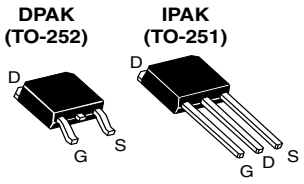
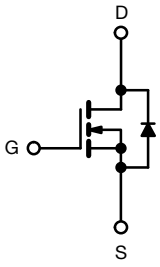
## Power MOSFET




N-Channel MOSFET

### FEATURES

- Dynamic dV/dt rating
- Surface-mount (IRFR014, SiHFR014)
- Straight lead (IRFU014, SiHFU014)
- Available in tape and reel
- Fast switching
- Ease of paralleling
- Simple drive requirements
- Material categorization: for definitions of compliance please see www.vishay.com/doc?99912

RoHS COMPLIANT
HALOGEN FREE Available

| PRODUCT SUMMARY | | |
|---|---|---|
| $V_{DS}$ (V) | 60 | |
| $R_{DS(on)}$ (Ω) | $V_{GS}$ = 10 V | 0.20 |
| $Q_g$ max. (nC) | 11 | |
| $Q_{gs}$ (nC) | 3.1 | |
| $Q_{gd}$ (nC) | 5.8 | |
| Configuration | Single | |

### 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) | IPAK (TO-251) |
| Lead (Pb)-free and Halogen-free | SiHFR014-GE3 | SiHFR014TRL-GE3 | SiHFR014TR-GE3 | SIHFU014-GE3 |
| Lead (Pb)-free | IRFR014PbF | IRFR014TRLPbF [a] | IRFR014TRPbF [a] | IRFU014PbF |
| | IRFR014TRRPbF | - | - | - |
| Lead (Pb)-free and Halogen-free | IRFR014PbF-BE3 [ab] | IRFR014TRLPbF-BE3 [ab] | IRFR014TRPbF-BE3 [ab] | - |

**Notes**

a. See device orientation
b. "-BE3" denotes alternate manufacturing location

| 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 | $I_D$ | 7.7 | A |
| | | $T_C$ = 100 °C | | 4.9 | |
| Pulsed drain current [a] | | | $I_{DM}$ | 31 | |
| Linear derating factor | | | | 0.20 | W/°C |
| Linear derating factor (PCB mount) [e] | | | | 0.020 | |
| Single pulse avalanche energy [b] | | | $E_{AS}$ | 27.4 | mJ |
| Maximum power dissipation | $T_C$ = 25 °C | | $P_D$ | 25 | 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 = 924 μH, $R_g$ = 25 Ω, $I_{AS}$ = 7.7 A (see fig. 12)
c. $I_{SD}$ ≤ 10 A, dI/dt ≤ 90 A/μs, $V_{DD}$ ≤ $V_{DS}$, $T_J$ ≤ 150 °C
d. 1.6 mm from case
e. When mounted on 1" square PCB (FR-4 or G-10 material)



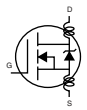
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| THERMAL RESISTANCE RATINGS | | | | | |
|---|---|---|---|---|---|
| **PARAMETER** | **SYMBOL** | **MIN.** | **TYP.** | **MAX.** | **UNIT** |
| Maximum junction-to-ambient | $R_{thJA}$ | - | - | 110 | °C/W |
| Maximum junction-to-ambient (PCB mount) [a] | $R_{thJA}$ | - | - | 50 | |
| Maximum junction-to-case (drain) | $R_{thJC}$ | - | - | 5.0 | |

