

N-Channel 650V (D-S) Power MOSFET

| PRODUCT SUMMARY | |
|-----------------------------------------|----------------------------|
| V_{DS} (V) at T_J max. | 650 |
| $R_{DS(on)}$ max. at 25 °C (Ω) | $V_{GS} = 10\text{ V}$ 0.9 |
| Q_g max. (nC) | 57 |
| Q_{gs} (nC) | 4.0 |
| Q_{gd} (nC) | 5.4 |
| Configuration | Single |

FEATURES

- Low figure-of-merit (FOM) $R_{on} \times Q_g$
- Low input capacitance (C_{iss})
- Reduced switching and conduction losses
- Ultra low gate charge (Q_g)
- Avalanche energy rated (UIS)

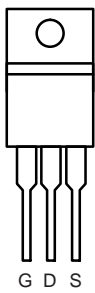


RoHS

APPLICATIONS

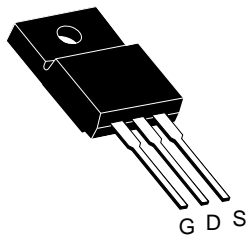
- Server and telecom power supplies
- Switch mode power supplies (SMPS)
- Power factor correction power supplies (PFC)
- Lighting
 - High-intensity discharge (HID)
 - Fluorescent ballast lighting
- Industrial

TO-220AB



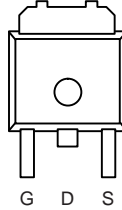
Top View

TO-220 FULLPAK



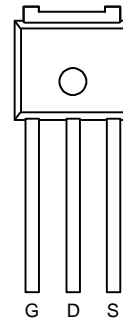
Top View

TO-252

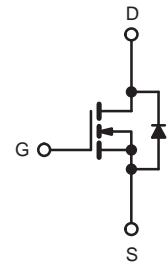


Top View

TO-251



Top View




N-Channel MOSFET

| ABSOLUTE MAXIMUM RATINGS ($T_C = 25\text{ °C}$, unless otherwise noted) | | | |
|---------------------------------------------------------------------------|------------------|-----------------------|------|
| PARAMETER | SYMBOL | LIMIT | UNIT |
| Drain-Source Voltage | V_{DS} | 650 | V |
| Gate-Source Voltage | V_{GS} | ± 30 | |
| Continuous Drain Current ($T_J = 150\text{ °C}$) | V_{GS} at 10 V | $T_C = 25\text{ °C}$ | 10 |
| | | $T_C = 100\text{ °C}$ | 8 |
| Pulsed Drain Current ^a | I_{DM} | 35 | A |
| Linear Derating Factor | | 1.67/1.5/0.3 | W/°C |
| Single Pulse Avalanche Energy ^b | E_{AS} | 86 | mJ |
| Maximum Power Dissipation | P_D | 178/156/53 | W |
| Operating Junction and Storage Temperature Range | T_J, T_{stg} | -55 to +150 | °C |
| Drain-Source Voltage Slope | dV/dt | $T_J = 125\text{ °C}$ | 50 |
| Reverse Diode dV/dt ^d | | 4.5 | |
| Soldering Recommendations (Peak Temperature) ^c | for 10 s | 300 | °C |

Notes

- Repetitive rating; pulse width limited by maximum junction temperature.
- $V_{DD} = 50\text{ V}$, starting $T_J = 25\text{ °C}$, $L = 28.2\text{ mH}$, $R_g = 25\ \Omega$, $I_{AS} = 3.5\text{ A}$.
- 1.6 mm from case.
- $I_{SD} \leq I_D$, $dI/dt = 100\text{ A}/\mu\text{s}$, starting $T_J = 25\text{ °C}$.

| THERMAL RESISTANCE RATINGS | | | | |
|----------------------------------|------------|------|------|------|
| PARAMETER | SYMBOL | TYP. | MAX. | UNIT |
| Maximum Junction-to-Ambient | R_{thJA} | - | 63 | °C/W |
| Maximum Junction-to-Case (Drain) | R_{thJC} | - | 0.6 | |

