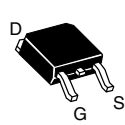


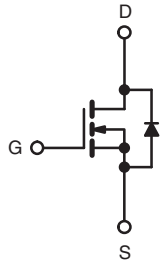
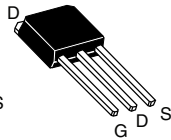
Power MOSFET

| PRODUCT SUMMARY | |
|--------------------------------|------------------------------|
| V _{DS} (V) | 600 |
| R _{DS(on)} (Max.) (Ω) | V _{GS} = 10 V 7.0 |
| Q _g (Max.) (nC) | 14 |
| Q _{gs} (nC) | 2.7 |
| Q _{gd} (nC) | 8.1 |
| Configuration | Single |

PAK (TO-252)



IPAK (TO-251)



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



RoHS
COMPLIANT
HALOGEN
FREE
Available

APPLICATIONS

- Switch Mode Power Supply (SMPS)
- Uninterruptible Power Supply
- Power Factor Correction

TYPICAL SMPS TOPOLOGIES

- Low Power Single Transistor Flyback

| ORDERING INFORMATION | | | | | |
|---------------------------------|----------------|--------------------------------|-------------------------------|--------------------------------|----------------|
| Package | PAK (TO-252) | PAK (TO-252) | PAK (TO-252) | PAK (TO-252) | IPAK (TO-251) |
| Lead (Pb)-free and Halogen-free | SiHFR1N60A-GE3 | SiHFR1N60ATRL-GE3 ^a | SiHFR1N60ATR-GE3 ^a | SiHFR1N60ATRR-GE3 ^a | SiHFU1N60A-GE3 |
| Lead (Pb)-free | IRFR1N60APbF | IRFR1N60ATRLPbF ^a | IRFR1N60ATRPbF ^a | IRFR1N60ATRRPbF ^a | IRFU1N60APbF |
| | SiHFR1N60A-E3 | SiHFR1N60ATL-E3 ^a | SiHFR1N60AT-E3 ^a | SiHFR1N60ATR-E3 ^a | SiHFU1N60A-E3 |

Note

- a. See device orientation.

| 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 | V _{GS} at 10 V | T _C = 25 °C | 1.4 | A | |
| | | T _C = 100 °C | 0.89 | | |
| Pulsed Drain Current ^a | I _{DM} | | 5.6 | | |
| Linear Derating Factor | | | 0.28 | W/°C | |
| Single Pulse Avalanche Energy ^b | E _{AS} | | 93 | mJ | |
| Repetitive Avalanche Current ^a | I _{AR} | | 1.4 | A | |
| Repetitive Avalanche Energy ^a | E _{AR} | | 3.6 | mJ | |
| Maximum Power Dissipation | T _C = 25 °C | | P _D | 36 | W |
| Peak Diode Recovery dV/dt ^c | | | dV/dt | 3.8 | V/ns |
| Operating Junction and Storage Temperature Range | T _J , T _{stg} | | - 55 to + 150 | °C | |
| Soldering Recommendations (Peak Temperature) ^d | for 10 s | | 300 | | |

Notes


- a. Repetitive rating; pulse width limited by maximum junction temperature (see fig. 11).
 b. Starting T_J = 25 °C, L = 95 mH, R_g = 25 Ω, I_{AS} = 1.4 A (see fig. 12).
 c. I_{SD} ≤ 1.4 A, di/dt ≤ 180 A/μs, V_{DD} ≤ V_{DS}, T_J ≤ 150 °C.
 d. 1.6 mm from case.



| THERMAL RESISTANCE RATINGS | | | | |
|--|------------|------|------|------|
| PARAMETER | SYMBOL | TYP. | MAX. | UNIT |
| Maximum Junction-to-Ambient | R_{thJA} | - | 110 | °C/W |
| Maximum Junction-to-Ambient (PCB Mount) ^a | R_{thJA} | - | 50 | |
| Maximum Junction-to-Case (Drain) | R_{thJC} | - | 3.5 | |

Note

a. When mounted on 1" square PCB (FR-4 or G-10 material).