**Note**

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

| SPECIFICATIONS ($T_J$ = 25 °C, unless otherwise noted) | | | | | | |
|---|---|---|---|---|---|---|
| **PARAMETER** | **SYMBOL** | **TEST CONDITIONS** | **MIN.** | **TYP.** | **MAX.** | **UNIT** |
| **Static** | | | | | | |
| Drain-source breakdown voltage | $V_{DS}$ | $V_{GS}$ = 0 V, $I_D$ = 250 µA | 60 | - | - | V |
| $V_{DS}$ temperature coefficient | $\Delta V_{DS}/T_J$ | Reference to 25 °C, $I_D$ = 1 mA | - | 0.068 | - | V/°C |
| Gate-source threshold voltage | $V_{GS(th)}$ | $V_{DS}$ = $V_{GS}$, $I_D$ = 250 µA | 2.0 | - | 4.0 | V |
| Gate-source leakage | $I_{GSS}$ | $V_{GS}$ = ± 20 V | - | - | ± 100 | nA |
| Zero gate voltage drain current | $I_{DSS}$ | $V_{DS}$ = 60 V, $V_{GS}$ = 0 V | - | - | 25 | µA |
| | | $V_{DS}$ = 48 V, $V_{GS}$ = 0 V, $T_J$ = 125 °C | - | - | 250 | |
| Drain-source on-state resistance | $R_{DS(on)}$ | $V_{GS}$ = 10 V; $I_D$ = 4.6 A [b] | - | - | 0.20 | Ω |
| Forward transconductance | $g_{fs}$ | $V_{DS}$ = 25 V, $I_D$ = 4.6 A | 2.4 | - | - | S |
| **Dynamic** | | | | | | |
| Input capacitance | $C_{iss}$ | $V_{GS}$ = 0 V, $V_{DS}$ = 25 V, f = 1.0 MHz, see fig. 5 | - | 300 | - | pF |
| Output capacitance | $C_{oss}$ | | - | 160 | - | |
| Reverse transfer capacitance | $C_{rss}$ | | - | 29 | - | |
| Total gate charge | $Q_g$ | $V_{GS}$ = 10 V; $I_D$ = 10 A, $V_{DS}$ = 48 V, see fig. 6 and 13 [b] | - | - | 11 | nC |
| Gate-source charge | $Q_{gs}$ | | - | - | 3.1 | |
| Gate-drain charge | $Q_{gd}$ | | - | - | 5.8 | |
| Turn-on delay time | $t_{d(on)}$ | $V_{DD}$ = 30 V, $I_D$ = 10 A, $R_g$ = 24 Ω, $R_D$ = 2.7 Ω, see fig. 10 [b] | - | 10 | - | ns |
| Rise time | $t_r$ | | - | 50 | - | |
| Turn-off delay time | $t_{d(off)}$ | | - | 13 | - | |
| Fall time | $t_f$ | | - | 19 | - | |
| Internal drain inductance | $L_D$ | Between lead, 6 mm (0.25") from package and center of die contact [c]  | - | 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  | - | - | 7.7 | A |
| Pulsed diode forward current [a] | $I_{SM}$ | | - | - | 31 | |
| Body diode voltage | $V_{SD}$ | $T_J$ = 25 °C, $I_S$ = 7.7 A, $V_{GS}$ = 0 V [b] | - | - | 1.6 | V |
| Body diode reverse recovery time | $t_{rr}$ | $T_J$ = 25 °C, $I_F$ = 10 A, dI/dt = 100 A/µs [b] | - | 70 | 140 | ns |
| Body diode reverse recovery charge | $Q_{rr}$ | | - | 0.20 | 0.40 | 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 ≤ 300 µs; duty cycle ≤ 2 %



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**TYPICAL CHARACTERISTICS** (25 °C, unless otherwise noted)