| SPECIFICATIONS ($T_J = 25\text{ °C}$, unless otherwise noted) | | | | | | | |
|-----------------------------------------------------------------|---------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------|------|------|-----------|---------------|
| PARAMETER | SYMBOL | TEST CONDITIONS | | MIN. | TYP. | MAX. | UNIT |
| Static | | | | | | | |
| Drain-Source Breakdown Voltage | V_{DS} | $V_{GS} = 0\text{ V}, I_D = 250\text{ }\mu\text{A}$ | | 650 | - | - | V |
| V_{DS} Temperature Coefficient | $\Delta V_{DS}/T_J$ | Reference to 25 °C , $I_D = 1\text{ mA}$ | | - | 0.65 | - | V/°C |
| Gate-Source Threshold Voltage (N) | $V_{GS(th)}$ | $V_{DS} = V_{GS}, I_D = 250\text{ }\mu\text{A}$ | | 2 | - | 4 | 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} | $V_{DS} = 650\text{ V}, V_{GS} = 0\text{ V}$ | | - | - | 1 | μA |
| | | $V_{DS} = 520\text{ V}, V_{GS} = 0\text{ V}, T_J = 125\text{ °C}$ | | - | - | 10 | |
| Drain-Source On-State Resistance | $R_{DS(on)}$ | $V_{GS} = 10\text{ V}$ | $I_D = 4\text{ A}$ | - | 0.82 | 0.9 | Ω |
| Forward Transconductance | g_{fs} | $V_{DS} = 30\text{ V}, I_D = 4\text{ A}$ | | - | 16 | - | S |
| Dynamic | | | | | | | |
| Input Capacitance | C_{iss} | $V_{GS} = 0\text{ V}, V_{DS} = 100\text{ V}, f = 1\text{ MHz}$ | | - | 1900 | - | pF |
| Output Capacitance | C_{oss} | | | - | 400 | - | |
| Reverse Transfer Capacitance | C_{rss} | | | - | 240 | - | |
| Effective Output Capacitance, Energy Related ^a | $C_{o(er)}$ | $V_{DS} = 0\text{ V to } 520\text{ V}, V_{GS} = 0\text{ V}$ | | - | 45 | - | |
| Effective Output Capacitance, Time Related ^b | $C_{o(tr)}$ | | | - | 62 | - | |
| Total Gate Charge | Q_g | $V_{GS} = 10\text{ V}$ | $I_D = 4\text{ A}, V_{DS} = 520\text{ V}$ | - | 40 | 57 | nC |
| Gate-Source Charge | Q_{gs} | | | - | 4.0 | - | |
| Gate-Drain Charge | Q_{gd} | | | - | 5.4 | - | |
| Turn-On Delay Time | $t_{d(on)}$ | $V_{DD} = 520\text{ V}, I_D = 4\text{ A}, V_{GS} = 10\text{ V}, R_g = 9.1\text{ }\Omega$ | | - | 25 | - | ns |
| Rise Time | t_r | | | - | 55 | - | |
| Turn-Off Delay Time | $t_{d(off)}$ | | | - | 70 | - | |
| Fall Time | t_f | | | - | 40 | - | |
| Gate Input Resistance | R_g | $f = 1\text{ MHz}, \text{ open drain}$ | | - | 3.5 | - | Ω |
| Drain-Source Body Diode Characteristics | | | | | | | |
| Continuous Source-Drain Diode Current | I_S | MOSFET symbol showing the integral reverse p - n junction diode  | | - | - | 7 | A |
| Pulsed Diode Forward Current | I_{SM} | | | - | - | 18 | |
| Diode Forward Voltage | V_{SD} | $T_J = 25\text{ °C}, I_S = 4\text{ A}, V_{GS} = 0\text{ V}$ | | - | - | 1.5 | V |
| Reverse Recovery Time | t_{rr} | $T_J = 25\text{ °C}, I_F = I_S = 4\text{ A}, dI/dt = 100\text{ A}/\mu\text{s}, V_R = 400\text{ V}$ | | - | 190 | - | ns |
| Reverse Recovery Charge | Q_{rr} | | | - | 2.3 | - | μC |
| Reverse Recovery Current | I_{RRM} | | | - | 10 | - | 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)

