

## N-Channel 60 V (D-S) MOSFET

### PRODUCT SUMMARY

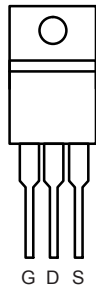
| $V_{DS}$ (V) | $R_{DS(on)}$ ( $\Omega$ ) | $I_D$ (A) <sup>a</sup> |
|--------------|---------------------------|------------------------|
| 60           | 0.024 at $V_{GS} = 10$ V  | 50                     |
|              | 0.028 at $V_{GS} = 4.5$ V | 40                     |

### FEATURES

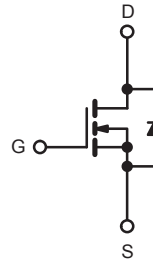
- Halogen-free According to IEC 61249-2-21 Definition
- Surface Mount
- Available in Tape and Reel
- Dynamic  $dV/dt$  Rating
- Logic-Level Gate Drive
- Fast Switching
- Compliant to RoHS Directive 2002/95/EC


**RoHS\***  
 COMPLIANT

TO-220AB



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>  | 60    | V    |
| Gate-Source Voltage                                       |                         |                         |                                   | V <sub>GS</sub>  | ± 20  |      |
| Continuous Drain Current <sup>f</sup>                     | V <sub>GS</sub> at 10 V | T <sub>C</sub> = 25 °C  | I <sub>D</sub>                    | 50               | A     |      |
| Continuous Drain Current                                  |                         | T <sub>C</sub> = 100 °C |                                   | 36               |       |      |
| Pulsed Drain Current <sup>a</sup>                         |                         |                         | I <sub>DM</sub>                   | 200              |       |      |
| Linear Derating Factor                                    |                         |                         |                                   | 1.0              | W/°C  |      |
| Linear Derating Factor (PCB Mount) <sup>e</sup>           |                         |                         |                                   | 0.025            |       |      |
| Single Pulse Avalanche Energy <sup>b</sup>                |                         |                         | E <sub>AS</sub>                   | 400              | mJ    |      |
| Maximum Power Dissipation                                 | T <sub>C</sub> = 25 °C  |                         | P <sub>D</sub>                    | 150              | W     |      |
| Maximum Power Dissipation (PCB Mount) <sup>e</sup>        | T <sub>A</sub> = 25 °C  |                         |                                   | 3.7              |       |      |
| Peak Diode Recovery dV/dt <sup>c</sup>                    |                         |                         | dV/dt                             | 4.5              | V/ns  |      |
| Operating Junction and Storage Temperature Range          |                         |                         | T <sub>J</sub> , T <sub>stg</sub> | - 55 to + 175    | °C    |      |
| Soldering Recommendations (Peak Temperature) <sup>d</sup> | for 10 s                |                         |                                   | 300 <sup>d</sup> |       |      |

#### Notes

- Repetitive rating; pulse width limited by maximum junction temperature (see fig. 11).
- $V_{DD} = 25$  V, starting  $T_J = 25$  °C,  $L = 179$   $\mu$ H,  $R_g = 25$   $\Omega$ ,  $I_{AS} = 51$  A (see fig. 12).
- $I_{SD} \leq 51$  A,  $dI/dt \leq 250$  A/ $\mu$ s,  $V_{DD} \leq V_{DS}$ ,  $T_J \leq 175$  °C.
- 1.6 mm from case.
- When mounted on 1" square PCB (FR-4 or G-10 material).
- Current limited by the package, (die current = 51 A).

**THERMAL RESISTANCE RATINGS**

| PARAMETER                                            | SYMBOL     | TYP. | MAX. | UNIT |
|------------------------------------------------------|------------|------|------|------|
| Maximum Junction-to-Ambient                          | $R_{thJA}$ | -    | 62   | °C/W |
| Maximum Junction-to-Ambient (PCB Mount) <sup>a</sup> | $R_{thJA}$ | -    | 40   |      |
| Maximum Junction-to-Case (Drain)                     | $R_{thJC}$ | -    | 1.0  |      |