| 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 |
| Gate-Source Threshold Voltage | $V_{GS(th)}$ | $V_{DS} = V_{GS}, I_D = 250\text{ }\mu\text{A}$ | 2.0 | - | 4.0 | |
| Gate-Source Leakage | I_{GSS} | $V_{GS} = \pm 30\text{ V}$ | - | - | ± 100 | nA |
| Zero Gate Voltage Drain Current | I_{DSS} | $V_{DS} = 600\text{ V}, V_{GS} = 0\text{ V}$ | - | - | 25 | μA |
| | | $V_{DS} = 480\text{ V}, V_{GS} = 0\text{ V}, T_J = 150\text{ }^\circ\text{C}$ | - | - | 250 | |
| Drain-Source On-State Resistance | $R_{DS(on)}$ | $V_{GS} = 10\text{ V}, I_D = 0.84\text{ A}^b$ | - | - | 7.0 | Ω |
| Forward Transconductance | g_{fs} | $V_{DS} = 50\text{ V}, I_D = 0.84\text{ A}$ | 0.88 | - | - | S |
| Dynamic | | | | | | |
| Input Capacitance | C_{iss} | $V_{GS} = 0\text{ V}, V_{DS} = 25\text{ V}, f = 1.0\text{ MHz}, \text{ see fig. 5}$ | - | 229 | - | pF |
| Output Capacitance | C_{oss} | | - | 32.6 | - | |
| Reverse Transfer Capacitance | C_{rss} | | - | 2.4 | - | |
| Output Capacitance | C_{oss} | $V_{GS} = 0\text{ V}$ | $V_{DS} = 1.0\text{ V}, f = 1.0\text{ MHz}$ | - | 320 | - |
| | | | $V_{DS} = 480\text{ V}, f = 1.0\text{ MHz}$ | - | 11.5 | - |
| Effective Output Capacitance | $C_{oss\text{ eff.}}$ | $V_{DS} = 0\text{ V to } 480\text{ V}^c$ | - | 130 | - | |
| Total Gate Charge | Q_g | $V_{GS} = 10\text{ V}, I_D = 1.4\text{ A}, V_{DS} = 400\text{ V}, \text{ see fig. 6 and 13}^b$ | - | - | 14 | nC |
| Gate-Source Charge | Q_{gs} | | - | - | 2.7 | |
| Gate-Drain Charge | Q_{gd} | | - | - | 8.1 | |
| Turn-On Delay Time | $t_{d(on)}$ | $V_{DD} = 250\text{ V}, I_D = 1.4\text{ A}, R_g = 2.15\text{ }\Omega, R_D = 178\text{ }\Omega, \text{ see fig. 10}^b$ | - | 9.8 | - | ns |
| Rise Time | t_r | | - | 14 | - | |
| Turn-Off Delay Time | $t_{d(off)}$ | | - | 18 | - | |
| Fall Time | t_f | | - | 20 | - | |
| Drain-Source Body Diode Characteristics | | | | | | |
| Continuous Source-Drain Diode Current | I_S | MOSFET symbol showing the integral reverse p - n junction diode  | - | - | 1.4 | A |
| Pulsed Diode Forward Current ^a | I_{SM} | | - | - | 5.6 | |
| Body Diode Voltage | V_{SD} | $T_J = 25\text{ }^\circ\text{C}, I_S = 1.4\text{ A}, V_{GS} = 0\text{ V}^b$ | - | - | 1.6 | V |
| Body Diode Reverse Recovery Time | t_{rr} | $T_J = 25\text{ }^\circ\text{C}, I_F = 1.4\text{ A}, dI/dt = 100\text{ A}/\mu\text{s}^b$ | - | 290 | 440 | ns |
| Body Diode Reverse Recovery Charge | Q_{rr} | | - | 510 | 760 | |
| Forward Turn-On Time | t_{on} | Intrinsic turn-on time is negligible (turn-on is dominated by L_S and L_D) | | | | |

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} .



