

## Power MOSFET



P-Channel MOSFET

### FEATURES

- Dynamic dV/dt rating
- Repetitive avalanche rated
- Surface mount (IRFR9014, SiHFR9014)
- Straight lead (IRFU9014, SiHFU9014)
- Available in tape and reel
- P-channel
- Fast switching
- Material categorization: for definitions of compliance please see [www.vishay.com/doc?99912](http://www.vishay.com/doc?99912)



**RoHS**  
COMPLIANT  
HALOGEN  
**FREE**  
Available

### PRODUCT SUMMARY

|                           |                  |      |
|---------------------------|------------------|------|
| $V_{DS}$ (V)              | -60              |      |
| $R_{DS(on)}$ ( $\Omega$ ) | $V_{GS} = -10$ V | 0.50 |
| $Q_g$ max. (nC)           | 12               |      |
| $Q_{gs}$ (nC)             | 3.8              |      |
| $Q_{gd}$ (nC)             | 5.1              |      |
| 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 | SiHFR9014-GE3   | SiHFR9014TRL-GE3 <sup>a</sup> | SiHFR9014TR-GE3 <sup>a</sup> | SiHFU9014-GE3 |
|                                 | IRFR9014PbF-BE3 | IRFR9014TRLPbF-BE3            | IRFR9014TRPbF-BE3            | -             |
| Lead (Pb)-free                  | IRFR9014PbF     | IRFR9014TRLPbF <sup>a</sup>   | IRFR9014TRPbF <sup>a</sup>   | IRFU9014PbF   |

#### Note

- a. See device orientation

### ABSOLUTE MAXIMUM RATINGS ( $T_C = 25^\circ\text{C}$ , unless otherwise noted)

| PARAMETER   | SYMBOL         | LIMIT                     | UNIT                |
|---|----------------|---------------------------|---------------------|
| Drain-source voltage                                      | $V_{DS}$       | -60                       | V                   |
| Gate-source voltage                                       | $V_{GS}$       | $\pm 20$                  |                     |
| Continuous drain current                                  | $I_D$          | $T_C = 25^\circ\text{C}$  | A                   |
|   |                | $T_C = 100^\circ\text{C}$ |                     |
| Pulsed drain current <sup>a</sup>                         | $I_{DM}$       | -20                       | W/ $^\circ\text{C}$ |
| Linear derating factor                                    |                | 0.20                      |                     |
| Linear derating factor (PCB mount) <sup>e</sup>           |                | 0.020                     |                     |
| Single pulse avalanche energy <sup>b</sup>                | $E_{AS}$       | 140                       | mJ                  |
| Repetitive avalanche current <sup>a</sup>                 | $I_{AR}$       | -5.1                      | A                   |
| Repetitive avalanche energy <sup>a</sup>                  | $E_{AR}$       | 2.5                       | mJ                  |
| Maximum power dissipation                                 | $P_D$          | $T_C = 25^\circ\text{C}$  | W                   |
| Maximum power dissipation (PCB mount) <sup>e</sup>        |                | $T_A = 25^\circ\text{C}$  |                     |
| Peak diode recovery dV/dt <sup>c</sup>                    | dV/dt          | -4.5                      | V/ns                |
| Operating junction and storage temperature range          | $T_J, T_{stg}$ | -55 to +150               | $^\circ\text{C}$    |
| Soldering recommendations (peak temperature) <sup>d</sup> | For 10 s       | 260                       |                     |

