

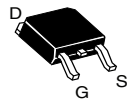
Power MOSFET



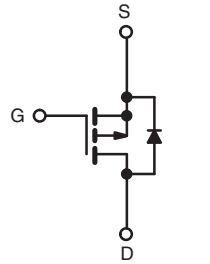
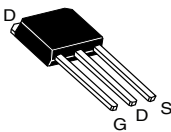
RoHS
COMPLIANT
HALOGEN
FREE
Available

| PRODUCT SUMMARY | | |
|---------------------------|------------------|------|
| V_{DS} (V) | - 60 | |
| $R_{DS(on)}$ (Ω) | $V_{GS} = -10$ V | 0.28 |
| Q_g (Max.) (nC) | 19 | |
| Q_{gs} (nC) | 5.4 | |
| Q_{gd} (nC) | 11 | |
| Configuration | Single | |

DPAK
(TO-252)



IPAK
(TO-251)



P-Channel MOSFET

FEATURES

- Dynamic dV/dt Rating
- Repetitive Avalanche Rated
- Surface Mount (IRFR9024, SiHFR9024)
- Straight Lead (IRFU9024, SiHFU9024)
- Available in Tape and Reel
- P-Channel
- Fast Switching
- Material categorization: For definitions of compliance please see www.vishay.com/doc?99912

DESCRIPTION

Third generation power MOSFETs from Vishay provide the designer with the best combination of fast switching, ruggedized device design, low on-resistance and cost-effectiveness.

The DPAK is designed for surface mounting using vapor phase, infrared, or wave soldering techniques. The straight lead version (IRFU, SiHFU series) is for through-hole mounting applications. Power dissipation levels up to 1.5 W are possible in typical surface mount applications.

| ORDERING INFORMATION | | | | | |
|---------------------------------|---------------|------------------------------|-------------------------------|-------------------------------|---------------|
| Package | DPAK (TO-252) | DPAK (TO-252) | DPAK (TO-252) | DPAK (TO-252) | IPAK (TO-251) |
| Lead (Pb)-free and Halogen-free | SiHFR9024-GE3 | SiHFR9024TR-GE3 ^a | SiHFR9024TRL-GE3 ^a | SiHFR9024TRR-GE3 ^a | SiHFU9024-GE3 |
| Lead (Pb)-free | IRFR9024PbF | IRFR9024TRPbF ^a | IRFR9024TRLPbF ^a | IRFR9024TRRPbF ^a | IRFU9024PbF |
| | SiHFR9024-E3 | SiHFR9024T-E3 ^a | SiHFR9024TL-E3 ^a | SiHFR9024TR-E3 ^a | SiHFU9024-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} | - 60 | V | |
| Gate-Source Voltage | V_{GS} | ± 20 | | |
| Continuous Drain Current | V_{GS} at - 10 V | $T_C = 25$ °C | - 8.8 | A |
| | | $T_C = 100$ °C | - 5.6 | |
| Pulsed Drain Current ^a | I_{DM} | - 35 | W/°C | |
| Linear Derating Factor | | 0.33 | | |
| Linear Derating Factor (PCB Mount) ^e | | 0.020 | | |
| Single Pulse Avalanche Energy ^b | E_{AS} | 300 | mJ | |
| Repetitive Avalanche Current ^a | I_{AR} | - 8.8 | A | |
| Repetitive Avalanche Energy ^a | E_{AR} | 5.0 | mJ | |
| Maximum Power Dissipation | P_D | $T_C = 25$ °C | 42 | W |
| Maximum Power Dissipation (PCB Mount) ^e | | $T_A = 25$ °C | 2.5 | |
| Peak Diode Recovery dV/dt ^c | dV/dt | - 4.5 | V/ns | |
| Operating Junction and Storage Temperature Range | T_J, T_{stg} | - 55 to + 150 | °C | |
| Soldering Recommendations (Peak Temperature) ^d | for 10 s | 260 | | |