TYPICAL CHARACTERISTICS (25 °C, unless otherwise noted)

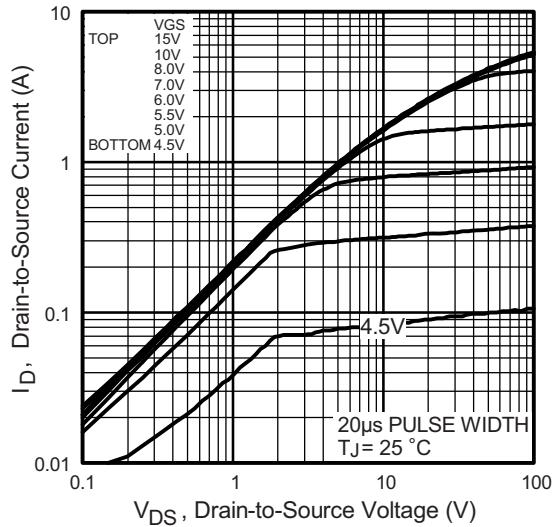


Fig. 1 - Typical Output Characteristics

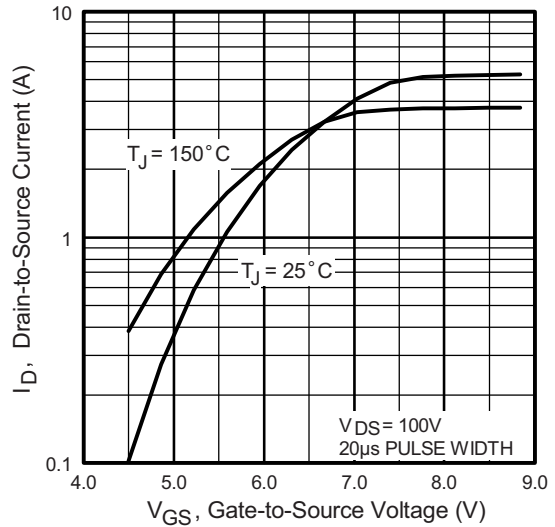


Fig. 3 - Typical Transfer Characteristics

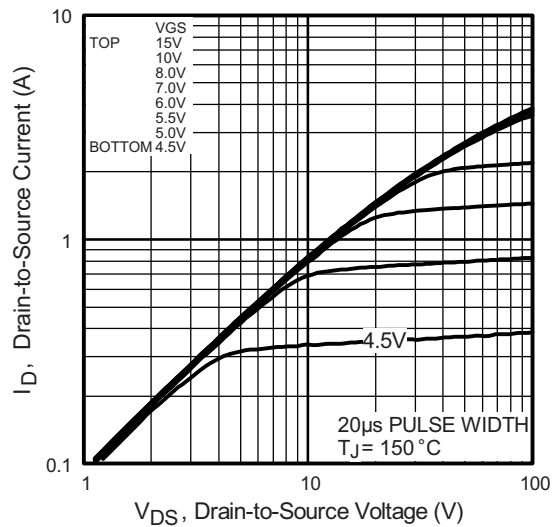


Fig. 2 - Typical Output Characteristics

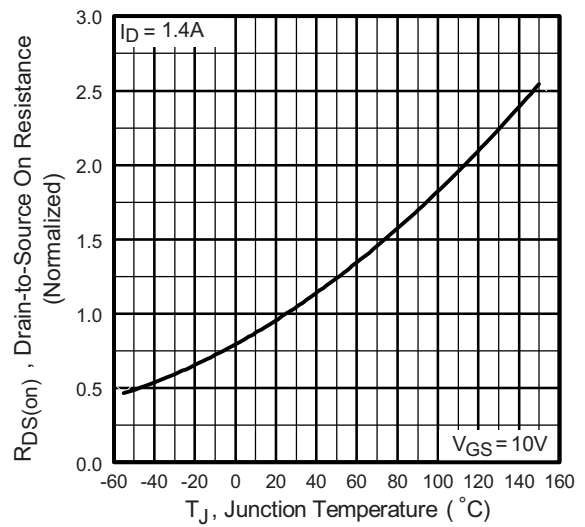


Fig. 4 - Normalized On-Resistance vs. Temperature