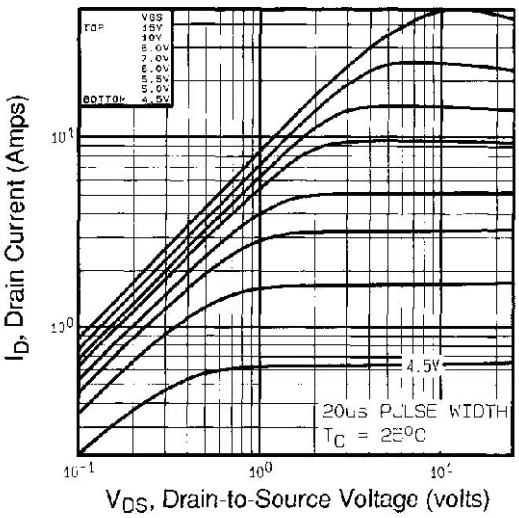



**Fig. 1 - Typical Output Characteristics, $T_C$ = 25 °C**

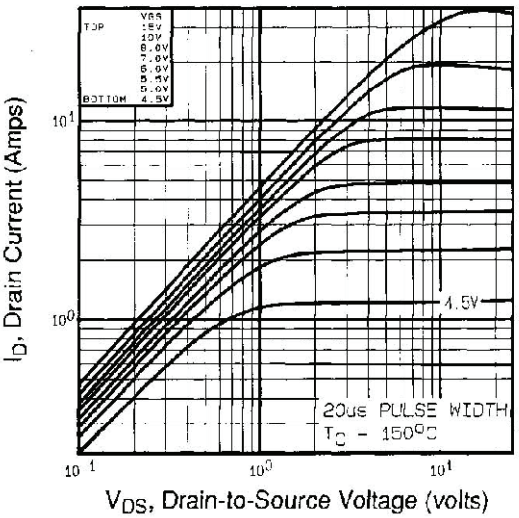



**Fig. 2 - Typical Output Characteristics, $T_C$ = 150 °C**

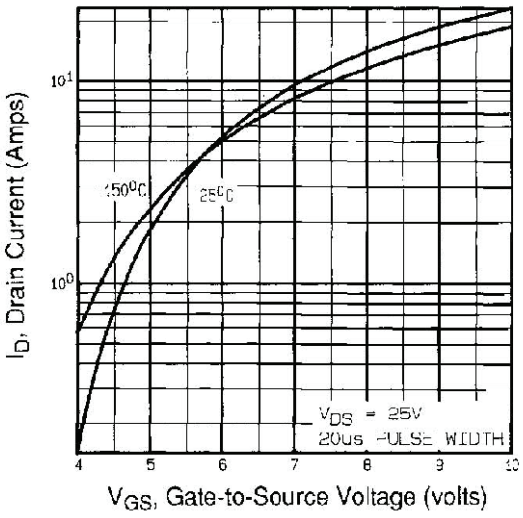



**Fig. 3 - Typical Transfer Characteristics**

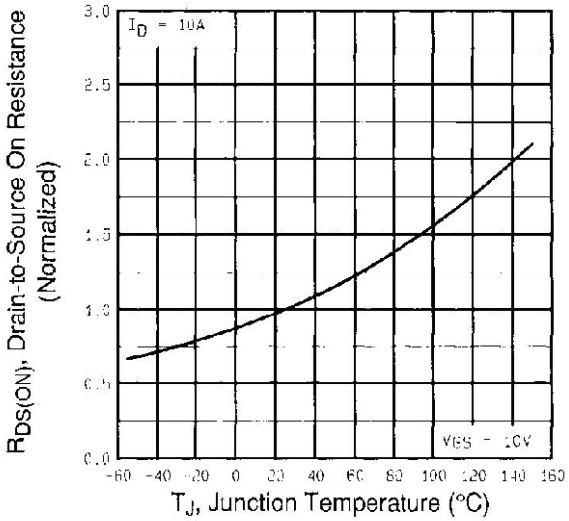



**Fig. 4 - Normalized On-Resistance vs. Temperature**


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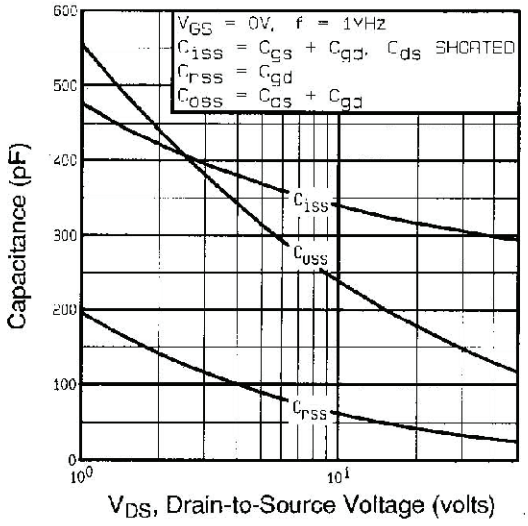



