

## IPD60R450E6-VB Datasheet

## N-Channel 650V (D-S) Super Junction Power MOSFET

## PRODUCT SUMMARY

|                                    |                 |      |
|------------------------------------|-----------------|------|
| $V_{DS}$ (V) at $T_J$ max.         | 650             |      |
| $R_{DS(on)}$ at 25 °C ( $\Omega$ ) | $V_{GS} = 10$ V | 0.42 |
| $Q_g$ max. (nC)                    | 38              |      |
| $Q_{gs}$ (nC)                      | 4               |      |
| $Q_{gd}$ (nC)                      | 4.2             |      |
| 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)

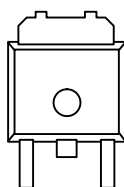


RoHS

## APPLICATIONS

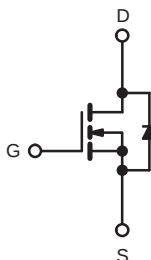
- Server and telecom power supplies
- Switch mode power supplies (SMPS)
- Power factor correction power supplies (PFC)
- Lighting
  - High-intensity discharge (HID)
  - Fluorescent ballast lighting
- Industrial

TO-252



G D S

Top View



N-Channel MOSFET

ABSOLUTE MAXIMUM RATINGS ( $T_C = 25$  °C, unless otherwise noted)

| PARAMETER                                                 |                         |                         | SYMBOL                            | LIMIT        | UNIT |
|-----------------------------------------------------------|-------------------------|-------------------------|-----------------------------------|--------------|------|
| Drain-Source Voltage                                      |                         |                         | V <sub>DS</sub>                   | 650          | V    |
| Gate-Source Voltage                                       |                         |                         | V <sub>GS</sub>                   | ± 30         |      |
| Continuous Drain Current (T <sub>J</sub> = 150 °C)        | V <sub>GS</sub> at 10 V | T <sub>C</sub> = 25 °C  | I <sub>D</sub>                    | 11           | A    |
|                                                           |                         | T <sub>C</sub> = 100 °C |                                   | 9.7          |      |
| Pulsed Drain Current <sup>a</sup>                         |                         |                         | I <sub>DM</sub>                   | 55           |      |
| Linear Derating Factor                                    |                         |                         |                                   | 1.67/1.5/0.3 | W/°C |
| Single Pulse Avalanche Energy <sup>b</sup>                |                         |                         | E <sub>AS</sub>                   | 132          | mJ   |
| Maximum Power Dissipation                                 |                         |                         | P <sub>D</sub>                    | 83/83/31     | W    |
| Operating Junction and Storage Temperature Range          |                         |                         | T <sub>J</sub> , T <sub>stg</sub> | -55 to +150  | °C   |
| Drain-Source Voltage Slope                                | T <sub>J</sub> = 125 °C |                         | dV/dt                             | 50           | V/ns |
| Reverse Diode dV/dt <sup>d</sup>                          |                         | 3.1                     |                                   |              |      |
| Soldering Recommendations (Peak Temperature) <sup>c</sup> | for 10 s                |                         |                                   | 300          | °C   |

## Notes

- Repetitive rating; pulse width limited by maximum junction temperature.
- $V_{DD} = 50$  V, starting  $T_J = 25$  °C,  $L = 28.2$  mH,  $R_g = 25$   $\Omega$ ,  $I_{AS} = 4.5$  A.
- 1.6 mm from case.
- $I_{SD} \leq I_D$ ,  $dI/dt = 100$  A/ $\mu$ s, starting  $T_J = 25$  °C.