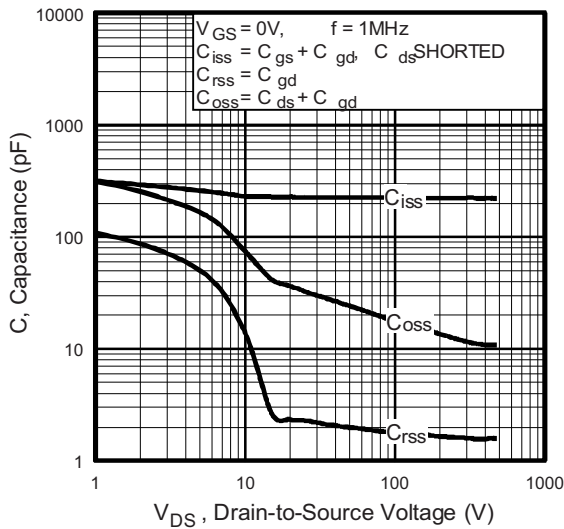


Fig. 5 - Typical Capacitance vs. Drain-to-Source Voltage

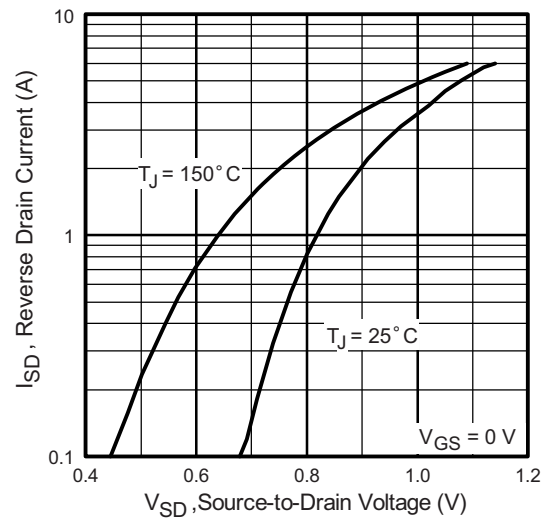


Fig. 7 - Typical Source-Drain Diode Forward Voltage



Fig. 6 - Typical Gate Charge vs. Gate-to-Source Voltage

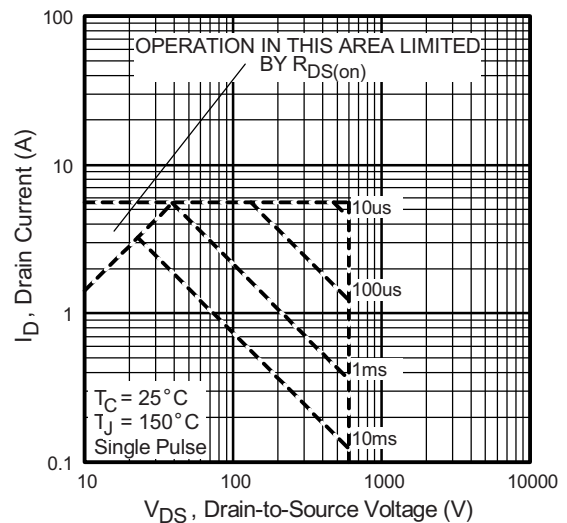


Fig. 8 - Maximum Safe Operating Area



Fig. 9 - Maximum Drain Current vs. Case Temperature

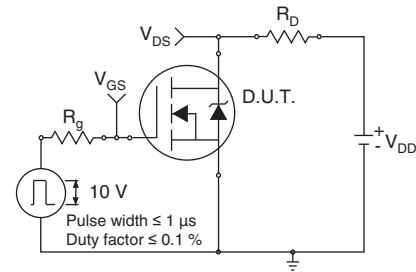