**Fig. 5 - Typical Capacitance vs. Drain-to-Source Voltage**

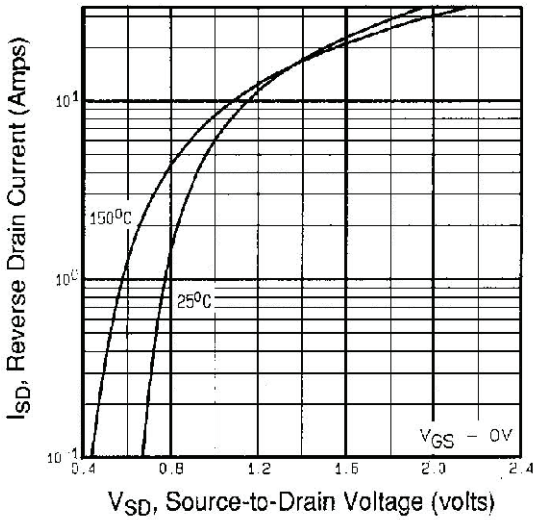



**Fig. 7 - Typical Source-Drain Diode Forward Voltage**

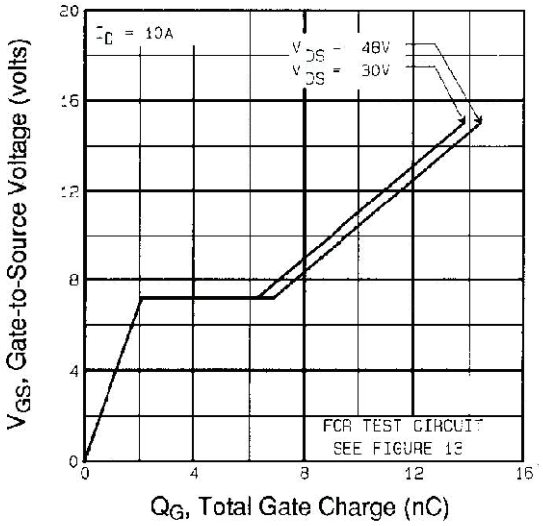



**Fig. 6 - Typical Gate Charge vs. Gate-to-Source Voltage**

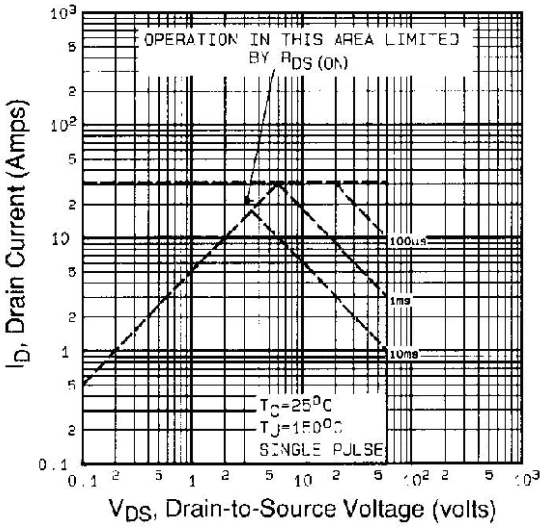



**Fig. 8 - Maximum Safe Operating Area**


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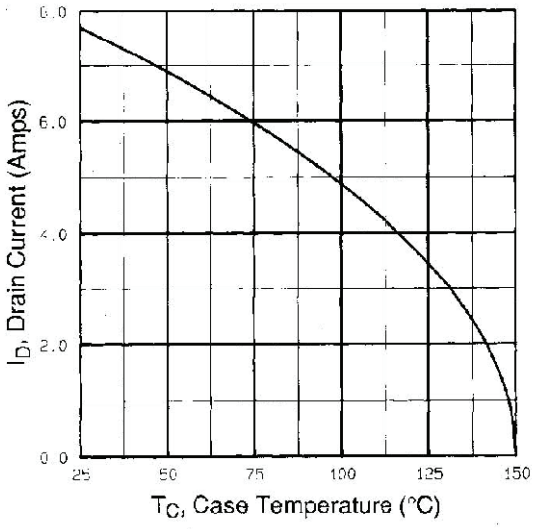



Fig. 9 - Maximum Drain Current vs. Case Temperature

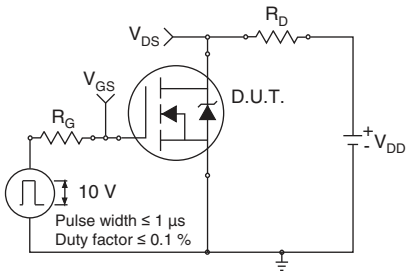



Fig. 10 - Switching Time Test Circuit

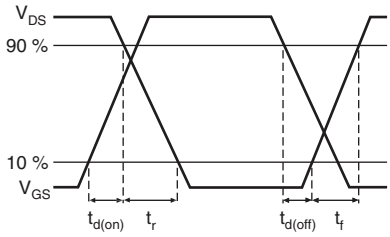



Fig. 11 - Switching Time Waveforms

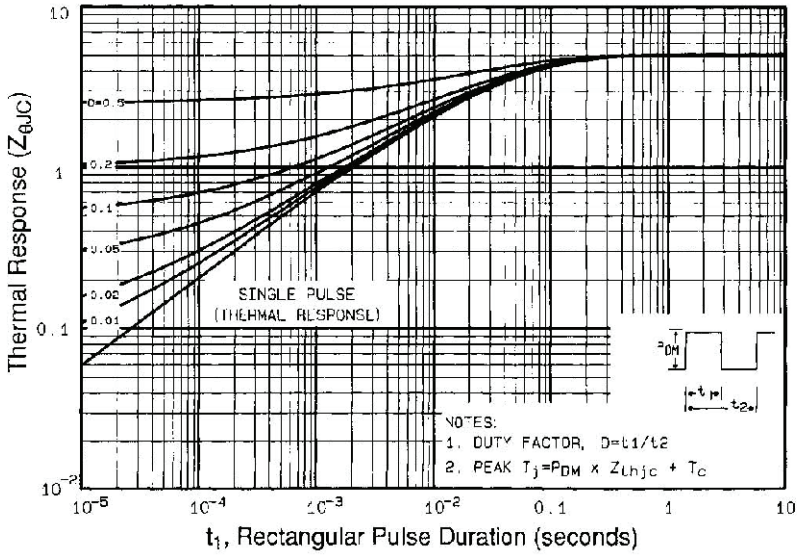



Fig. 12 - Maximum Effective Transient Thermal Impedance, Junction-to-Case


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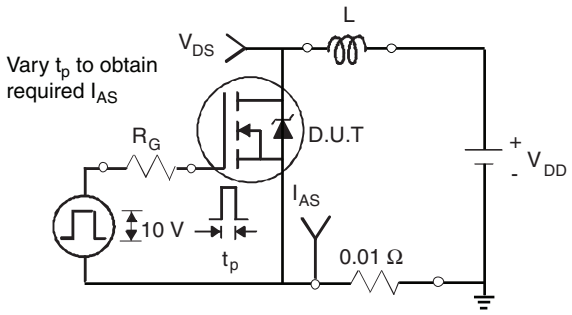