**THERMAL RESISTANCE RATINGS**

| PARAMETER                        | SYMBOL     | TYP. | MAX. | UNIT |
|----------------------------------|------------|------|------|------|
| Maximum Junction-to-Ambient      | $R_{thJA}$ | -    | 60   | °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 $25\text{ }^\circ\text{C}$ , $I_D = 1\text{ mA}$                                                                                            |                                              | -    | 0.65 | -         | V/ $^\circ\text{C}$ |
| 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                                       | $I_{GSS}$           | $V_{GS} = \pm 20\text{ V}$                                                                                                                               |                                              | -    | -    | $\pm 100$ | nA                  |
|                                                           |                     | $V_{GS} = \pm 30\text{ V}$                                                                                                                               |                                              | -    | -    | $\pm 1$   | $\mu\text{A}$       |
| Zero Gate Voltage Drain Current                           | $I_{DSS}$           | $V_{DS} = 650\text{ V}$ , $V_{GS} = 0\text{ V}$                                                                                                          |                                              | -    | -    | 1         | $\mu\text{A}$       |
|                                                           |                     | $V_{DS} = 520\text{ V}$ , $V_{GS} = 0\text{ V}$ , $T_J = 125\text{ }^\circ\text{C}$                                                                      |                                              | -    | -    | 10        |                     |
| Drain-Source On-State Resistance                          | $R_{DS(on)}$        | $V_{GS} = 10\text{ V}$                                                                                                                                   | $I_D = 5\text{ A}$                           | -    | 0.42 | -         | $\Omega$            |
| Forward Transconductance                                  | $g_{fs}$            | $V_{DS} = 30\text{ V}$ , $I_D = 5\text{ A}$                                                                                                              |                                              | -    | 16   | -         | S                   |
| Dynamic                                                   |                     |                                                                                                                                                          |                                              |      |      |           |                     |
| Input Capacitance                                         | $C_{iss}$           | $V_{GS} = 0\text{ V}$ ,<br>$V_{DS} = 100\text{ V}$ ,<br>$f = 1\text{ MHz}$                                                                               |                                              | -    | 680  | -         | pF                  |
| Output Capacitance                                        | $C_{oss}$           |                                                                                                                                                          |                                              | -    | 140  | -         |                     |
| Reverse Transfer Capacitance                              | $C_{rss}$           |                                                                                                                                                          |                                              | -    | 5    | -         |                     |
| Effective Output Capacitance, Energy Related <sup>a</sup> | $C_{o(er)}$         | $V_{DS} = 0\text{ V to } 520\text{ V}$ , $V_{GS} = 0\text{ V}$                                                                                           |                                              | -    | 63   | -         |                     |
| Effective Output Capacitance, Time Related <sup>b</sup>   | $C_{o(tr)}$         |                                                                                                                                                          |                                              | -    | 113  | -         |                     |
| Total Gate Charge                                         | $Q_g$               | $V_{GS} = 10\text{ V}$                                                                                                                                   | $I_D = 5\text{ A}$ , $V_{DS} = 520\text{ V}$ | -    | 38   | 56        | nC                  |
| Gate-Source Charge                                        | $Q_{gs}$            |                                                                                                                                                          |                                              | -    | 4    | -         |                     |
| Gate-Drain Charge                                         | $Q_{gd}$            |                                                                                                                                                          |                                              | -    | 4.5  | -         |                     |
| Turn-On Delay Time                                        | $t_{d(on)}$         | $V_{DD} = 520\text{ V}$ , $I_D = 5\text{ A}$ ,<br>$V_{GS} = 10\text{ V}$ , $R_g = 9.1\text{ }\Omega$                                                     |                                              | -    | 13   | 25        | ns                  |
| Rise Time                                                 | $t_r$               |                                                                                                                                                          |                                              | -    | 11   | 35        |                     |
| Turn-Off Delay Time                                       | $t_{d(off)}$        |                                                                                                                                                          |                                              | -    | 81   | 90        |                     |
| Fall Time                                                 | $t_f$               |                                                                                                                                                          |                                              | -    | 25   | 40        |                     |
| Gate Input Resistance                                     | $R_g$               | $f = 1\text{ MHz}$ , open drain                                                                                                                          |                                              | -    | 3.5  | -         | $\Omega$            |
| Drain-Source Body Diode Characteristics                   |                     |                                                                                                                                                          |                                              |      |      |           |                     |
| Continuous Source-Drain Diode Current                     | $I_S$               | MOSFET symbol showing the integral reverse p - n junction diode<br> |                                              | -    | -    | 11        | A                   |
| Pulsed Diode Forward Current                              | $I_{SM}$            |                                                                                                                                                          |                                              | -    | -    | 55        |                     |
| Diode Forward Voltage                                     | $V_{SD}$            | $T_J = 25\text{ }^\circ\text{C}$ , $I_S = 5\text{ A}$ , $V_{GS} = 0\text{ V}$                                                                            |                                              | -    | -    | 1.5       | V                   |
| Reverse Recovery Time                                     | $t_{rr}$            | $T_J = 25\text{ }^\circ\text{C}$ , $I_F = I_S = 5\text{ A}$ ,<br>$di/dt = 100\text{ A}/\mu\text{s}$ , $V_R = 400\text{ V}$                               |                                              | -    | 270  | -         | ns                  |
| Reverse Recovery Charge                                   | $Q_{rr}$            |                                                                                                                                                          |                                              | -    | 3.3  | -         | $\mu\text{C}$       |
| Reverse Recovery Current                                  | $I_{RRM}$           |                                                                                                                                                          |                                              | -    | 30   | -         | A                   |