#### Notes

- Repetitive rating; pulse width limited by maximum junction temperature (see fig. 11)
- $V_{DD} = -25$  V, starting  $T_J = 25^\circ\text{C}$ ,  $L = 6.3$  mH,  $R_g = 25 \Omega$ ,  $I_{AS} = -5.1$  A (see fig. 12)
- $I_{SD} \leq -6.7$  A,  $dI/dt \leq 90$  A/ $\mu\text{s}$ ,  $V_{DD} \leq V_{DS}$ ,  $T_J \leq 150^\circ\text{C}$
- 1.6 mm from case
- 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) <sup>a</sup> | $R_{thJA}$ | -    | -    | 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 ( $T_J = 25\text{ }^\circ\text{C}$ , unless otherwise noted) |                     |  |   |      |        |           |               |
|---|---------------------|--|---|------|--------|-----------|---------------|
| PARAMETER   | SYMBOL              | TEST CONDITIONS  |   | MIN. | TYP.   | MAX.      | UNIT          |
| <b>Static</b>   |                     |  |   |      |        |           |               |
| 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 $25\text{ }^\circ\text{C}$ , $I_D = -1\text{ mA}$   |   | -    | -0.059 | -         | 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   | $I_{GSS}$           | $V_{GS} = \pm 20\text{ V}$   |   | -    | -      | $\pm 100$ | nA            |
| Zero gate voltage drain current   | $I_{DSS}$           | $V_{DS} = -60\text{ V}, V_{GS} = 0\text{ V}$   |   | -    | -      | -100      | $\mu\text{A}$ |
|   |                     | $V_{DS} = -48\text{ V}, V_{GS} = 0\text{ V}, T_J = 125\text{ }^\circ\text{C}$  |   | -    | -      | -500      |               |
| Drain-source on-state resistance  | $R_{DS(on)}$        | $V_{GS} = -10\text{ V}$  | $I_D = -3.1\text{ A}^b$   | -    | -      | 0.50      | $\Omega$      |
| Forward transconductance  | $g_{fs}$            | $V_{DS} = -25\text{ V}, I_D = -3.1\text{ A}^b$   |   | 1.4  | -      | -         | S             |
| <b>Dynamic</b>  |                     |  |   |      |        |           |               |
| Input capacitance   | $C_{iss}$           | $V_{GS} = 0\text{ V}, V_{DS} = -25\text{ V}, f = 1.0\text{ MHz}$ , see fig. 5  |   | -    | 270    | -         | pF            |
| Output capacitance  | $C_{oss}$           |  |   | -    | 170    | -         |               |
| Reverse transfer capacitance  | $C_{rss}$           |  |   | -    | 31     | -         |               |
| Total gate charge   | $Q_g$               | $V_{GS} = -10\text{ V}$  | $I_D = -6.7\text{ A}, V_{DS} = -48\text{ V}$ , see fig. 6 and 13 <sup>b</sup> | -    | -      | 12        | nC            |
| Gate-source charge  | $Q_{gs}$            |  |   | -    | -      | 3.8       |               |
| Gate-drain charge   | $Q_{gd}$            |  |   | -    | -      | 5.1       |               |
| Turn-on delay time  | $t_{d(on)}$         | $V_{DD} = -30\text{ V}, I_D = -6.7\text{ A}, R_g = 24\text{ }\Omega, R_D = 4.0\text{ }\Omega$ , see fig. 10 <sup>b</sup> |   | -    | 11     | -         | ns            |
| Rise time   | $t_r$               |  |   | -    | 63     | -         |               |
| Turn-off delay time   | $t_{d(off)}$        |  |   | -    | 9.6    | -         |               |
| Fall time   | $t_f$               |  |   | -    | 31     | -         |               |
| Internal drain inductance   | $L_D$               | Between lead, 6 mm (0.25") from package and center of die contact <sup>c</sup>   |   | -    | 4.5    | -         | nH            |
| Internal source inductance  | $L_S$               |  |   | -    | 7.5    | -         |               |
| <b>Drain-Source Body Diode Characteristics</b>                              |                     |  |   |      |        |           |               |
| Continuous source-drain diode current                                       | $I_S$               | MOSFET symbol showing the integral reverse p - n junction diode  |   | -    | -      | -5.1      | A             |
| Pulsed diode forward current <sup>a</sup>                                   | $I_{SM}$            |  |   | -    | -      | -20       |               |
| Body diode voltage  | $V_{SD}$            | $T_J = 25\text{ }^\circ\text{C}, I_S = -5.1\text{ A}, V_{GS} = 0\text{ V}^b$   |   | -    | -      | -5.5      | V             |
| Body diode reverse recovery time  | $t_{rr}$            | $T_J = 25\text{ }^\circ\text{C}, I_F = -6.7\text{ A}, di/dt = 100\text{ A}/\mu\text{s}^b$                                |   | -    | 80     | 160       | ns            |
| Body diode reverse recovery charge  | $Q_{rr}$            |  |   | -    | 0.096  | 0.19      | $\mu\text{C}$ |
| 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)