**Fig. 13 - Unclamped Inductive Test Circuit**

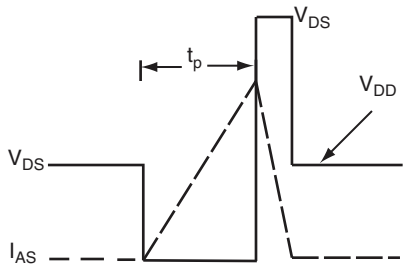



**Fig. 14 - Unclamped Inductive Waveforms**

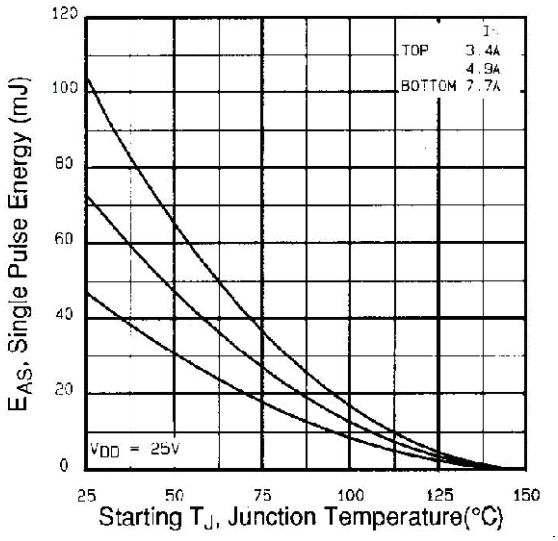



**Fig. 15 - Maximum Avalanche Energy vs. Drain Current**

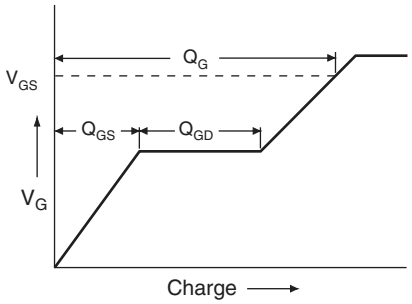



**Fig. 16 - Basic Gate Charge Waveform**

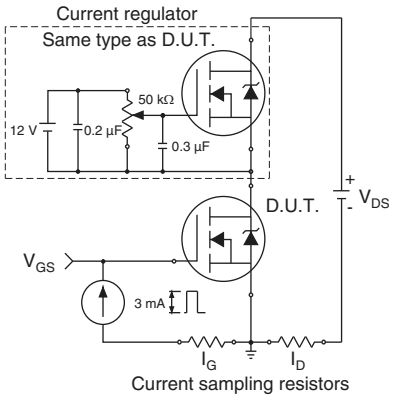
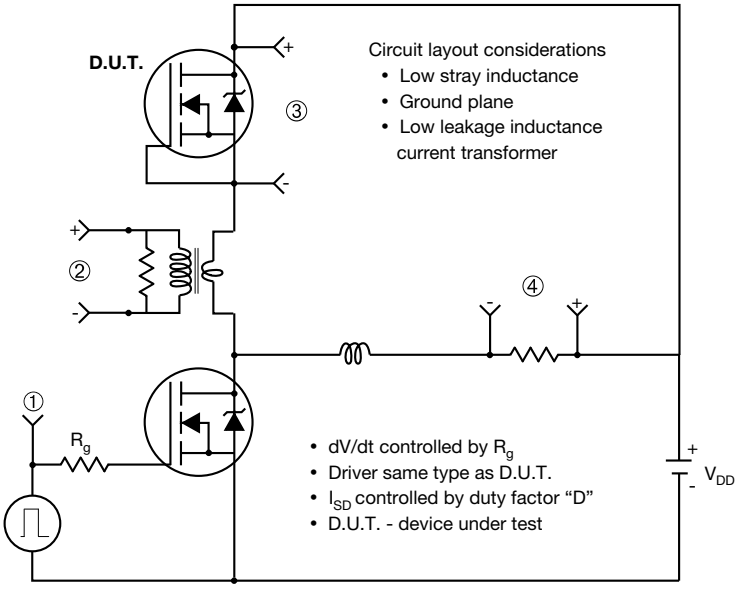
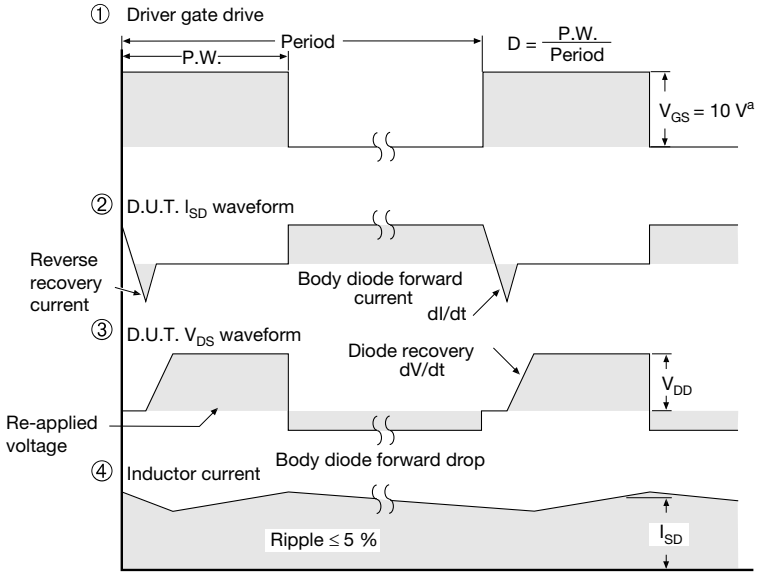



**Fig. 17 - Gate Charge Test Circuit**


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**Peak Diode Recovery dV/dt Test Circuit**