Notes

- a. Repetitive rating; pulse width limited by maximum junction temperature (see fig. 11).
 b. $V_{DD} = -25$ V, starting $T_J = 25$ °C, $L = 4.5$ mH, $R_g = 25$ Ω , $I_{AS} = -8.8$ A (see fig. 12).
 c. $I_{SD} \leq -11$ A, $dI/dt \leq 140$ A/ μ s, $V_{DD} \leq V_{DS}$, $T_J \leq 150$ °C.
 d. 1.6 mm from case.
 e. When mounted on 1" square PCB (FR-4 or G-10 material).



| THERMAL RESISTANCE RATINGS | | | | | | |
|--|------------|------|------|------|------|--|
| PARAMETER | SYMBOL | MIN. | 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} | - | - | 3.0 | | |

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} | $V_{GS} = 0\text{ V}, I_D = 250\text{ }\mu\text{A}$ | | - 60 | - | - V | |
| V_{DS} Temperature Coefficient | $\Delta V_{DS}/T_J$ | Reference to $25\text{ }^\circ\text{C}$, $I_D = 1\text{ mA}$ | | - | - 0.063 | - V/°C | |
| Gate-Source Threshold Voltage | $V_{GS(th)}$ | $V_{DS} = V_{GS}, I_D = 250\text{ }\mu\text{A}$ | | - 2.0 | - | - 4.0 V | |
| Gate-Source Leakage | I_{GSS} | $V_{GS} = \pm 20\text{ V}$ | | - | - | $\pm 100\text{ nA}$ | |
| Zero Gate Voltage Drain Current | I_{DSS} | $V_{DS} = -60\text{ V}, V_{GS} = 0\text{ V}$ | | - | - | - 100 μA | |
| | | $V_{DS} = -48\text{ V}, V_{GS} = 0\text{ V}, T_J = 125\text{ }^\circ\text{C}$ | | - | - | - 500 μA | |
| Drain-Source On-State Resistance | $R_{DS(on)}$ | $V_{GS} = -10\text{ V}$ | $I_D = -5.3\text{ A}^b$ | - | - | 0.28 Ω | |
| Forward Transconductance | g_{fs} | $V_{DS} = -25\text{ V}, I_D = -5.3\text{ A}$ | | 2.9 | - | - S | |
| Dynamic | | | | | | | |
| Input Capacitance | C_{iss} | $V_{GS} = 0\text{ V}, V_{DS} = -25\text{ V}, f = 1.0\text{ MHz}$ | | - | 570 | - pF | |
| Output Capacitance | C_{oss} | | | - | 360 | - | - |
| Reverse Transfer Capacitance | C_{rss} | | | - | 65 | - | - |
| Total Gate Charge | Q_g | $V_{GS} = -10\text{ V}$ | $I_D = -11\text{ A}, V_{DS} = -48\text{ V},$ see fig. 6 and 13 ^b | - | - | 19 nC | |
| Gate-Source Charge | Q_{gs} | | | - | - | 5.4 | - |
| Gate-Drain Charge | Q_{gd} | | | - | - | 11 | - |
| Turn-On Delay Time | $t_{d(on)}$ | $V_{DD} = -30\text{ V}, I_D = -11\text{ A}, R_g = 18\text{ }\Omega, R_D = 2.5\text{ }\Omega,$ see fig. 10 ^b | | - | 13 | - ns | |
| Rise Time | t_r | | | - | 68 | - | - |
| Turn-Off Delay Time | $t_{d(off)}$ | | | - | 15 | - | - |
| Fall Time | t_f | | | - | 29 | - | - |
| Internal Drain Inductance | L_D | Between lead, 6 mm (0.25") from package and center of die contact | | - | 4.5 | - nH | |
| Internal Source Inductance | L_S | | | - | 7.5 | - | - |
| Drain-Source Body Diode Characteristics | | | | | | | |
| Continuous Source-Drain Diode Current | I_S | MOSFET symbol showing the integral reverse p - n junction diode | | - | - | - 8.8 A | |
| Pulsed Diode Forward Current ^a | I_{SM} | | | - | - | - 35 | - |
| Body Diode Voltage | V_{SD} | $T_J = 25\text{ }^\circ\text{C}, I_S = -8.8\text{ A}, V_{GS} = 0\text{ V}^b$ | | - | - | - 6.3 V | |
| Body Diode Reverse Recovery Time | t_{rr} | $T_J = 25\text{ }^\circ\text{C}, I_F = -11\text{ A}, di/dt = 100\text{ A}/\mu\text{s}^b$ | | - | 100 | 200 ns | |
| Body Diode Reverse Recovery Charge | Q_{rr} | | | - | 0.32 | 0.64 | μC |
| 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 $\leq 2\%$.