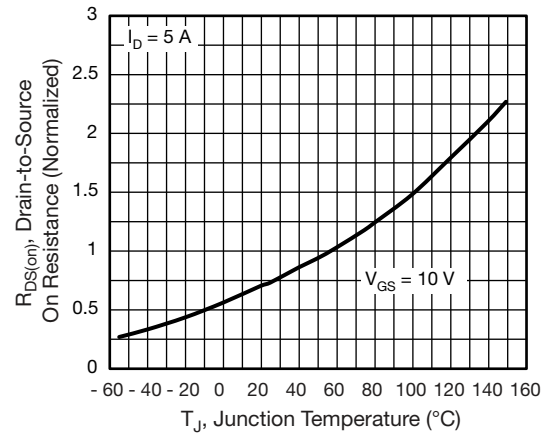
**Notes**

- 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 %  $V_{DSS}$ .

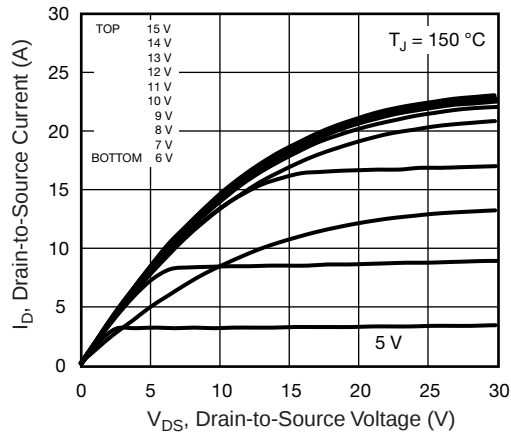
**TYPICAL CHARACTERISTICS** (25 °C, unless otherwise noted)



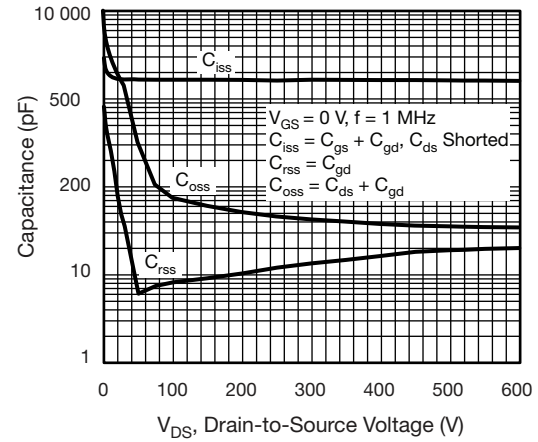
**Fig. 1 - Typical Output Characteristics**



