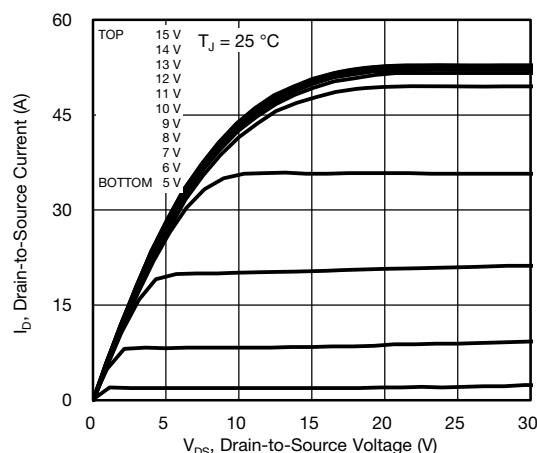
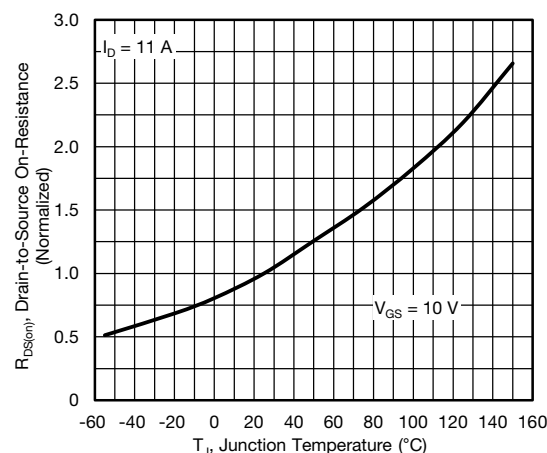
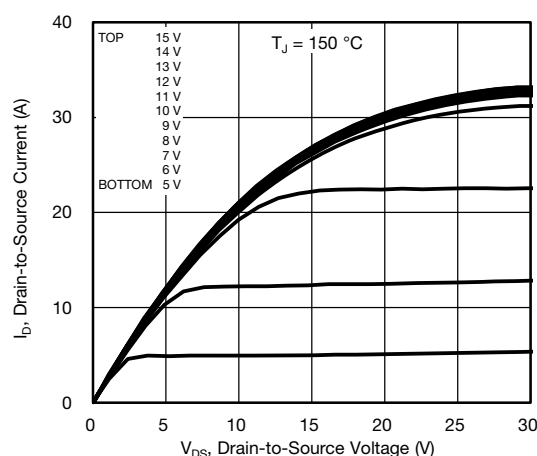
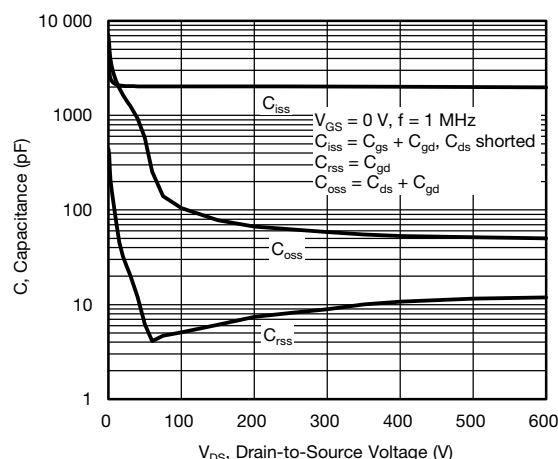
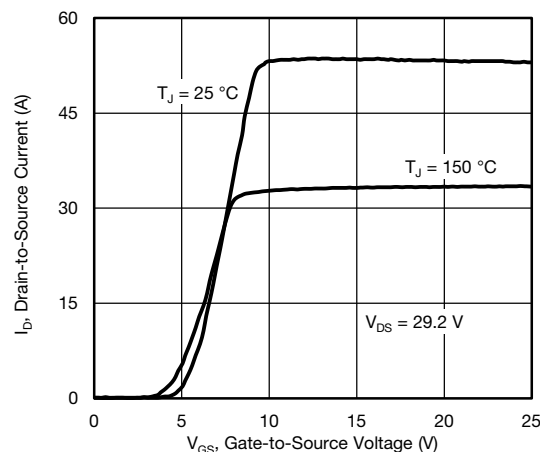
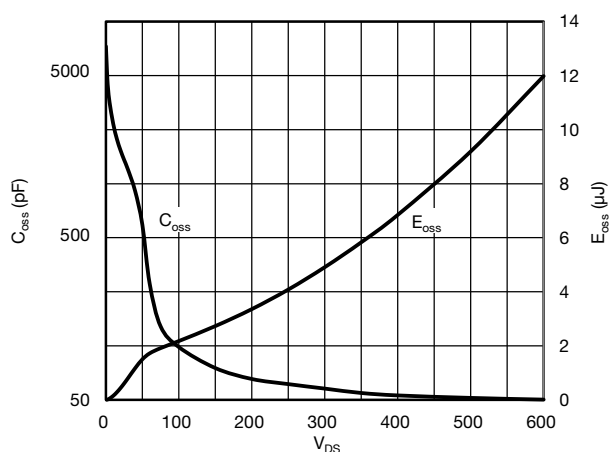
| PARAMETER | SYMBOL | TYP. | MAX. | UNIT |
|----------------------------------|------------|------|------|------|
| Maximum junction-to-ambient | R_{thJA} | - | 65 | °C/W |
| Maximum junction-to-case (drain) | R_{thJC} | - | 3.6 | |

