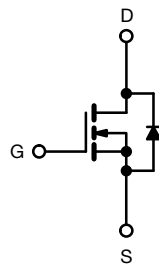


EF Series Power MOSFET With Fast Body Diode



N-Channel MOSFET

FEATURES

- 4th generation E series technology
- Low figure-of-merit (FOM) $R_{DS(on)} \times Q_g$
- Low effective capacitance ($C_{o(er)}$)
- Reduced switching and conduction losses
- Avalanche energy rated (UIS)
- Material categorization: for definitions of compliance please see www.vishay.com/doc?99912



RoHS
COMPLIANT
HALOGEN
FREE

APPLICATIONS

- Server and telecom power supplies
- Switch mode power supplies (SMPS)
- Power factor correction power supplies (PFC)
- Lighting
 - High-intensity discharge (HID)
 - Fluorescent ballast lighting
- Industrial
 - Welding
 - Induction heating
 - Motor drives
 - Battery chargers
 - Solar (PV inverters)

PRODUCT SUMMARY

| | | |
|---|-----------------|-------|
| V_{DS} (V) at T_J max. | 650 | |
| $R_{DS(on)}$ typ. (Ω) at 25 °C | $V_{GS} = 10$ V | 0.175 |
| Q_g max. (nC) | 32 | |
| Q_{gs} (nC) | 9 | |
| Q_{gd} (nC) | 7 | |
| Configuration | Single | |

ORDERING INFORMATION

| | |
|---------------------------------|--------------------|
| Package | DPAK (TO-252) |
| Lead (Pb)-free and halogen-free | SiHD186N60EF-GE3 |
| | SiHD186N60EFT1-GE3 |
| | SiHD186N60EFT4-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} | 40 | W/°C |
| Linear derating factor | | 1.25 | |
| Single pulse avalanche energy ^b | E_{AS} | 68 | mJ |
| Maximum power dissipation | P_D | 156 | W |
| Operating junction and storage temperature range | T_J, T_{stg} | -55 to +150 | °C |
| Drain-source voltage slope | dv/dt | 70 | V/ns |
| Reverse diode dv/dt ^d | | 50 | |
| Soldering recommendations (peak temperature) ^c | For 10 s | 260 | °C |


Notes

- Repetitive rating; pulse width limited by maximum junction temperature
- $V_{DS} = 120$ V, starting $T_J = 25$ °C, $L = 28.2$ mH, $R_g = 25$ Ω , $I_{AS} = 2.2$ A
- 1.6 mm from case
- $I_{SD} \leq I_D$, $di/dt = 120$ A/ μ s, starting $T_J = 25$ °C