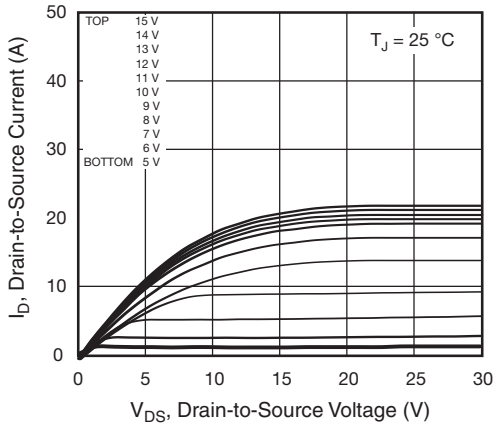


Fig. 1 - Typical Output Characteristics

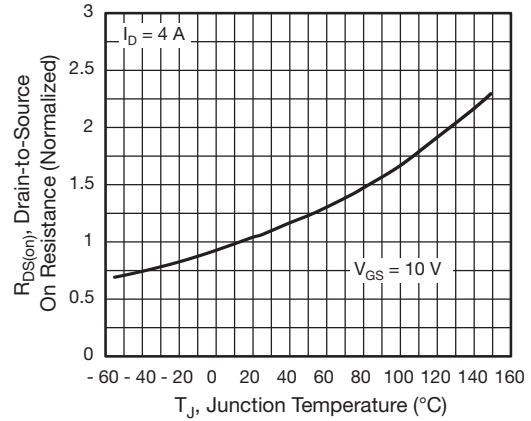


Fig. 4 - Normalized On-Resistance vs. Temperature

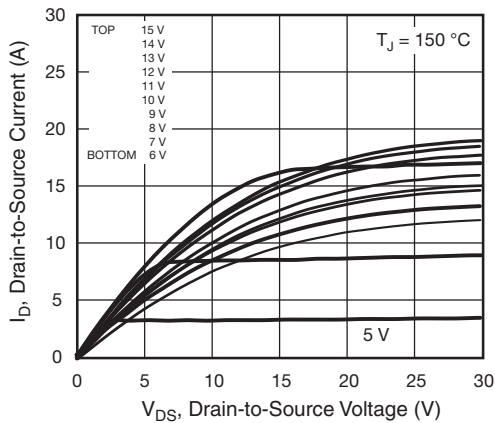


Fig. 2 - Typical Output Characteristics

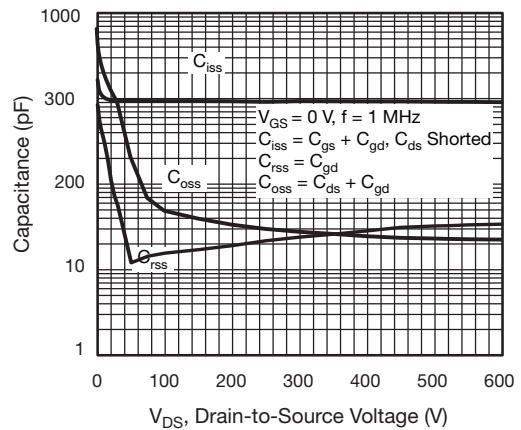


Fig. 5 - Typical Capacitance vs. Drain-to-Source Voltage

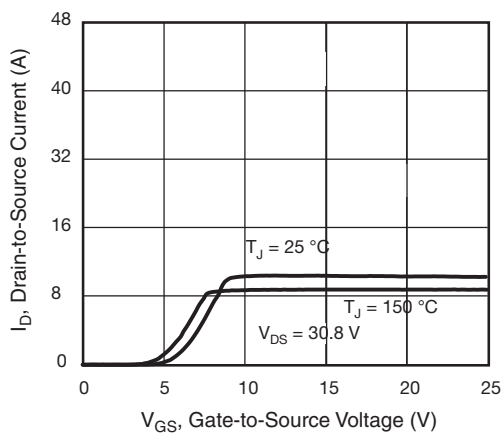


Fig. 3 - Typical Transfer Characteristics

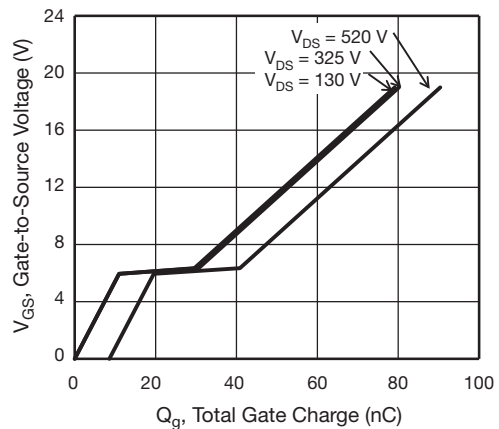