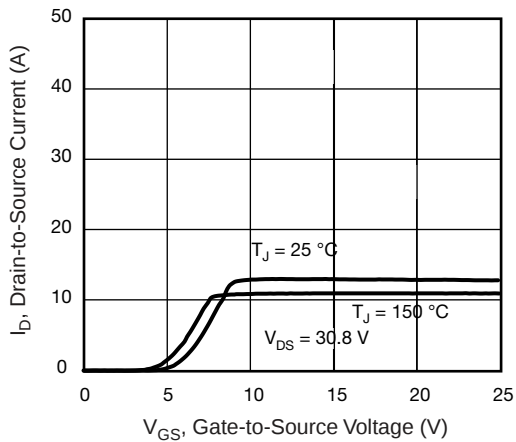
**Fig. 4 - Normalized On-Resistance vs. Temperature**



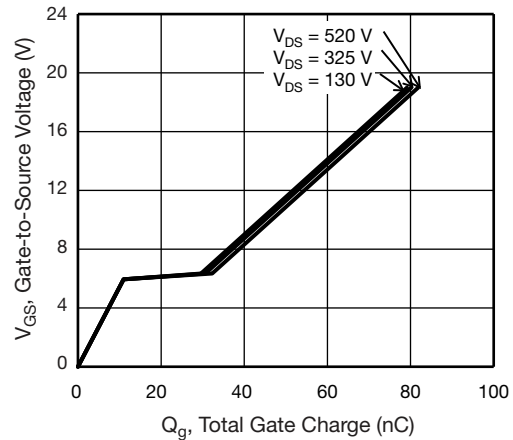
**Fig. 2 - Typical Output Characteristics**