TYPICAL CHARACTERISTICS (25 °C, unless otherwise noted)

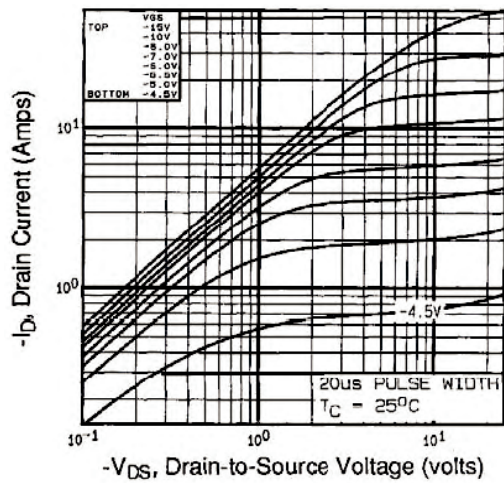


Fig. 1 - Typical Output Characteristics, $T_C = 25\text{ }^\circ\text{C}$

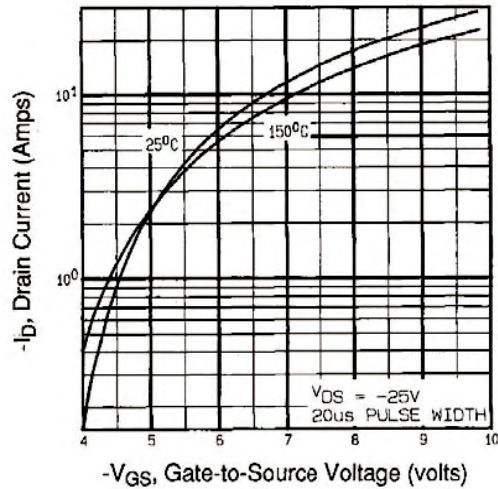


Fig. 3 - Typical Transfer Characteristics

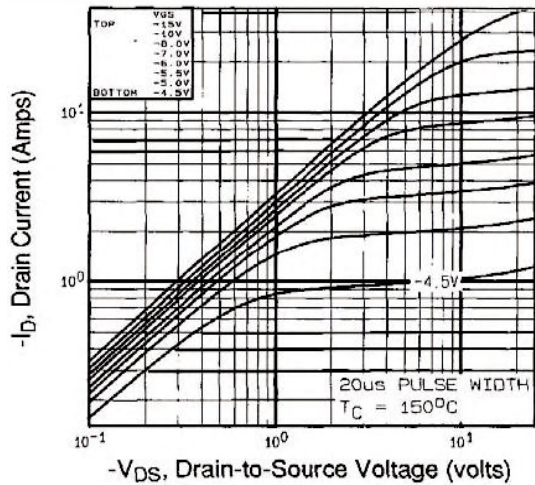


Fig. 2 - Typical Output Characteristics, $T_C = 150\text{ }^\circ\text{C}$

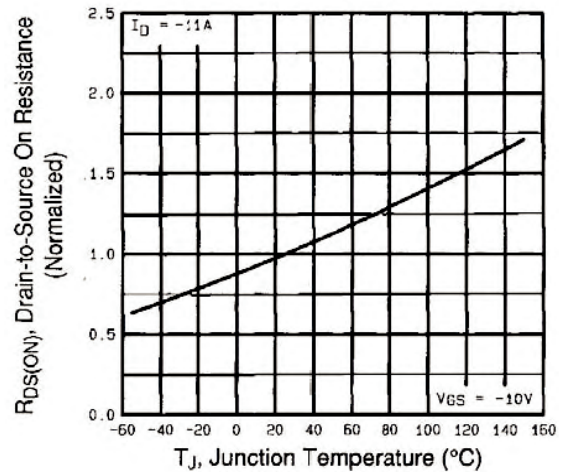


Fig. 4 - Normalized On-Resistance vs. Temperature