Fig. 6 - Typical Gate Charge vs. Gate-to-Source Voltage

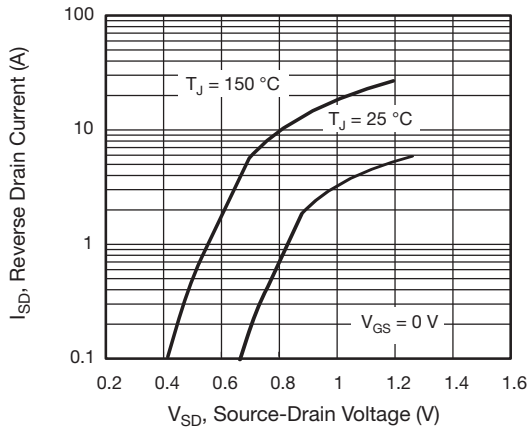


Fig. 7 - Typical Source-Drain Diode Forward Voltage

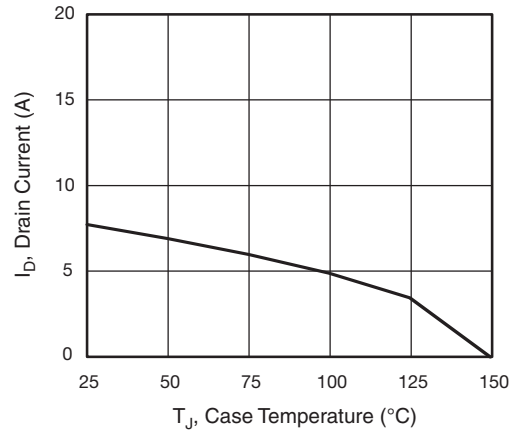


Fig. 9 - Maximum Drain Current vs. Case Temperature

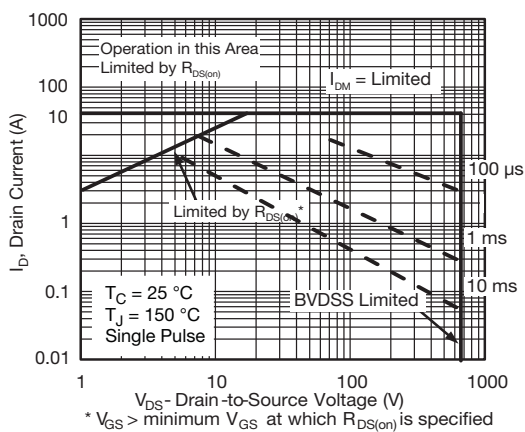


Fig. 8 - Maximum Safe Operating Area

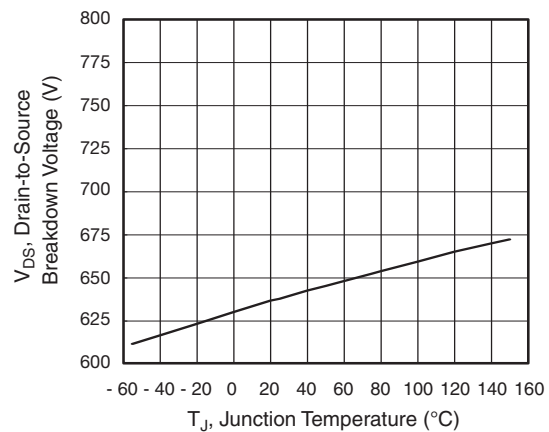


Fig. 10 - Temperature vs. Drain-to-Source Voltage

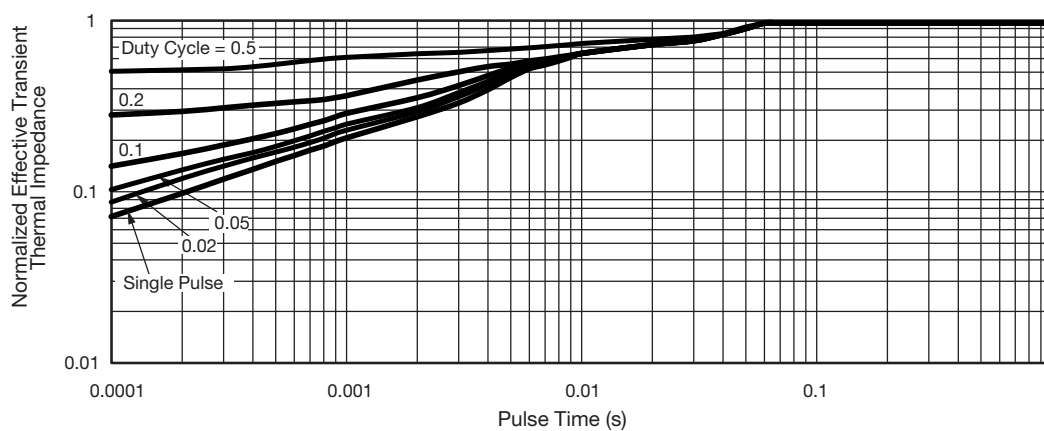


Fig. 11 - Normalized Thermal Transient Impedance, Junction-to-Case