Fig. 10a - Switching Time Test Circuit

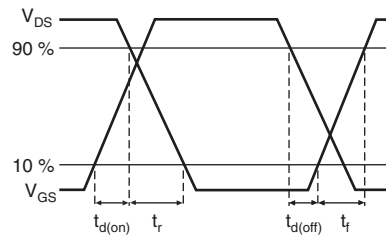


Fig. 10b - Switching Time Waveforms

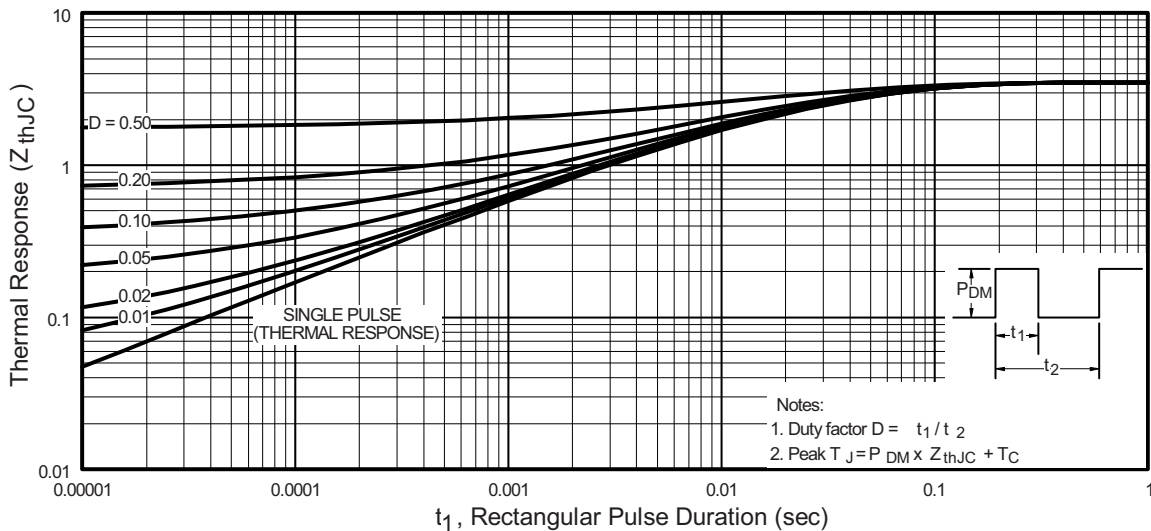


Fig. 11 - Maximum Effective Transient Thermal Impedance, Junction-to-Case

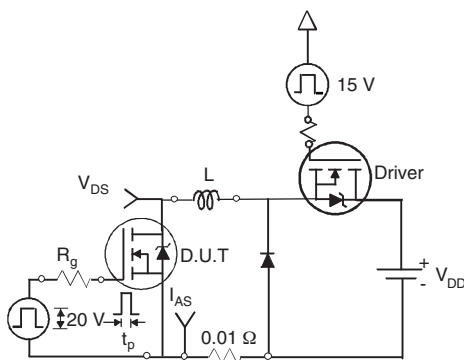


Fig. 12a - Unclamped Inductive Test Circuit

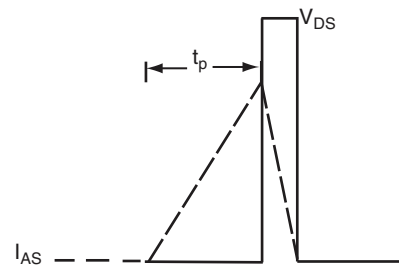


Fig. 12b - Unclamped Inductive Waveforms