**Note**

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

**Fig. 18 - For N-Channel**

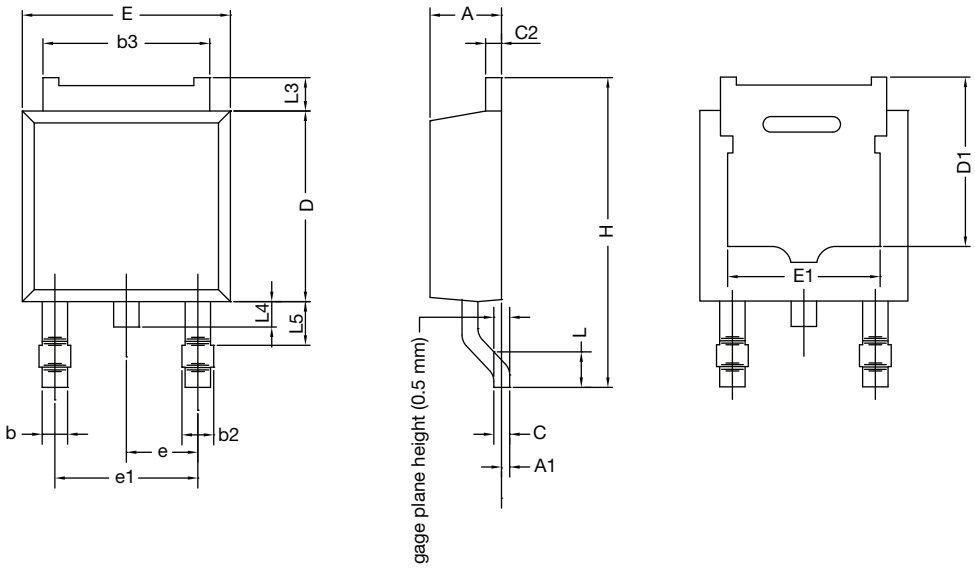
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# TO-252AA Case Outline

## 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**

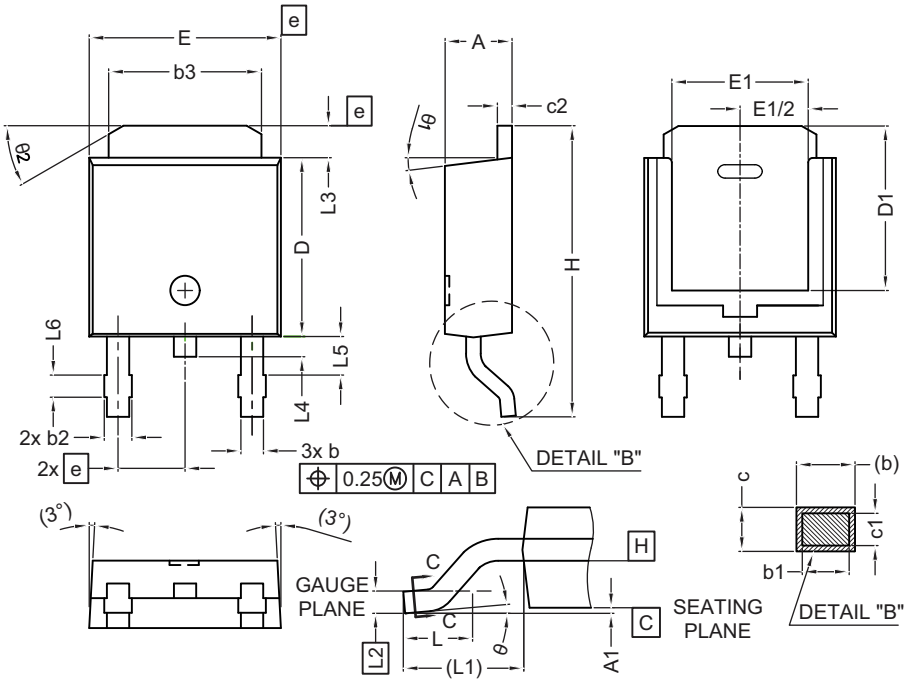
- Dimension L3 is for reference only



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## VERSION 2: FACILITY CODE = N




| | MILLIMETERS | |
|---|---|---|
| DIM. | 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 |

| | MILLIMETERS | |
|---|---|---|
| DIM. | 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 |
| θ | 0° | 10° |
| θ1 | 0° | 15° |
| θ2 | 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: E19-0649-Rev. Q, 16-Dec-2019
DWG: 5347