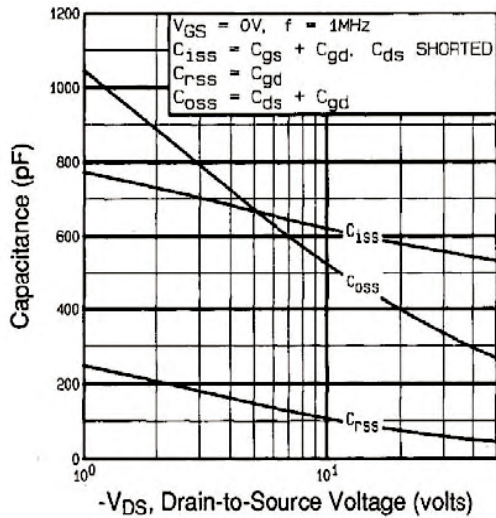


Fig. 5 - Typical Capacitance vs. Drain-to-Source Voltage

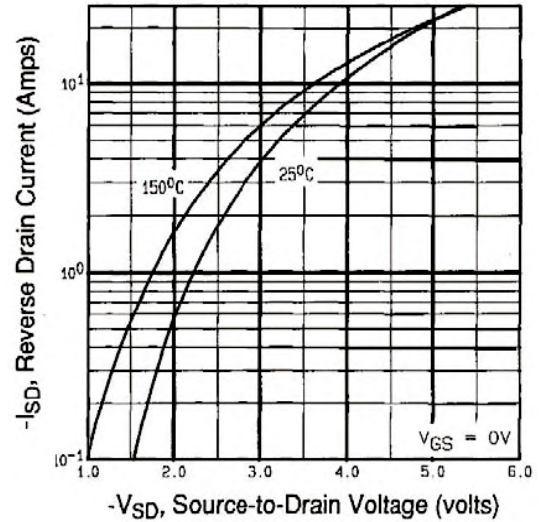


Fig. 7 - Typical Source-Drain Diode Forward Voltage

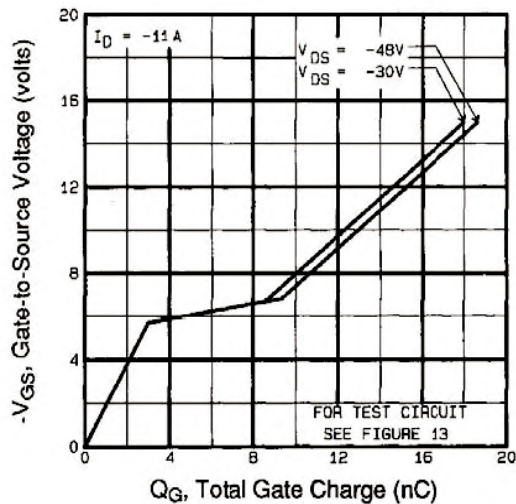


Fig. 6 - Typical Gate Charge vs. Gate-to-Source Voltage

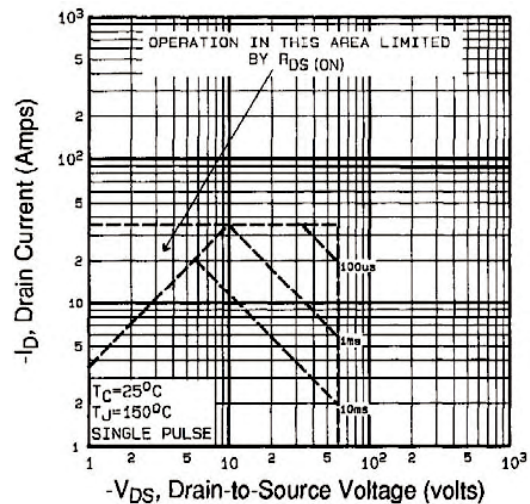


Fig. 8 - Maximum Safe Operating Area

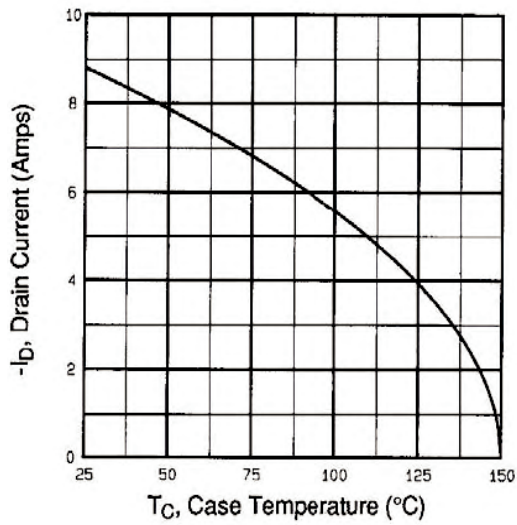


Fig. 9 - Maximum Drain Current vs. Case Temperature