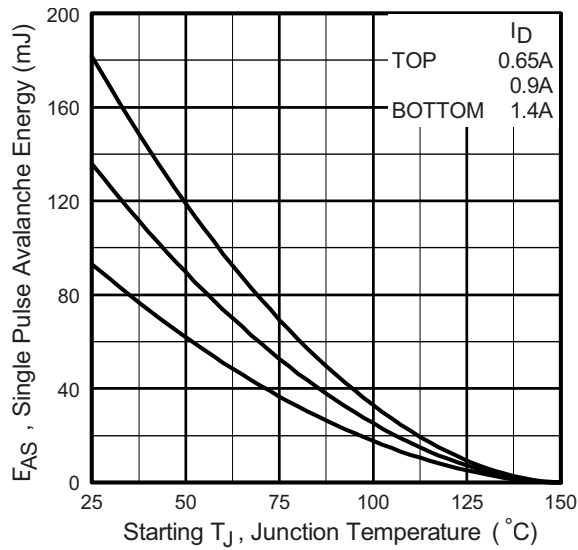


Fig. 12c - Maximum Avalanche Energy vs. Drain Current

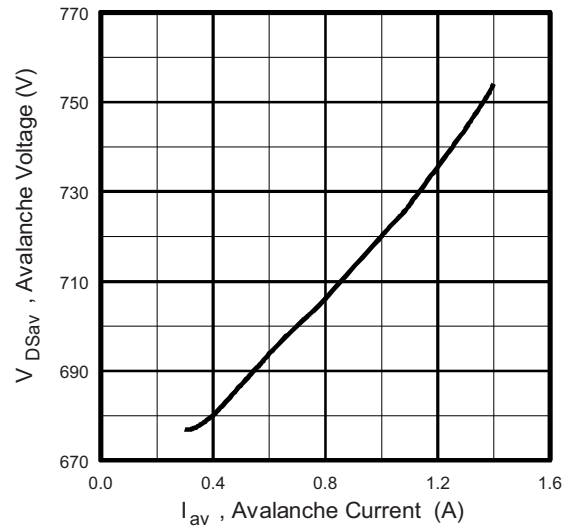


Fig. 12d - Basic Gate Charge Waveform

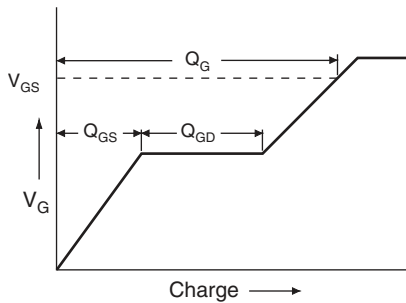


Fig. 13a - Maximum Avalanche Energy vs. Drain Current

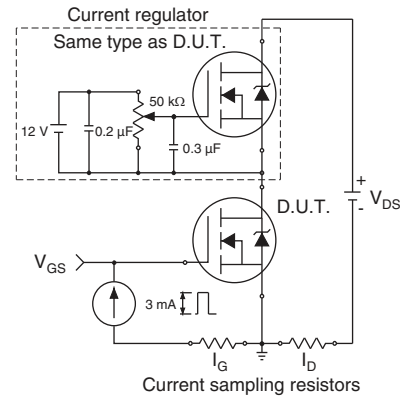
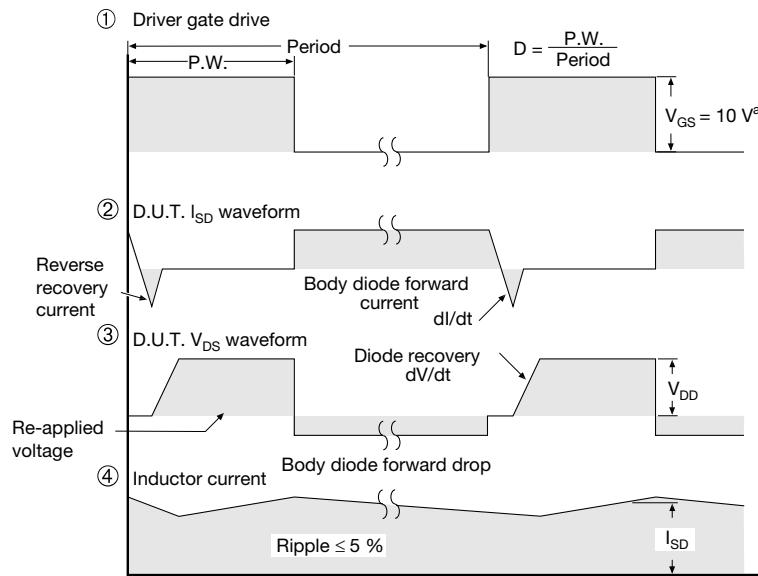
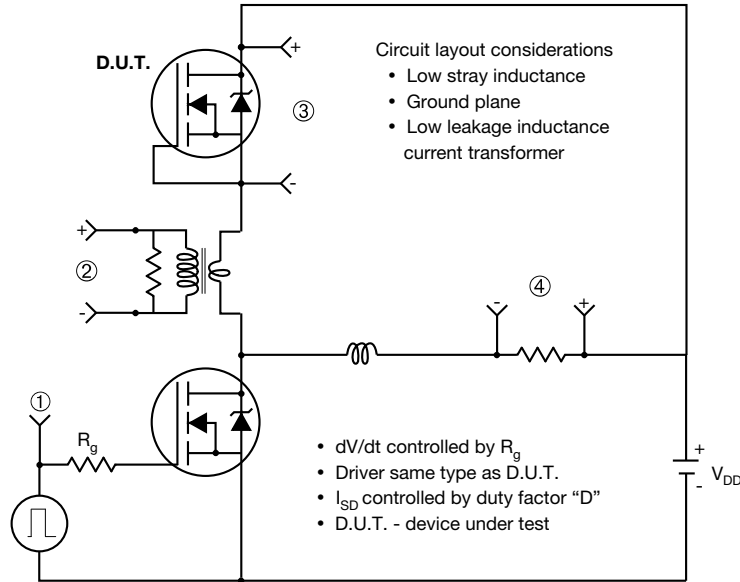