**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

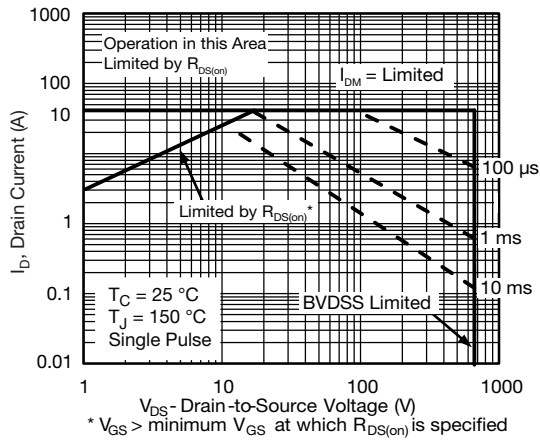


Fig. 8 - Maximum Safe Operating Area

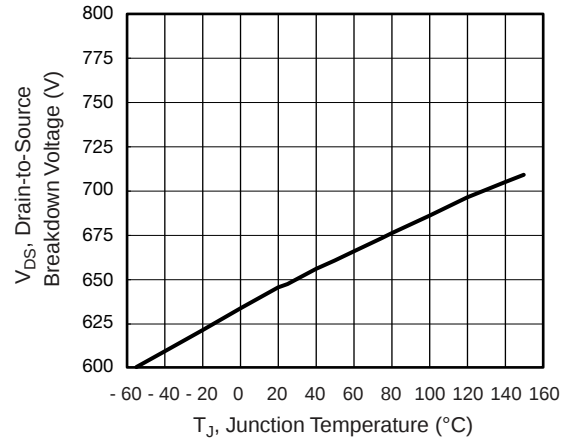


Fig. 10 - Temperature vs. Drain-to-Source Voltage

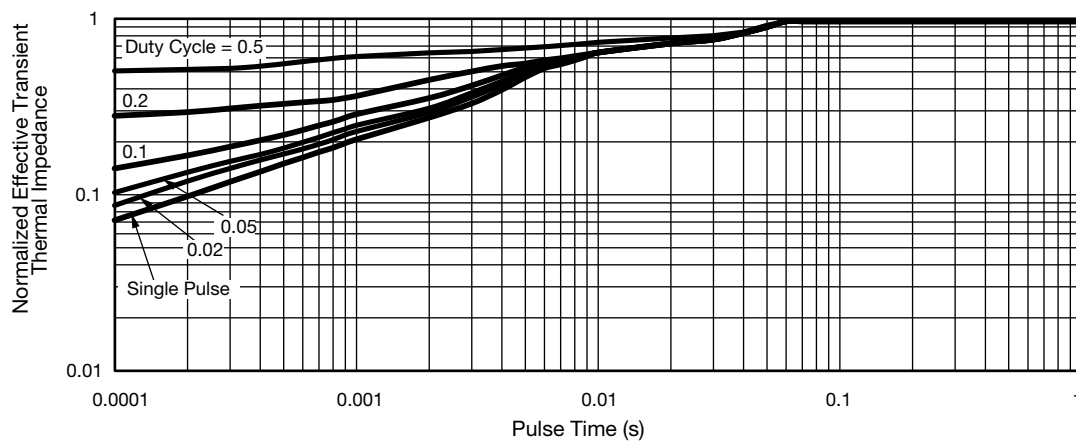


Fig. 11 - Normalized Thermal Transient Impedance, Junction-to-Case



Fig. 12 - Switching Time Test Circuit



Fig. 16 - Basic Gate Charge Waveform

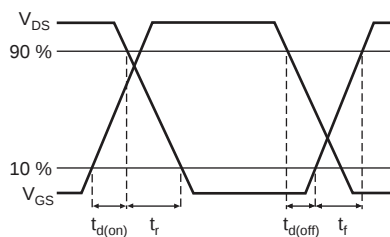


Fig. 13 - Switching Time Waveforms

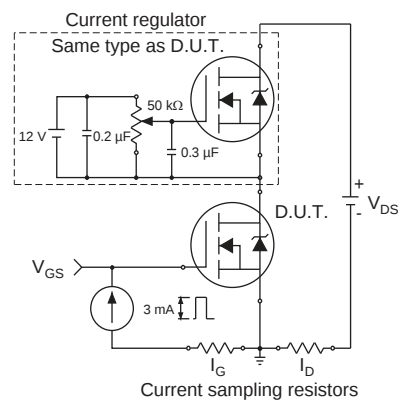