**THERMAL RESISTANCE RATINGS**

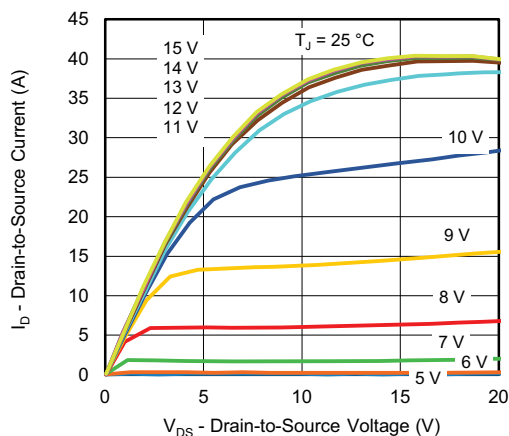
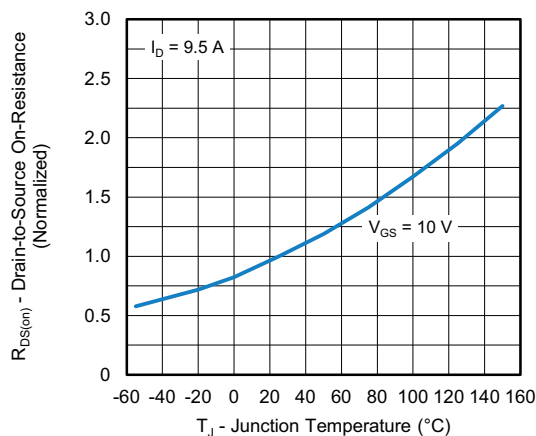
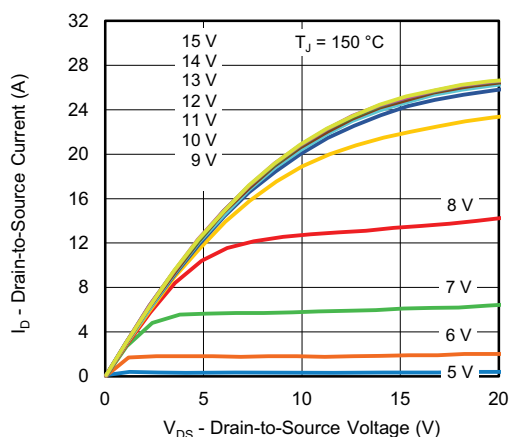
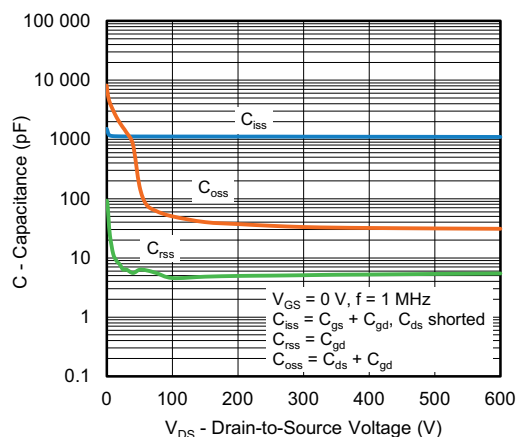
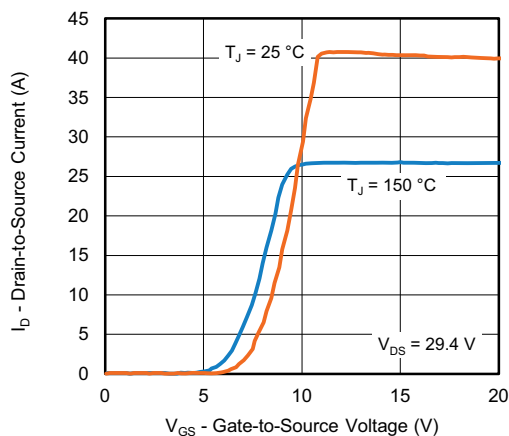
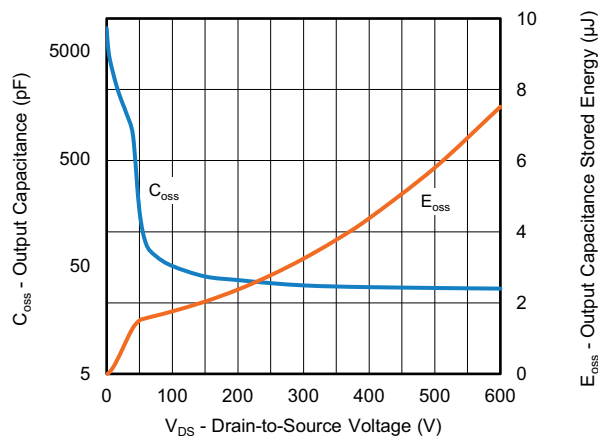
| PARAMETER | SYMBOL | TYP. | MAX. | UNIT |
|----------------------------------|------------|------|------|------|
| Maximum junction-to-ambient | R_{thJA} | - | 62 | °C/W |
| Maximum junction-to-case (drain) | R_{thJC} | - | 0.8 | |