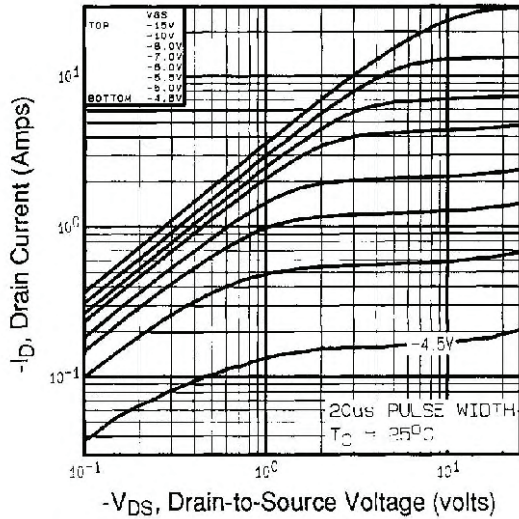


Fig. 1 - Typical Output Characteristics,  $T_C = 25^\circ\text{C}$

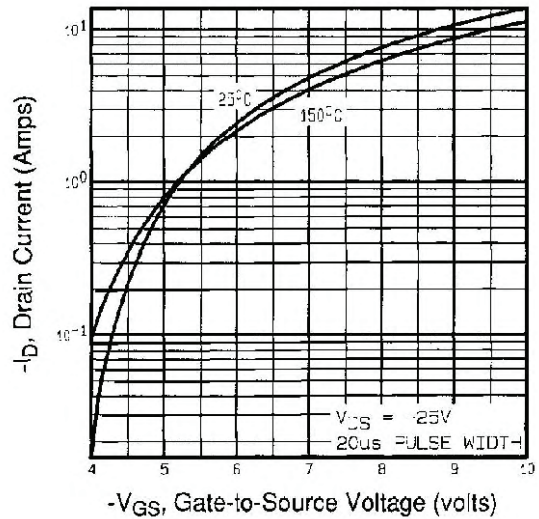


Fig. 3 - Typical Transfer Characteristics

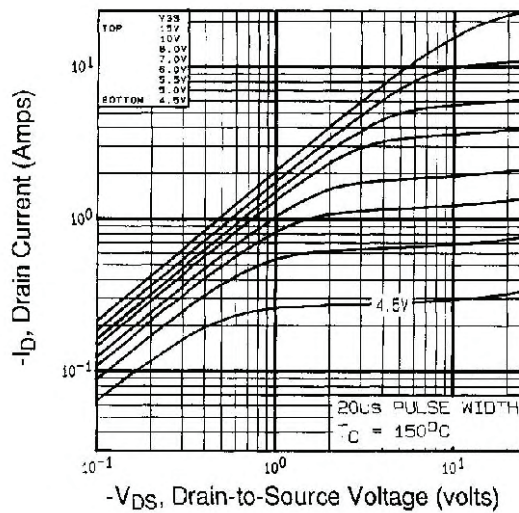


Fig. 2 - Typical Output Characteristics,  $T_C = 150^\circ\text{C}$

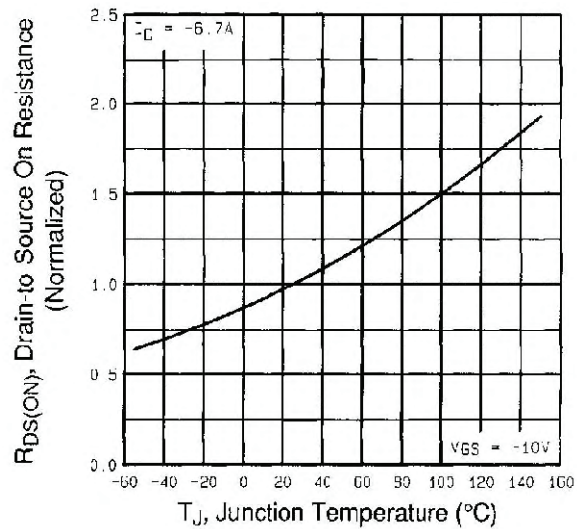


Fig. 4 - Normalized On-Resistance vs. Temperature

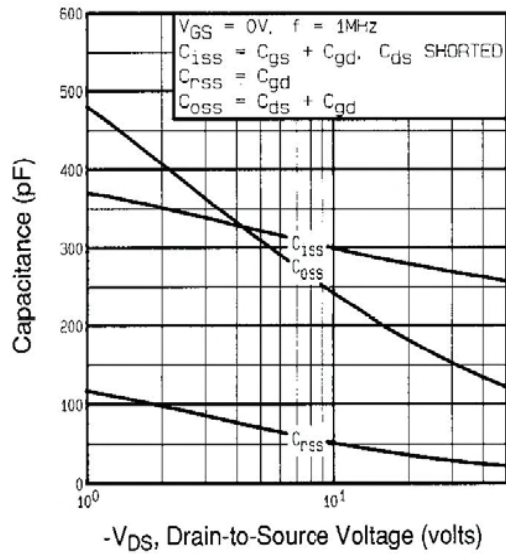