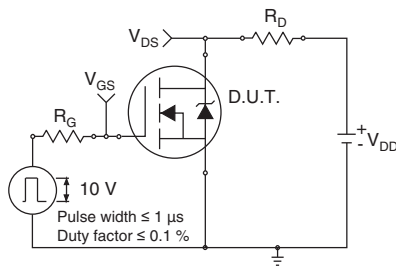


Fig. 12 - Switching Time Test Circuit

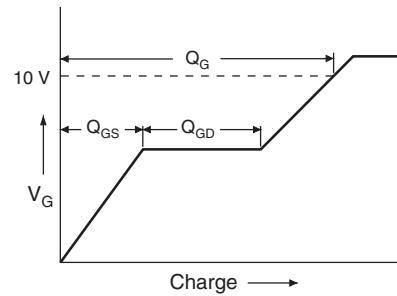


Fig. 16 - Basic Gate Charge Waveform

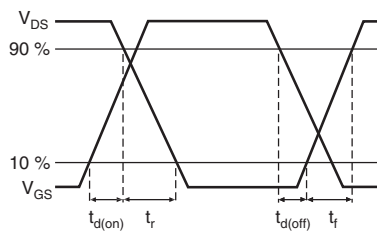


Fig. 13 - Switching Time Waveforms

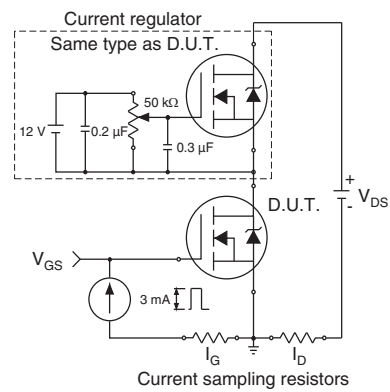


Fig. 17 - Gate Charge Test Circuit

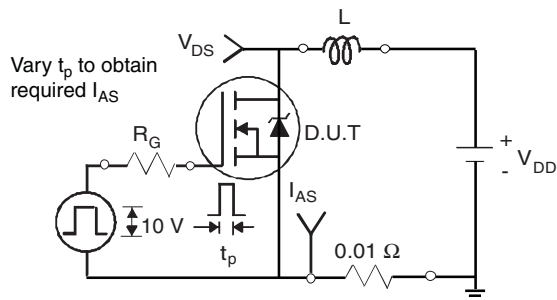


Fig. 14 - Unclamped Inductive Test Circuit

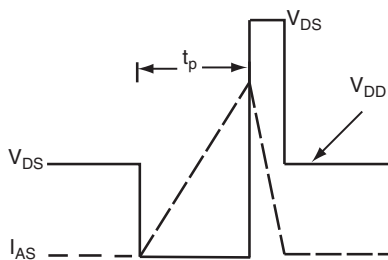
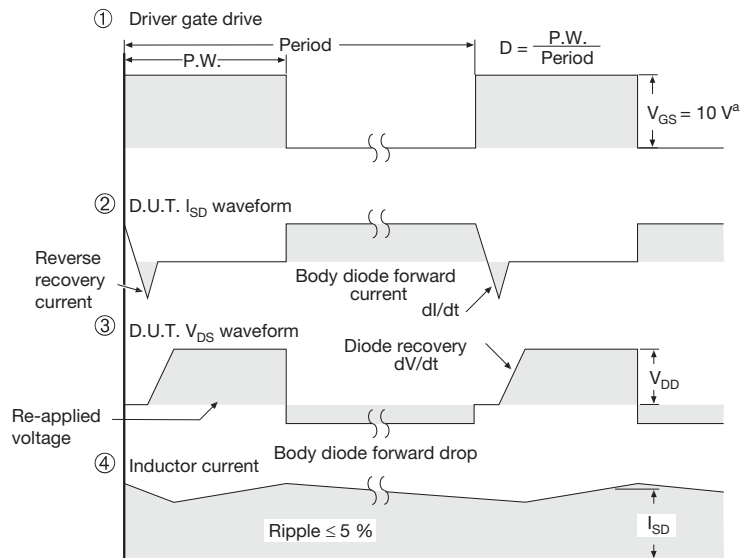
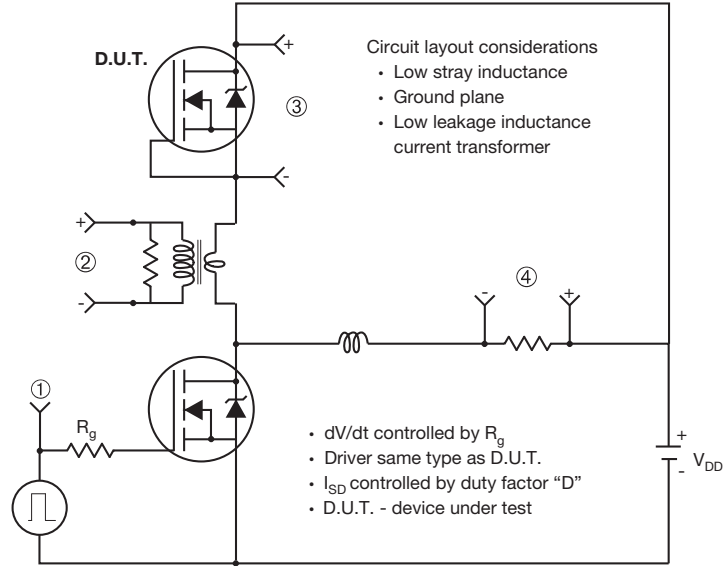