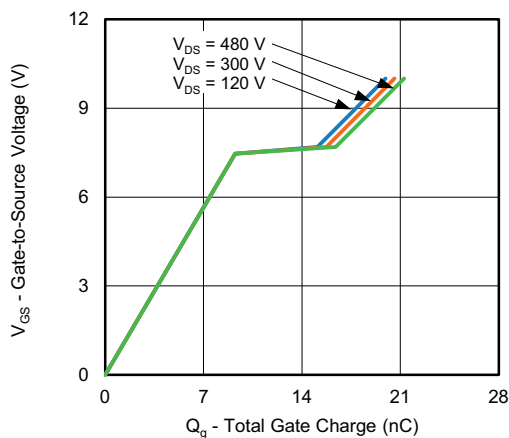
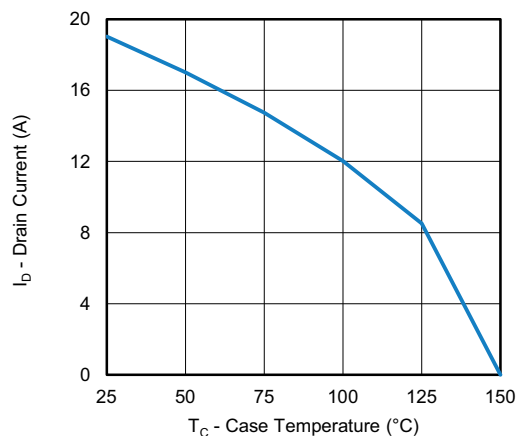
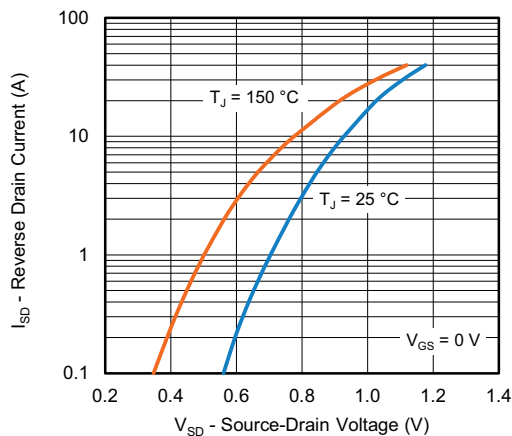
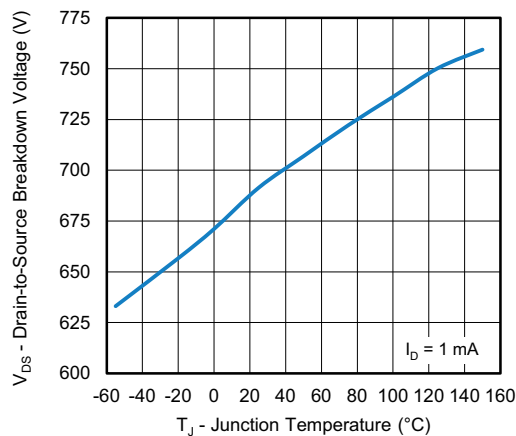
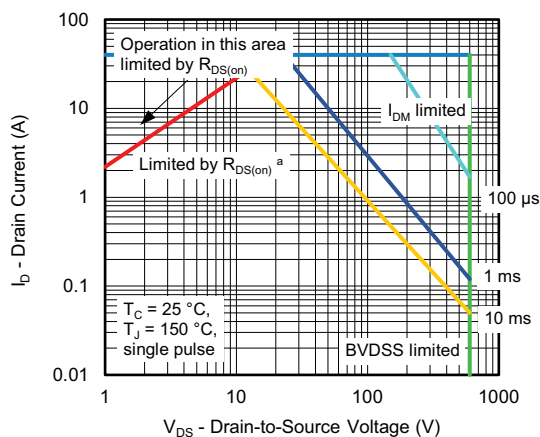
SPECIFICATIONS ($T_J = 25\text{ }^{\circ}\text{C}$, unless otherwise noted)

| 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 $25\text{ }^{\circ}\text{C}$, $I_D = 1\text{ mA}$ | | - | 0.62 | - | V/ $^{\circ}\text{C}$ |
| Gate-source threshold voltage (N) | $V_{GS(th)}$ | $V_{DS} = V_{GS}$, $I_D = 250\text{ }\mu\text{A}$ | | 3.0 | - | 5.0 | 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 |
| | | $V_{DS} = 480\text{ V}$, $V_{GS} = 0\text{ V}$, $T_J = 125\text{ }^{\circ}\text{C}$ | | - | - | 2 | mA |
| Drain-source on-state resistance | $R_{DS(on)}$ | $V_{GS} = 10\text{ V}$ | $I_D = 9.5\text{ A}$ | - | 0.175 | 0.201 | Ω |
| Forward transconductance ^a | g_{fs} | $V_{DS} = 10\text{ V}$, $I_D = 9.5\text{ A}$ | | - | 6.5 | - | S |
| Dynamic | | | | | | | |
| Input capacitance | C_{iss} | $V_{GS} = 0\text{ V}$, $V_{DS} = 100\text{ V}$, $f = 1\text{ MHz}$ | | - | 1118 | - | pF |
| Output capacitance | C_{oss} | | | - | 50 | - | |
| Reverse transfer capacitance | C_{rss} | | | - | 5 | - | |
| Effective output capacitance, energy related ^a | $C_{o(er)}$ | $V_{DS} = 0\text{ V to } 480\text{ V}$, $V_{GS} = 0\text{ V}$ | | - | 38 | - | |
| Effective output capacitance, time related ^b | $C_{o(tr)}$ | | | - | 242 | - | |
| Total gate charge | Q_g | $V_{GS} = 10\text{ V}$ | $I_D = 9.5\text{ A}$, $V_{DS} = 480\text{ V}$ | - | 21 | 32 | nC |
| Gate-source charge | Q_{gs} | | | - | 9 | - | |
| Gate-drain charge | Q_{gd} | | | - | 7 | - | |
| Turn-on delay time | $t_{d(on)}$ | $V_{DD} = 480\text{ V}$, $I_D = 9.5\text{ A}$, $V_{GS} = 10\text{ V}$, $R_g = 9.1\text{ }\Omega$ | | - | 17 | 34 | ns |
| Rise time | t_r | | | - | 32 | 64 | |
| Turn-off delay time | $t_{d(off)}$ | | | - | 24 | 48 | |
| Fall time | t_f | | | - | 7 | 14 | |
| Gate input resistance | R_g | $f = 1\text{ MHz}$, open drain | | 0.2 | 0.6 | 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  | | - | - | 19 | A |
| Pulsed diode forward current | I_{SM} | | | - | - | 40 | |
| Diode forward voltage | V_{SD} | $T_J = 25\text{ }^{\circ}\text{C}$, $I_S = 9.5\text{ A}$, $V_{GS} = 0\text{ V}$ | | - | - | 1.2 | V |
| Reverse recovery time | t_{rr} | $T_J = 25\text{ }^{\circ}\text{C}$, $I_F = I_S = 9.5\text{ A}$, $di/dt = 100\text{ A}/\mu\text{s}$, $V_R = 400\text{ V}$ | | - | 113 | 226 | ns |
| Reverse recovery charge | Q_{rr} | | | - | 0.6 | 1.2 | 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_{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
Note