Fig. 5 - Typical Capacitance vs. Drain-to-Source Voltage



Fig. 7 - Typical Source-Drain Diode Forward Voltage

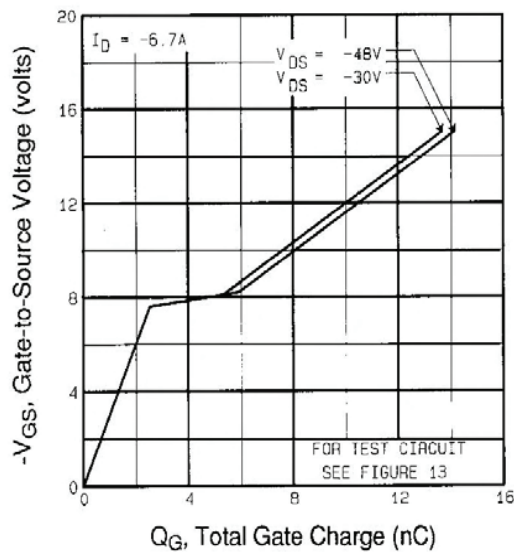


Fig. 6 - Typical Gate Charge vs. Gate-to-Source Voltage

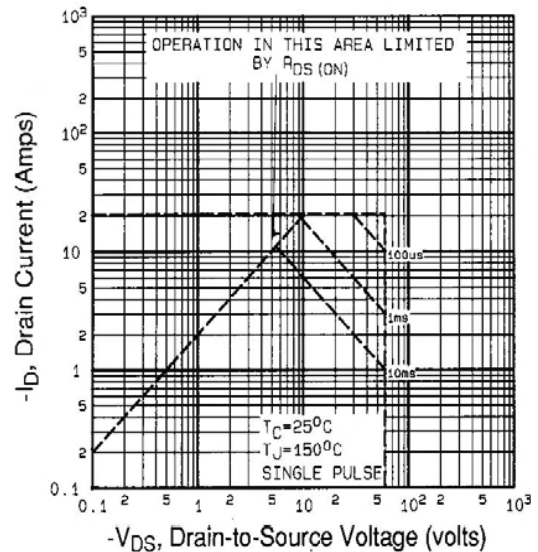


Fig. 8 - Maximum Safe Operating Area



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



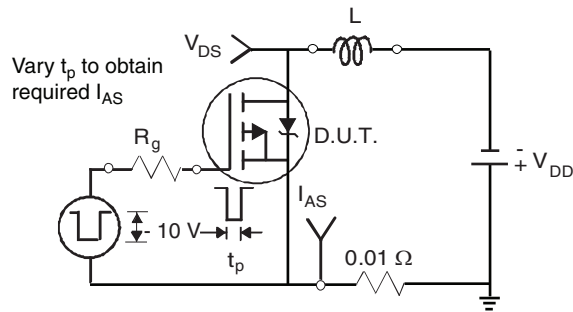