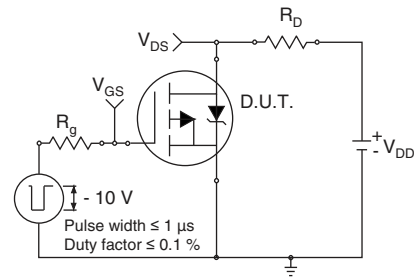


Fig. 10a - Switching Time Test Circuit

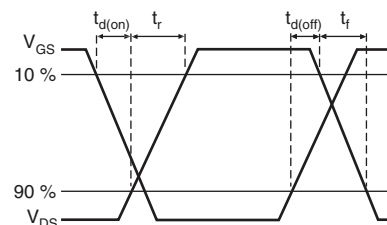


Fig. 10b - Switching Time Waveforms

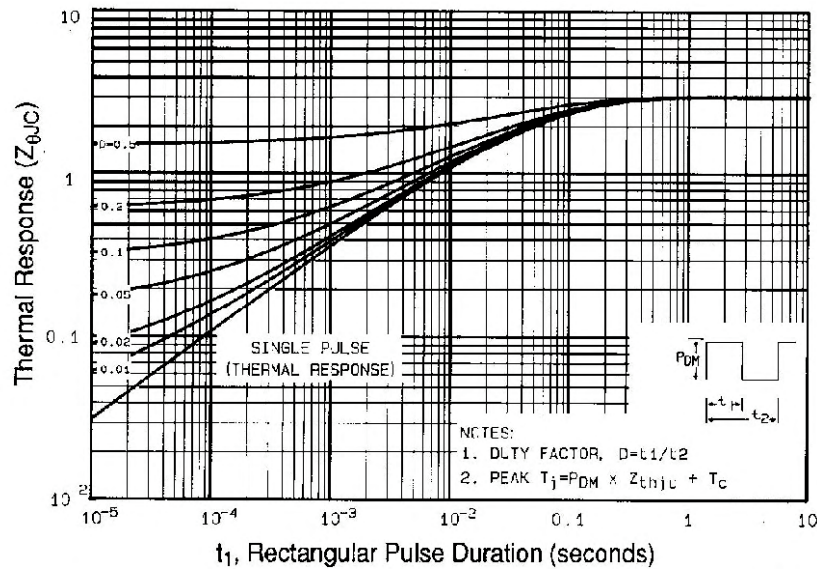


Fig. 11 - Maximum Effective Transient Thermal Impedance, Junction-to-Case

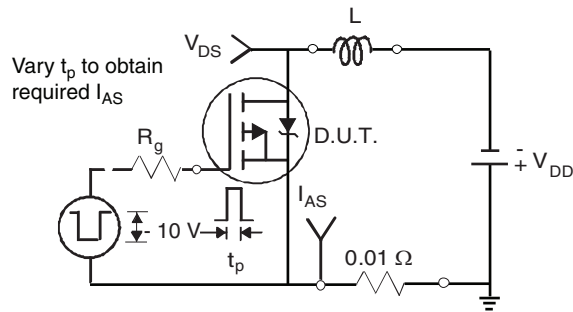


Fig. 12a - Unclamped Inductive Test Circuit

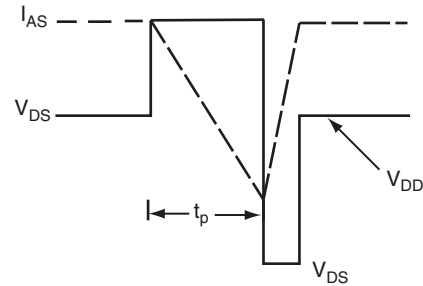


Fig. 12b - Unclamped Inductive Waveforms