Fig. 15 - Unclamped Inductive Waveforms

Peak Diode Recovery dV/dt Test Circuit

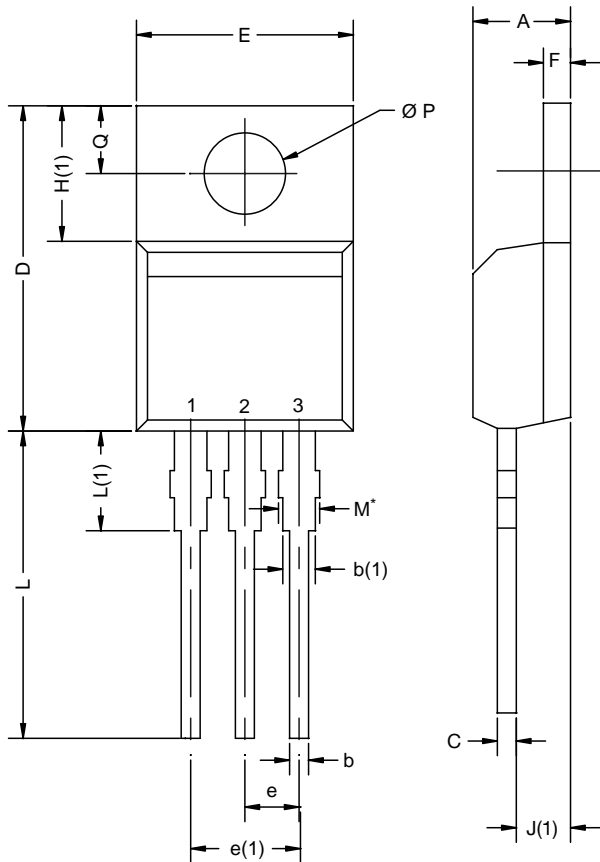


Note

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

Fig. 18 - For N-Channel

TO-220AB



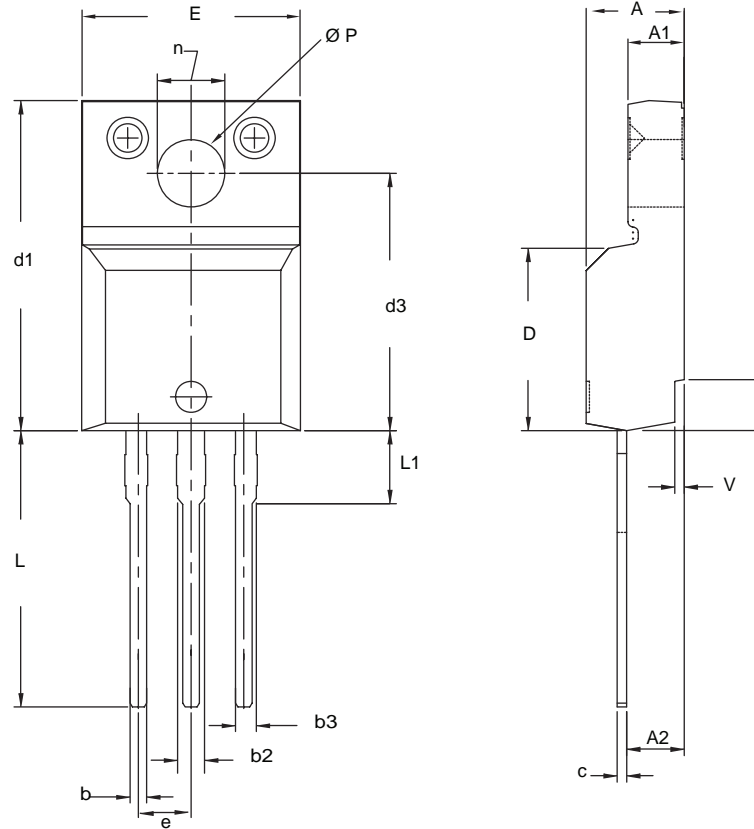
| DIM. | MILLIMETERS | | INCHES | |
|-----------------|-------------|-------|--------|-------|
| | MIN. | MAX. | MIN. | MAX. |
| A | 4.25 | 4.65 | 0.167 | 0.183 |
| b | 0.69 | 1.01 | 0.027 | 0.040 |
| b(1) | 1.20 | 1.73 | 0.047 | 0.068 |
| c | 0.36 | 0.61 | 0.014 | 0.024 |
| D | 14.85 | 15.49 | 0.585 | 0.610 |
| E | 10.04 | 10.51 | 0.395 | 0.414 |
| e | 2.41 | 2.67 | 0.095 | 0.105 |
| e(1) | 4.88 | 5.28 | 0.192 | 0.208 |
| F | 1.14 | 1.40 | 0.045 | 0.055 |
| H(1) | 6.09 | 6.48 | 0.240 | 0.255 |
| J(1) | 2.41 | 2.92 | 0.095 | 0.115 |
| L | 13.35 | 14.02 | 0.526 | 0.552 |
| L(1) | 3.32 | 3.82 | 0.131 | 0.150 |
| $\varnothing P$ | 3.54 | 3.94 | 0.139 | 0.155 |
| Q | 2.60 | 3.00 | 0.102 | 0.118 |

ECN: X12-0208-Rev. N, 08-Oct-12