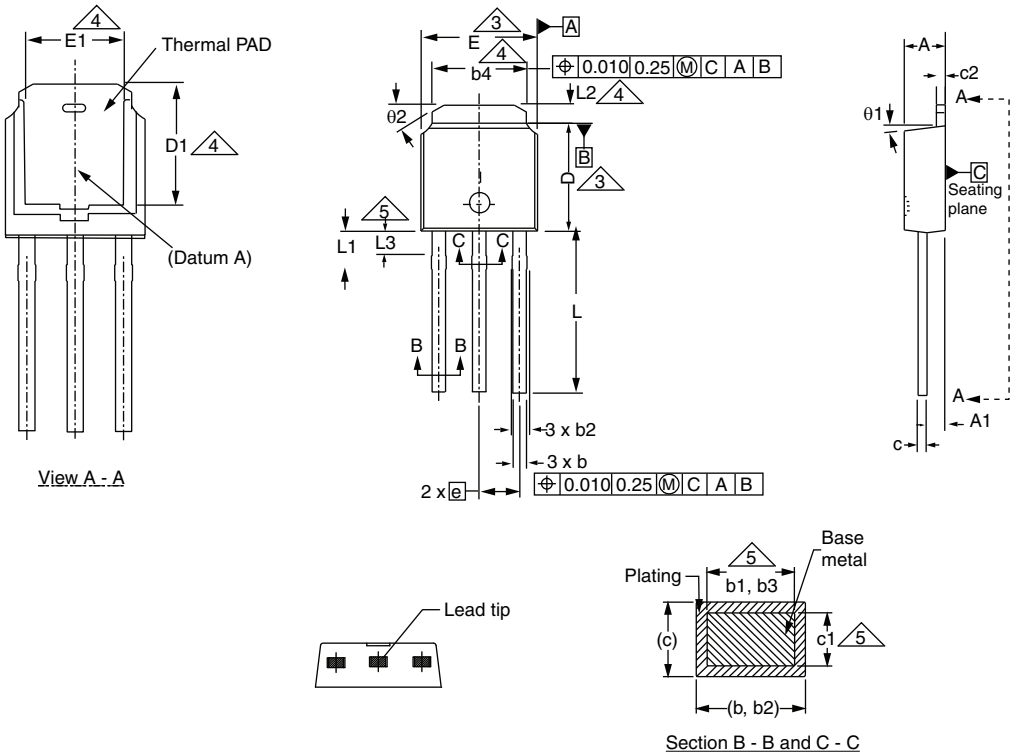


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# Case Outline for TO-251AA (High Voltage)

## OPTION 1:




| | MILLIMETERS | | INCHES | |
|---|---|---|---|---|
| DIM. | 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 |

| | MILLIMETERS | | INCHES | |
|---|---|---|---|---|
| DIM. | 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 |
| θ1 | 0' | 15' | 0' | 15' |
| θ2 | 25' | 35' | 25' | 35' |

ECN: E21-0682-Rev. C, 27-Dec-2021
DWG: 5968

**Notes**

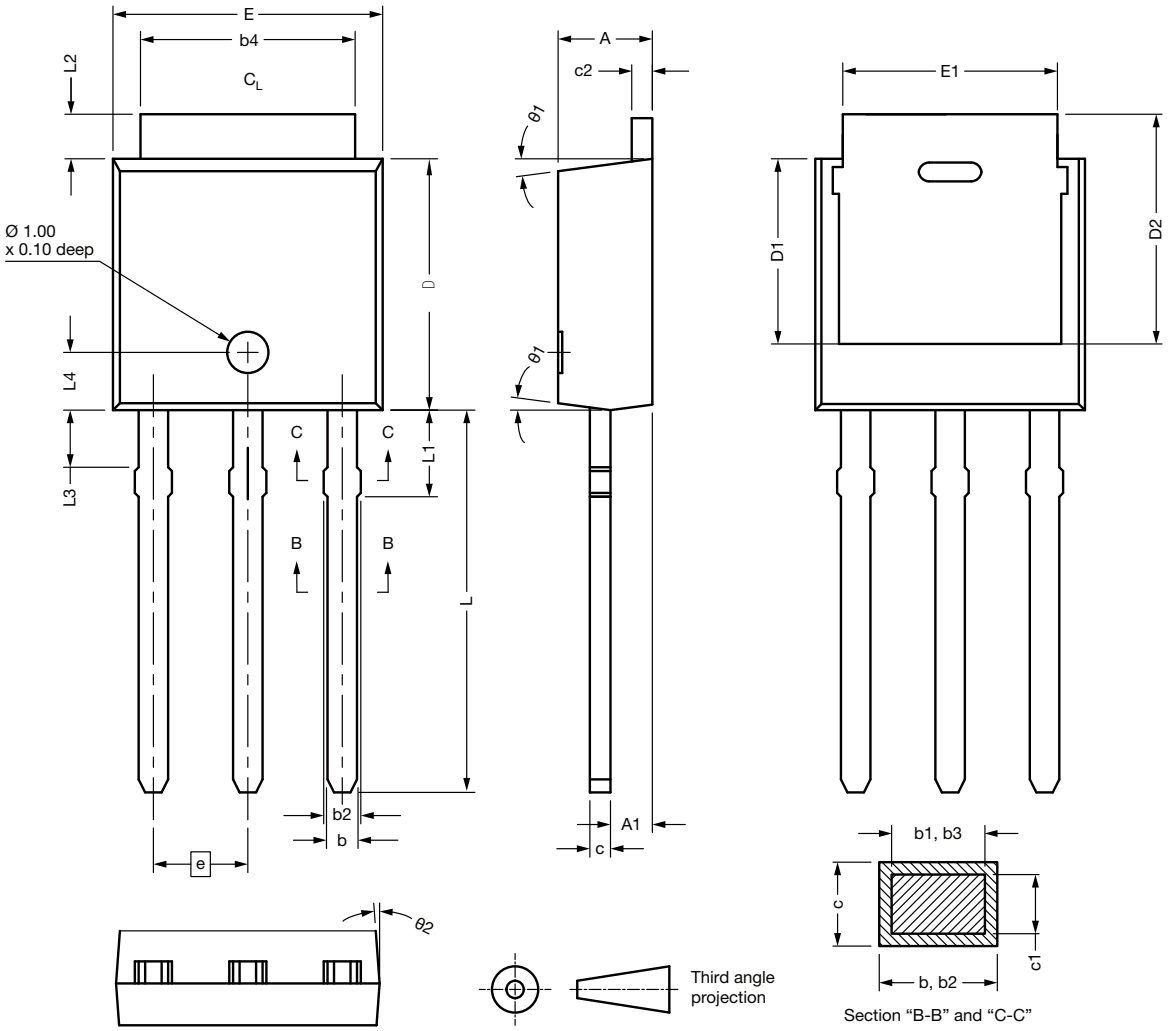
- Dimensioning and tolerancing per ASME Y14.5M-1994
- Dimension are shown in inches and millimeters
- Dimension D and E do not include mold flash. Mold flash shall not exceed 0.13 mm (0.005") per side. These dimensions are measured at the outermost extremes of the plastic body
- Thermal pad contour optional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