a. $V_{GS} >$ minimum V_{GS} at which $R_{DS(on)}$ is specified

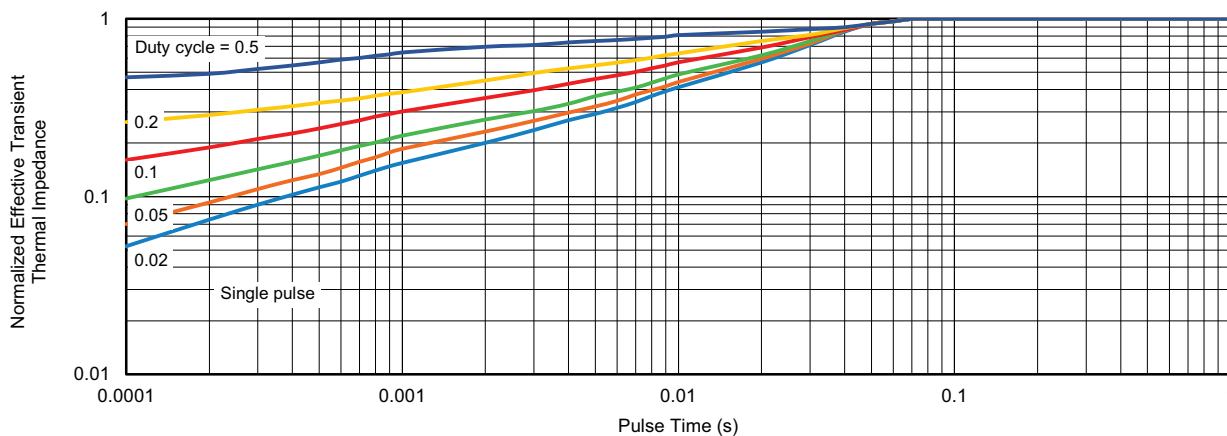

Fig. 12 - Normalized Transient Thermal Impedance, Junction-to-Case

Fig. 13 - Switching Time Test Circuit

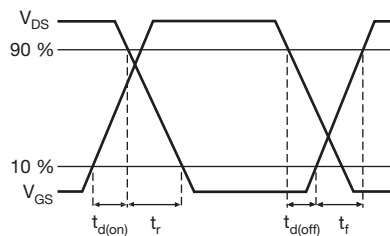
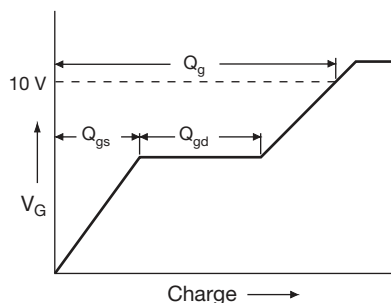
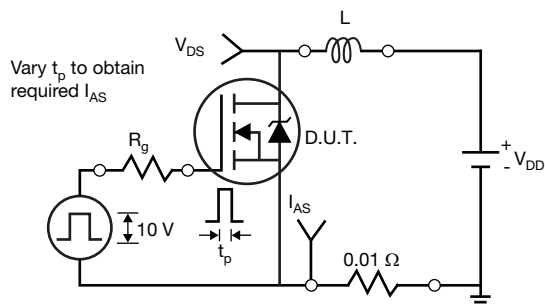
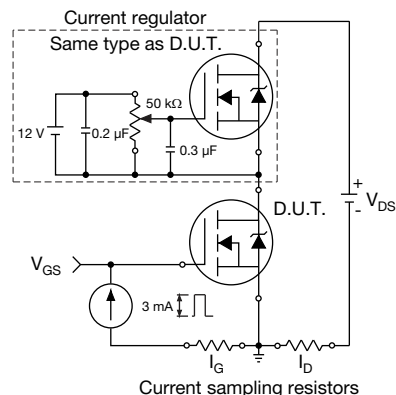
Fig. 16 - Unclamped Inductive Waveforms