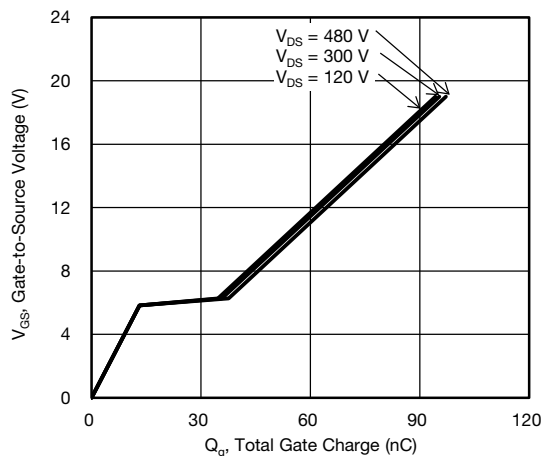
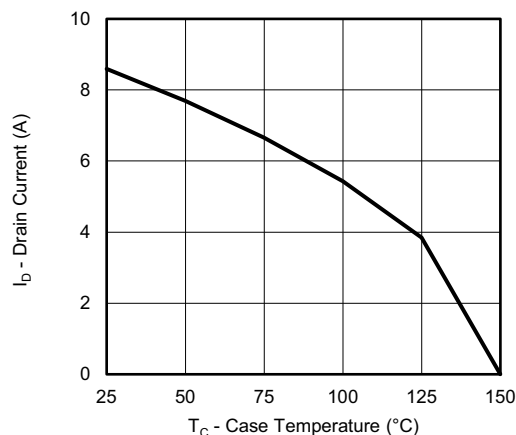
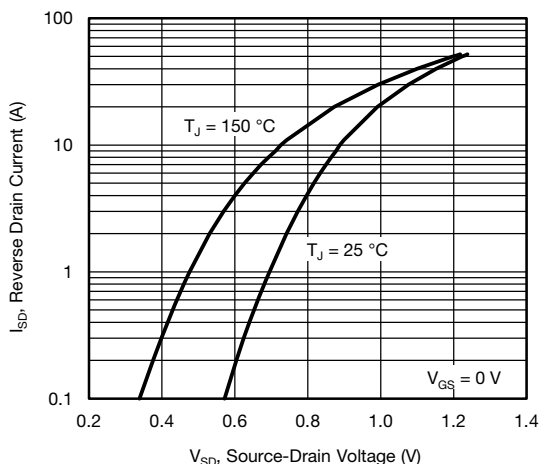
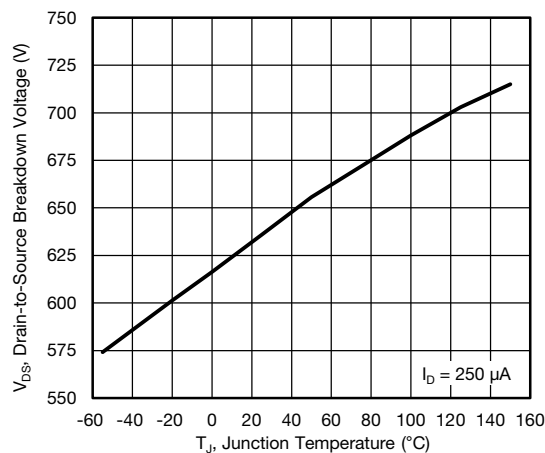
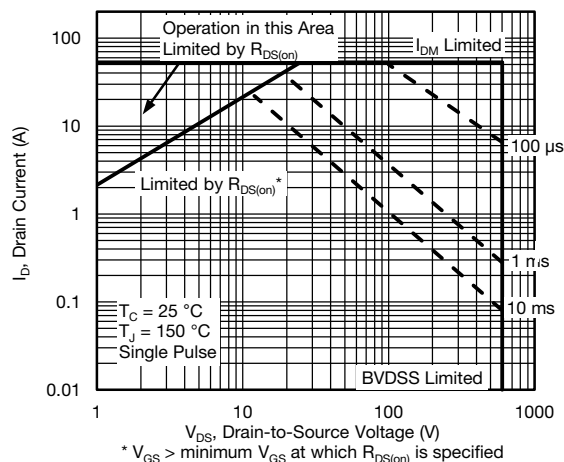
SPECIFICATIONS ($T_J = 25\text{ }^{\circ}\text{C}$, unless otherwise noted)