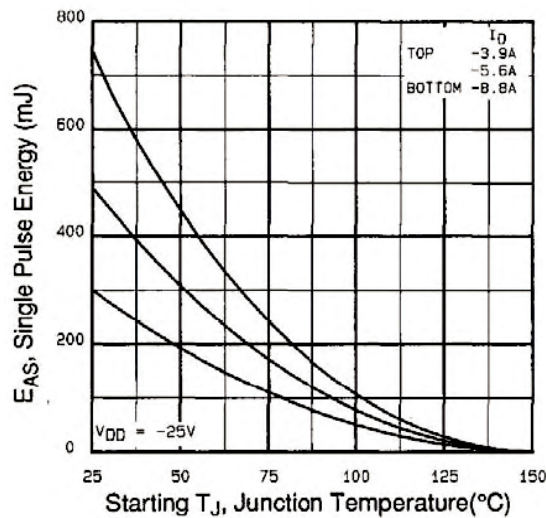


Fig. 12c - Maximum Avalanche Energy vs. Drain Current

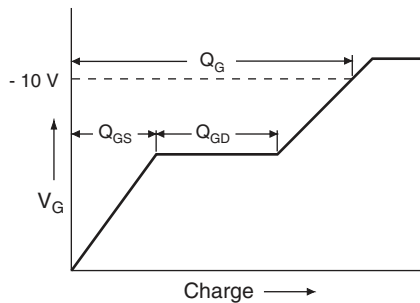


Fig. 13a - Basic Gate Charge Waveform

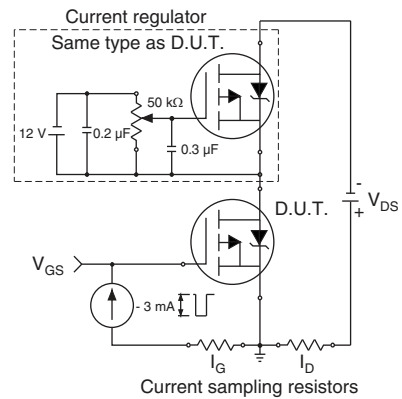


Fig. 13b - Gate Charge Test Circuit

Peak Diode Recovery dV/dt Test Circuit



Note
• Compliment N-Channel of D.U.T. for driver



Fig. 14 - For P-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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