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-252AA Case Outline

VERSION 1: FACILITY CODE = Y



| MILLIMETERS | | |
|-------------|----------|-------|
| DIM. | MIN. | MAX. |
| A | 2.18 | 2.38 |
| A1 | - | 0.127 |
| b | 0.64 | 0.88 |
| b2 | 0.76 | 1.14 |
| b3 | 4.95 | 5.46 |
| C | 0.46 | 0.61 |
| C2 | 0.46 | 0.89 |
| D | 5.97 | 6.22 |
| D1 | 4.10 | - |
| E | 6.35 | 6.73 |
| E1 | 4.32 | - |
| H | 9.40 | 10.41 |
| e | 2.28 BSC | |
| e1 | 4.56 BSC | |
| L | 1.40 | 1.78 |
| L3 | 0.89 | 1.27 |
| L4 | - | 1.02 |
| L5 | 1.01 | 1.52 |

Note

- Dimension L3 is for reference only



VERSION 2: FACILITY CODE = N



| DIM. | MILLIMETERS | |
|------|-------------|-------|
| | MIN. | MAX. |
| A | 2.18 | 2.39 |
| A1 | - | 0.13 |
| b | 0.65 | 0.89 |
| b1 | 0.64 | 0.79 |
| b2 | 0.76 | 1.13 |
| b3 | 4.95 | 5.46 |
| c | 0.46 | 0.61 |
| c1 | 0.41 | 0.56 |
| c2 | 0.46 | 0.60 |
| D | 5.97 | 6.22 |
| D1 | 5.21 | - |
| E | 6.35 | 6.73 |
| E1 | 4.32 | - |
| e | 2.29 BSC | |
| H | 9.94 | 10.34 |

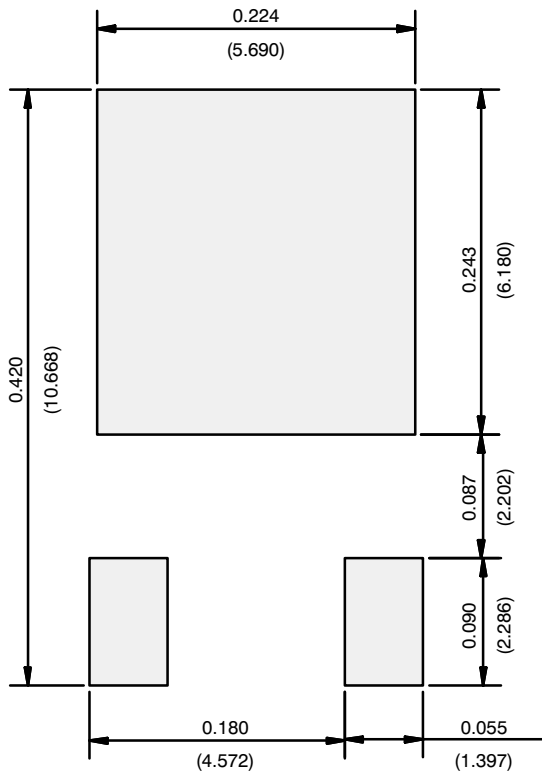
| DIM. | MILLIMETERS | |
|--------|-------------|------|
| | MIN. | MAX. |
| L | 1.50 | 1.78 |
| L1 | 2.74 ref. | |
| L2 | 0.51 BSC | |
| L3 | 0.89 | 1.27 |
| L4 | - | 1.02 |
| L5 | 1.14 | 1.49 |
| L6 | 0.65 | 0.85 |
| theta | 0° | 10° |
| theta1 | 0° | 15° |
| theta2 | 25° | 35° |

Notes

- Dimensioning and tolerance confirm to ASME Y14.5M-1994
- All dimensions are in millimeters. Angles are in degrees
- Heat sink side flash is max. 0.8 mm
- Radius on terminal is optional

ECN: E22-0399-Rev. R, 03-Oct-2022
DWG: 5347

RECOMMENDED MINIMUM PADS FOR DPAK (TO-252)



Recommended Minimum Pads
Dimensions in Inches/(mm)

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