Fig. 12a - Unclamped Inductive Test Circuit

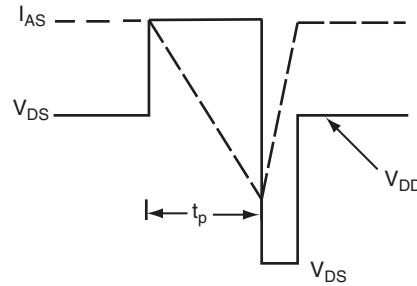


Fig. 12b - Unclamped Inductive Waveforms

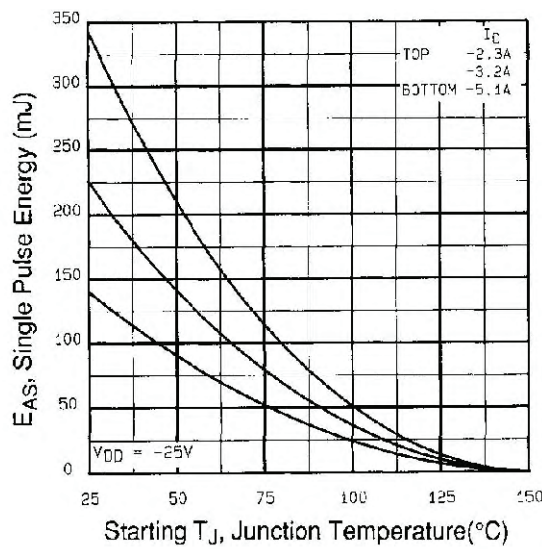


Fig. 12c - Maximum Avalanche Energy vs. Drain Current

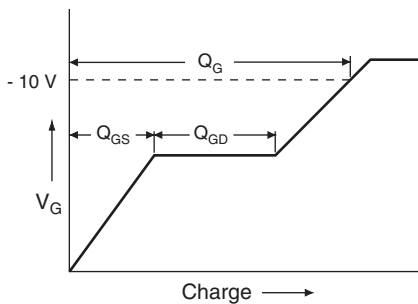


Fig. 13a - Basic Gate Charge Waveform

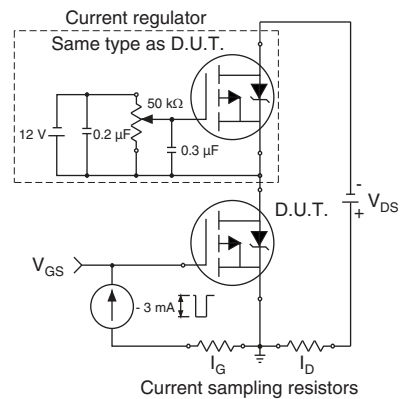
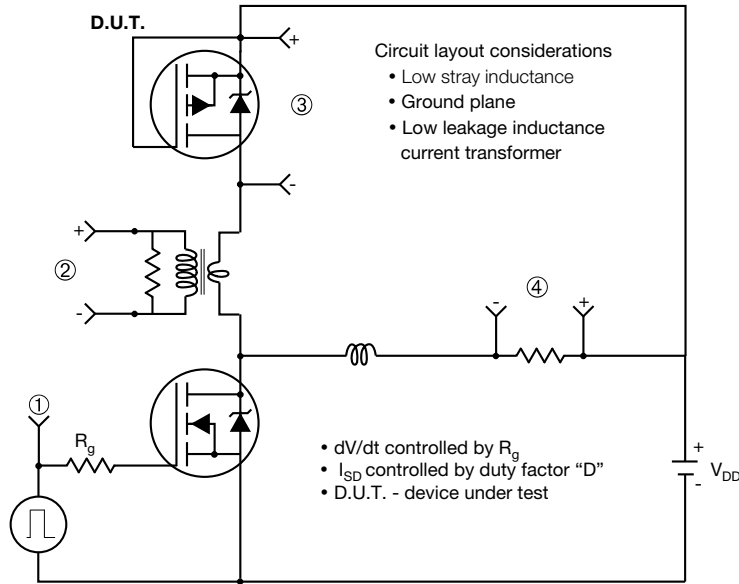
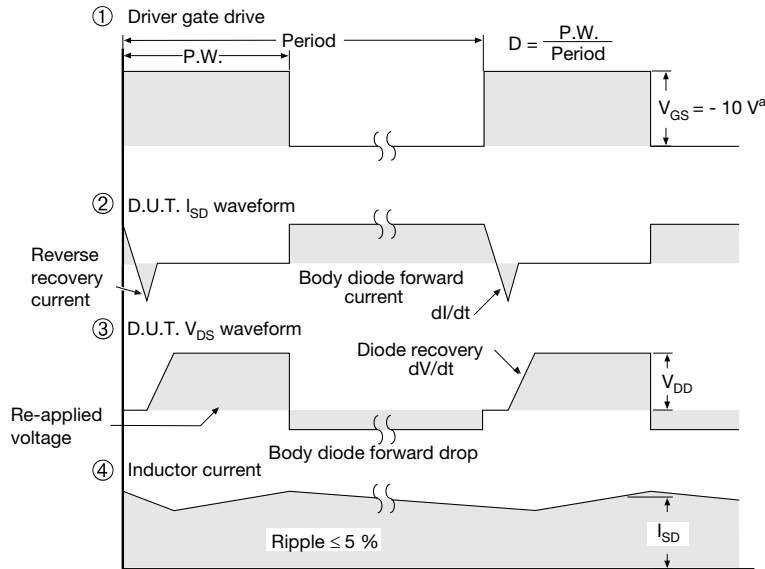