Fig. 13b - Gate Charge Test Circuit

Peak Diode Recovery dV/dt Test Circuit



Note

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

Fig. 14 - For N-Channel

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TO-252AA Case Outline



| DIM. | MILLIMETERS | | INCHES | |
|--|-------------|-------|-----------|-------|
| | MIN. | MAX. | MIN. | MAX. |
| A | 2.18 | 2.38 | 0.086 | 0.094 |
| A1 | - | 0.127 | - | 0.005 |
| b | 0.64 | 0.88 | 0.025 | 0.035 |
| b2 | 0.76 | 1.14 | 0.030 | 0.045 |
| b3 | 4.95 | 5.46 | 0.195 | 0.215 |
| C | 0.46 | 0.61 | 0.018 | 0.024 |
| C2 | 0.46 | 0.89 | 0.018 | 0.035 |
| D | 5.97 | 6.22 | 0.235 | 0.245 |
| D1 | 4.10 | - | 0.161 | - |
| E | 6.35 | 6.73 | 0.250 | 0.265 |
| E1 | 4.32 | - | 0.170 | - |
| H | 9.40 | 10.41 | 0.370 | 0.410 |
| e | 2.28 BSC | | 0.090 BSC | |
| e1 | 4.56 BSC | | 0.180 BSC | |
| L | 1.40 | 1.78 | 0.055 | 0.070 |
| L3 | 0.89 | 1.27 | 0.035 | 0.050 |
| L4 | - | 1.02 | - | 0.040 |
| L5 | 1.01 | 1.52 | 0.040 | 0.060 |
| ECN: T16-0236-Rev. P, 16-May-16 DWG: 5347 | | | | |

Notes

- Dimension L3 is for reference only.

TO-251AA (HIGH VOLTAGE)



| DIM. | MILLIMETERS | | INCHES | |
|------|-------------|------|--------|-------|
| | MIN. | MAX. | MIN. | MAX. |
| A | 2.18 | 2.39 | 0.086 | 0.094 |
| A1 | 0.89 | 1.14 | 0.035 | 0.045 |
| b | 0.64 | 0.89 | 0.025 | 0.035 |
| b1 | 0.65 | 0.79 | 0.026 | 0.031 |
| b2 | 0.76 | 1.14 | 0.030 | 0.045 |
| b3 | 0.76 | 1.04 | 0.030 | 0.041 |
| b4 | 4.95 | 5.46 | 0.195 | 0.215 |
| c | 0.46 | 0.61 | 0.018 | 0.024 |
| c1 | 0.41 | 0.56 | 0.016 | 0.022 |
| c2 | 0.46 | 0.86 | 0.018 | 0.034 |
| D | 5.97 | 6.22 | 0.235 | 0.245 |

| DIM. | MILLIMETERS | | INCHES | |
|--------|-------------|------|----------|-------|
| | MIN. | MAX. | MIN. | MAX. |
| D1 | 5.21 | - | 0.205 | - |
| E | 6.35 | 6.73 | 0.250 | 0.265 |
| E1 | 4.32 | - | 0.170 | - |
| e | 2.29 BSC | | 2.29 BSC | |
| L | 8.89 | 9.65 | 0.350 | 0.380 |
| L1 | 1.91 | 2.29 | 0.075 | 0.090 |
| L2 | 0.89 | 1.27 | 0.035 | 0.050 |
| L3 | 1.14 | 1.52 | 0.045 | 0.060 |
| theta1 | 0' | 15' | 0' | 15' |
| theta2 | 25' | 35' | 25' | 35' |

ECN: S-82111-Rev. A, 15-Sep-08
 DWG: 5968

Notes

1. Dimensioning and tolerancing per ASME Y14.5M-1994.
2. Dimension are shown in inches and millimeters.
3. Dimension D and E do not include mold flash. Mold flash shall not exceed 0.13 mm (0.005") per side. These dimensions are measured at the outermost extremes of the plastic body.
4. Thermal pad contour optional with dimensions b4, L2, E1 and D1.
5. Lead dimension uncontrolled in L3.
6. Dimension b1, b3 and c1 apply to base metal only.
7. Outline conforms to JEDEC outline TO-251AA.

RECOMMENDED MINIMUM PADS FOR DPAK (TO-252)



Recommended Minimum Pads
Dimensions in Inches/(mm)

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