 DWG: 5471

Notes

* M = 1.32 mm to 1.62 mm (dimension including protrusion)
 Heatsink hole for HVM

TO-220 FULLPAK (HIGH VOLTAGE)



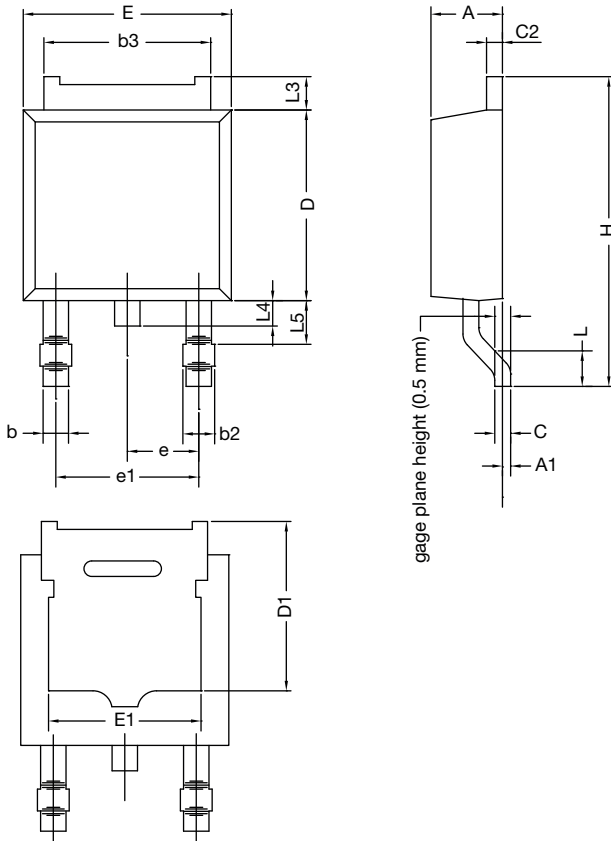
| DIM. | MILLIMETERS | | INCHES | |
|------|-------------|--------|-----------|-------|
| | MIN. | MAX. | MIN. | MAX. |
| A | 4.570 | 4.830 | 0.180 | 0.190 |
| A1 | 2.570 | 2.830 | 0.101 | 0.111 |
| A2 | 2.510 | 2.850 | 0.099 | 0.112 |
| b | 0.622 | 0.890 | 0.024 | 0.035 |
| b2 | 1.229 | 1.400 | 0.048 | 0.055 |
| b3 | 1.229 | 1.400 | 0.048 | 0.055 |
| c | 0.440 | 0.629 | 0.017 | 0.025 |
| D | 8.650 | 9.800 | 0.341 | 0.386 |
| d1 | 15.88 | 16.120 | 0.622 | 0.635 |
| d3 | 12.300 | 12.920 | 0.484 | 0.509 |
| E | 10.360 | 10.630 | 0.408 | 0.419 |
| e | 2.54 BSC | | 0.100 BSC | |
| L | 13.200 | 13.730 | 0.520 | 0.541 |
| L1 | 3.100 | 3.500 | 0.122 | 0.138 |
| n | 6.050 | 6.150 | 0.238 | 0.242 |
| Ø P | 3.050 | 3.450 | 0.120 | 0.136 |
| u | 2.400 | 2.500 | 0.094 | 0.098 |
| v | 0.400 | 0.500 | 0.016 | 0.020 |