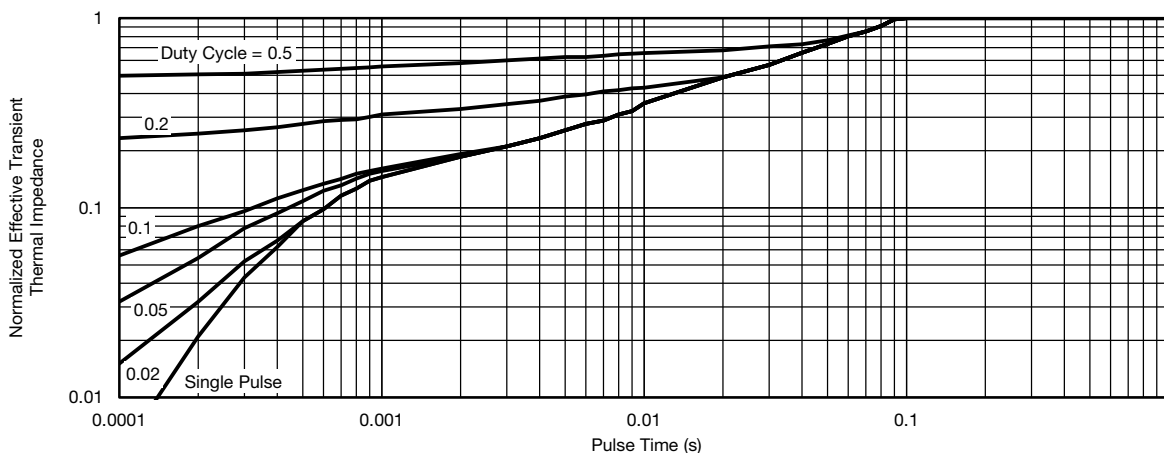
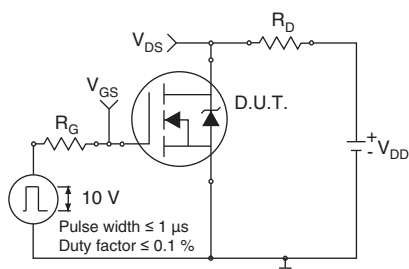
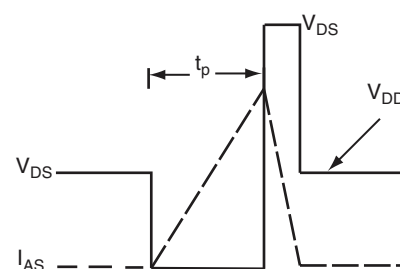
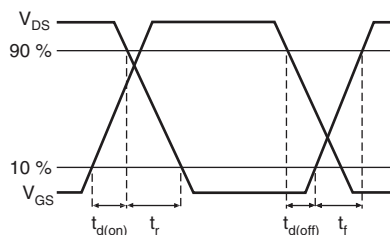
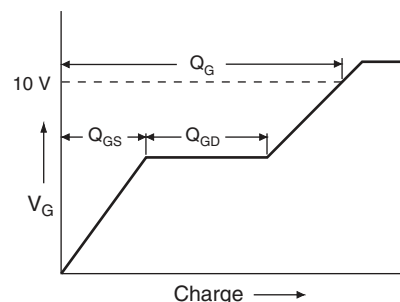
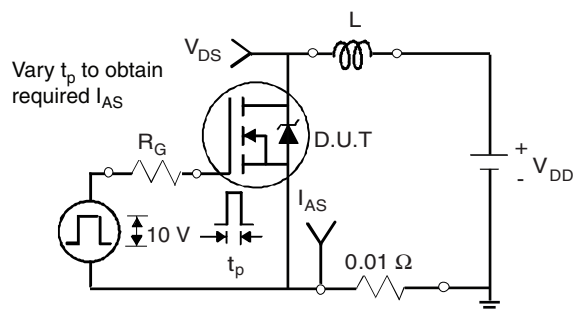
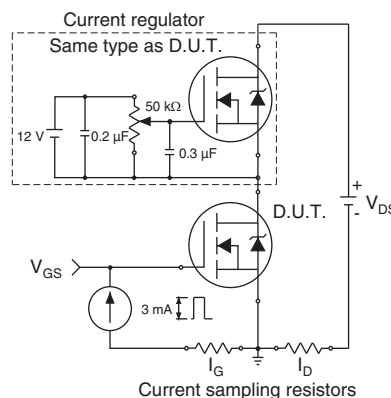
| PARAMETER | SYMBOL | TEST CONDITIONS | MIN. | TYP. | MAX. | UNIT |
|---|---------------------|---|------|-------|-----------|-----------------------|
| Static | | | | | | |
| Drain-source breakdown voltage | V_{DS} | $V_{GS} = 0\text{ V}$, $I_D = 250\text{ }\mu\text{A}$ | 600 | - | - | V |
| V_{DS} temperature coefficient | $\Delta V_{DS}/T_J$ | Reference to $25\text{ }^{\circ}\text{C}$, $I_D = 1\text{ mA}$ | - | 0.59 | - | V/ $^{\circ}\text{C}$ |
| Gate-source threshold voltage (N) | $V_{GS(th)}$ | $V_{DS} = V_{GS}$, $I_D = 250\text{ }\mu\text{A}$ | 2.0 | - | 4.0 | V |
| Gate-source leakage | I_{GSS} | $V_{GS} = \pm 20\text{ V}$ | - | - | ± 100 | nA |
| | | $V_{GS} = \pm 30\text{ V}$ | - | - | ± 1 | μA |
| Zero gate voltage drain current | I_{DSS} | $V_{DS} = 480\text{ V}$, $V_{GS} = 0\text{ V}$ | - | - | 1 | μA |
| | | $V_{DS} = 480\text{ V}$, $V_{GS} = 0\text{ V}$, $T_J = 125\text{ }^{\circ}\text{C}$ | - | - | 500 | |
| Drain-source on-state resistance | $R_{DS(on)}$ | $V_{GS} = 10\text{ V}$, $I_D = 11\text{ A}$ | - | 0.153 | 0.176 | Ω |
| Forward transconductance | g_{fs} | $V_{DS} = 30\text{ V}$, $I_D = 11\text{ A}$ | - | 7 | - | S |
| Dynamic | | | | | | |
| Input capacitance | C_{iss} | $V_{GS} = 0\text{ V}$, $V_{DS} = 100\text{ V}$, $f = 1\text{ MHz}$ | - | 2030 | - | pF |