For technical questions, contact: hvmos.techsupport@vishay.com

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## OPTION 2: FACILITY CODE = N




| DIM. | MIN. | NOM. | MAX. |
|---|---|---|---|
| A | 2.180 | 2.285 | 2.390 |
| A1 | 0.890 | 1.015 | 1.140 |
| b | 0.640 | 0.765 | 0.890 |
| b1 | 0.640 | 0.715 | 0.790 |
| b2 | 0.760 | 0.950 | 1.140 |
| b3 | 0.760 | 0.900 | 1.040 |
| b4 | 4.950 | 5.205 | 5.460 |
| c | 0.460 | - | 0.610 |
| c1 | 0.410 | - | 0.560 |
| c2 | 0.460 | - | 0.610 |
| D | 5.970 | 6.095 | 6.220 |
| D1 | 4.300 | - | - |

| DIM. | MIN. | NOM. | MAX. |
|---|---|---|---|
| D2 | 5.380 | - | - |
| E | 6.350 | 6.540 | 6.730 |
| E1 | 4.32 | - | - |
| e | 2.29 BSC | | |
| L | 8.890 | 9.270 | 9.650 |
| L1 | 1.910 | 2.100 | 2.290 |
| L2 | 0.890 | 1.080 | 1.270 |
| L3 | 1.140 | 1.330 | 1.520 |
| L4 | 1.300 | 1.400 | 1.500 |
| θ1 | 0° | 7.5° | 15° |
| θ2 | 4° | - | - |

ECN: E21-0682-Rev. C, 27-Dec-2021
DWG: 5968

**Notes**

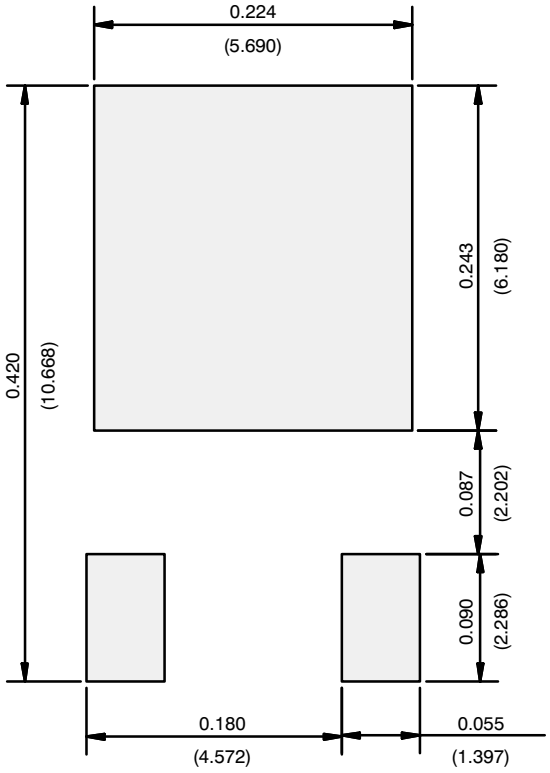
- Dimensioning and tolerancing per ASME Y14.5M-1994
- All dimension are in millimeters, angles are in degrees
- Heat sink side flash is max. 0.8 mm



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## RECOMMENDED MINIMUM PADS FOR DPAK (TO-252)




Recommended Minimum Pads
Dimensions in Inches/(mm)

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APPLICATION NOTE

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