ECN: X09-0126-Rev. B, 26-Oct-09
DWG: 5972

Notes

1. To be used only for process drawing.
2. These dimensions apply to all TO-220, FULLPAK leadframe versions 3 leads.
3. All critical dimensions should C meet $C_{pk} > 1.33$.
4. All dimensions include burrs and plating thickness.
5. No chipping or package damage.

TO-252AA CASE OUTLINE

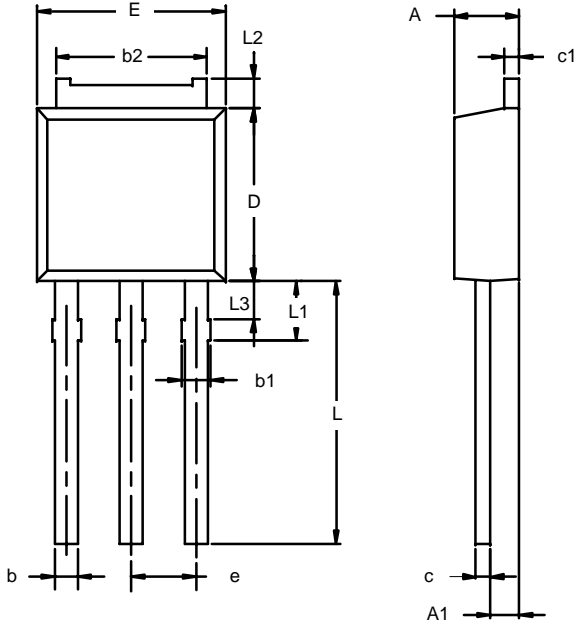


| DIM. | MILLIMETERS | | INCHES | |
|----------------------------------------------|-------------|-------|-----------|-------|
| | MIN. | MAX. | MIN. | MAX. |
| A | 2.18 | 2.38 | 0.086 | 0.094 |
| A1 | - | 0.127 | - | 0.005 |
| b | 0.64 | 0.88 | 0.025 | 0.035 |
| b2 | 0.76 | 1.14 | 0.030 | 0.045 |
| 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 | 5.21 | - | 0.205 | - |
| 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 | 1.14 | 1.52 | 0.045 | 0.060 |
| ECN: X12-0247-Rev. M, 24-Dec-12 DWG: 5347 | | | | |

Note

- Dimension L3 is for reference only.

TO-251AA (DPAK)



Note: Dimension L3 is for reference only.

| Dim | MILLIMETERS | | INCHES | |
|---------------------------------------------|-------------|------|-----------|-------|
| | Min | Max | Min | Max |
| A | 2.21 | 2.38 | 0.087 | 0.094 |
| A1 | 0.89 | 1.14 | 0.035 | 0.045 |
| b | 0.71 | 0.89 | 0.028 | 0.035 |
| b1 | 0.76 | 1.14 | 0.030 | 0.045 |
| b2 | 5.23 | 5.43 | 0.206 | 0.214 |
| c | 0.46 | 0.58 | 0.018 | 0.023 |
| c1 | 0.46 | 0.58 | 0.018 | 0.023 |
| D | 5.97 | 6.22 | 0.235 | 0.245 |
| E | 6.48 | 6.73 | 0.255 | 0.265 |
| e | 2.28 BSC | | 0.090 BSC | |
| L | 8.89 | 9.53 | 0.350 | 0.375 |
| L1 | 1.91 | 2.28 | 0.075 | 0.090 |
| L2 | 0.89 | 1.27 | 0.035 | 0.050 |
| L3 | 1.15 | 1.52 | 0.045 | 0.060 |
| ECN: S-03946—Rev. E, 09-Jul-01 DWG: 5346 | | | | |

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