| Output capacitance | C_{oss} | | - | 105 | - | |
| Reverse transfer capacitance | C_{rss} | | - | 5 | - | |
| Effective output capacitance, energy related ^a | $C_{o(er)}$ | $V_{GS} = 0\text{ V}$, $V_{DS} = 0\text{ V to } 480\text{ V}$ | - | 86 | - | |
| Effective output capacitance, time related ^b | $C_{o(tr)}$ | | - | 299 | - | |
| Total gate charge | Q_g | $V_{GS} = 10\text{ V}$, $I_D = 11\text{ A}$, $V_{DS} = 480\text{ V}$ | - | 56 | 84 | nC |
| Gate-source charge | Q_{gs} | | - | 14 | - | |
| Gate-drain charge | Q_{gd} | | - | 24 | - | |
| Turn-on delay time | $t_{d(on)}$ | $V_{DD} = 480\text{ V}$, $I_D = 11\text{ A}$, $R_g = 9.1\text{ }\Omega$, $V_{GS} = 10\text{ V}$ | - | 21 | 42 | ns |
| Rise time | t_r | | - | 31 | 62 | |
| Turn-off delay time | $t_{d(off)}$ | | - | 59 | 89 | |
| Fall time | t_f | | - | 27 | 54 | |
| Gate input resistance | R_g | $f = 1\text{ MHz}$, open drain | 0.2 | 0.56 | 1.2 | Ω |
| Drain-Source Body Diode Characteristics | | | | | | |
| Continuous source-drain diode current | I_S | MOSFET symbol showing the integral reverse p - n junction diode  | - | - | 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} | $T_J = 25\text{ }^{\circ}\text{C}$, $I_F = I_S = 11\text{ A}$, $dI/dt = 100\text{ A}/\mu\text{s}$, $V_R = 400\text{ V}$ | - | 135 | 270 | ns |
| Reverse recovery charge | Q_{rr} | | - | 0.76 | 1.52 | μC |
| Reverse recovery current | I_{RRM} | | - | 11 | - | 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_{DS}
b. $C_{oss(tr)}$ is a fixed capacitance that gives the charging time as C_{oss} while V_{DS} is rising from 0 % to 80 % V_{DS}