Fig. 13b - Gate Charge Test Circuit

### Peak Diode Recovery dV/dt Test Circuit



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



**Note**  
a.  $V_{GS} = -5\text{ V}$  for logic level and  $-3\text{ V}$  drive devices

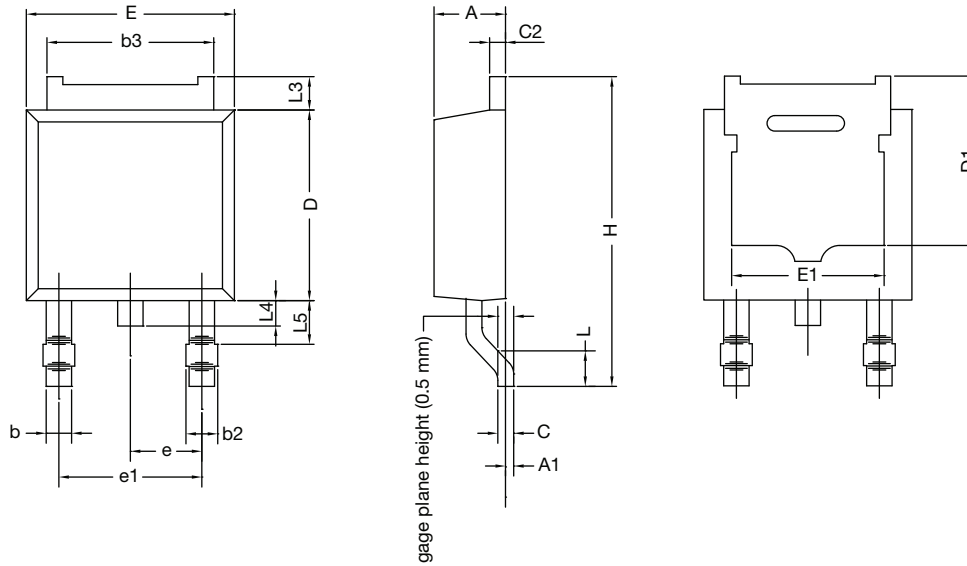
**Fig. 14 - For P-Channel**

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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



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

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

**OPTION 1:**



| 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 |
| 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



**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 |
| $\theta_1$ | 0°       | 7.5°  | 15°   |
| $\theta_2$ | 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

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



Recommended Minimum Pads  
Dimensions in Inches/(mm)

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