Fig. 17 - Gate Charge Test Circuit

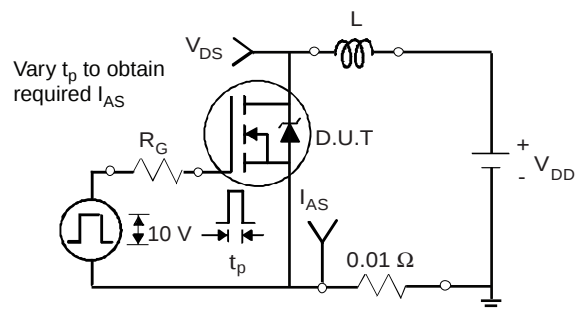
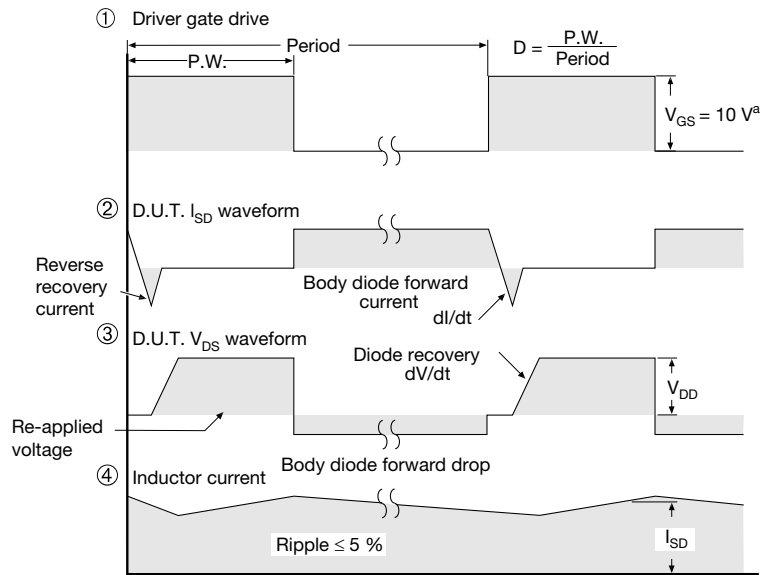
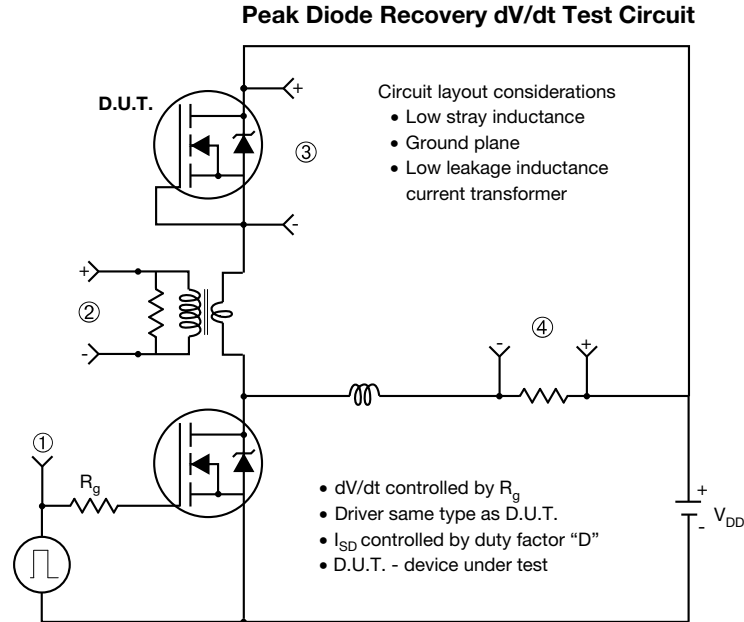


Fig. 14 - Unclamped Inductive Test Circuit



Fig. 15 - Unclamped Inductive Waveforms

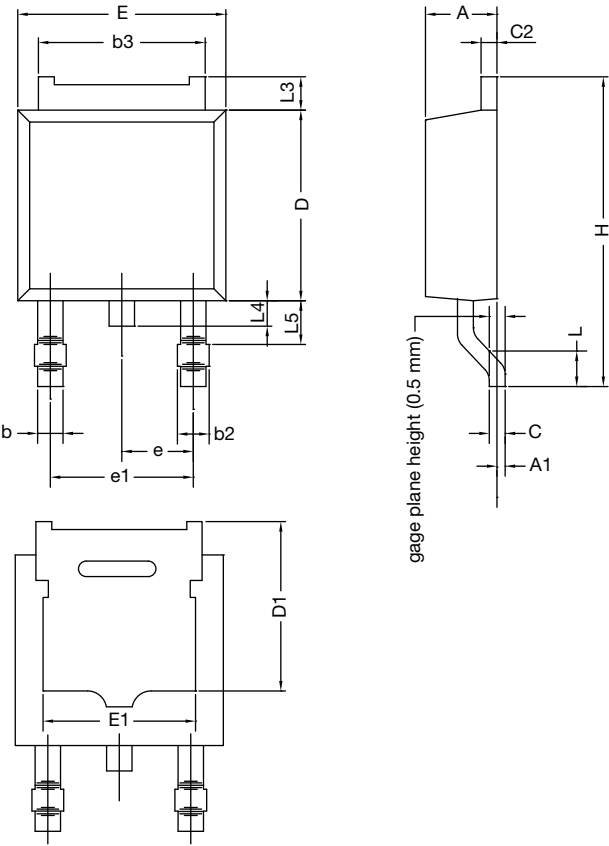


**Note**

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

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

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.

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