TYPICAL CHARACTERISTICS (25 °C, unless otherwise noted)

Fig. 1 - Typical Output Characteristics, $T_J = 25\text{ °C}$

Fig. 4 - Normalized On-Resistance vs. Temperature

Fig. 2 - Typical Output Characteristics, $T_J = 150\text{ °C}$

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 - Typical Drain-to-Source Voltage vs. Temperature

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

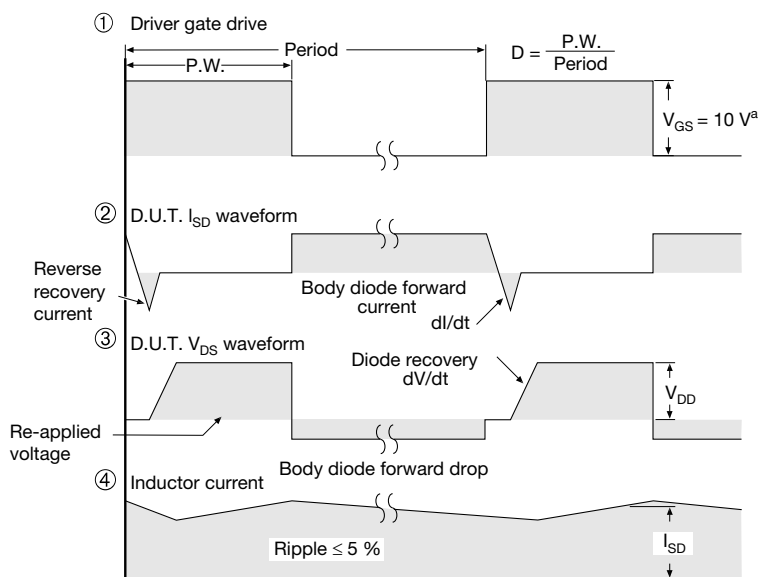
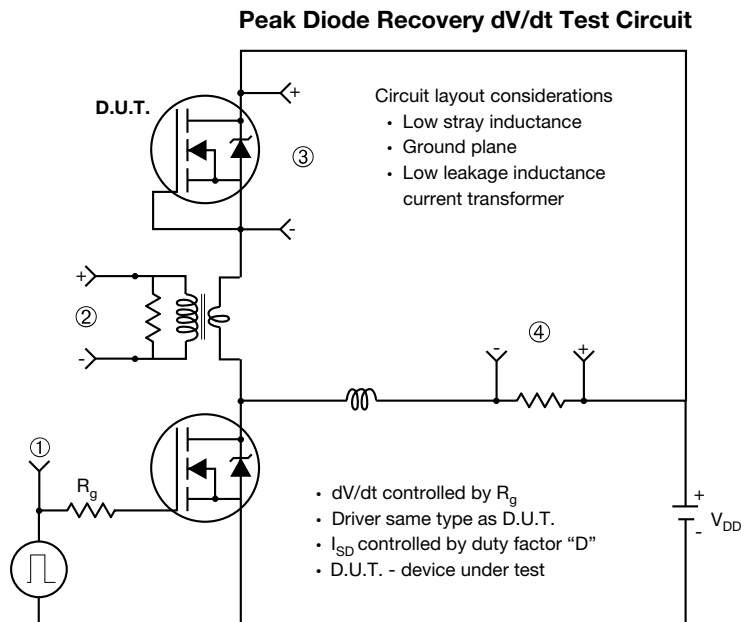


Fig. 19 - For N-Channel

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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 DWG: 6021 | | | | |



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