**Note**

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

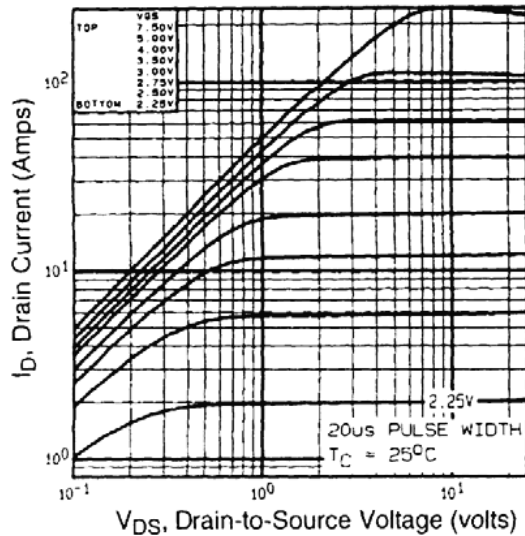
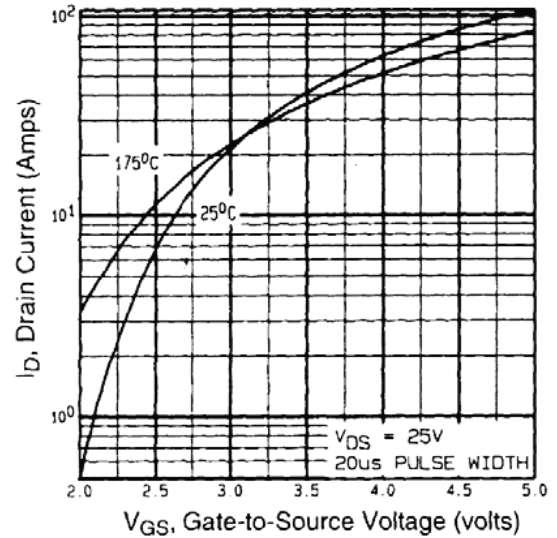
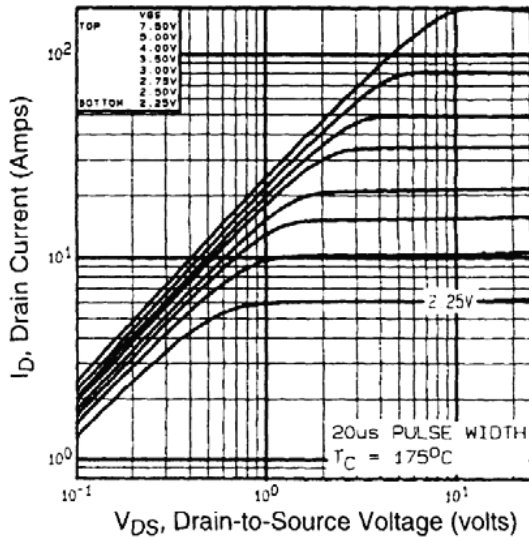
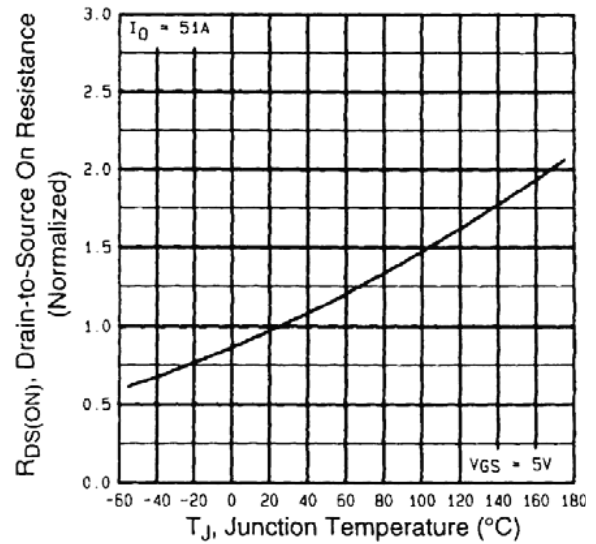
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**SPECIFICATIONS** ( $T_J = 25^\circ\text{C}$ , unless otherwise noted)

| PARAMETER                                 | SYMBOL                           | TEST CONDITIONS                                                                                                             |                                                                                  | MIN. | TYP.  | MAX.            | UNIT |
|-------------------------------------------|----------------------------------|-----------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------|------|-------|-----------------|------|
| Static                                    |                                  |                                                                                                                             |                                                                                  |      |       |                 |      |
| Drain-Source Breakdown Voltage            | V <sub>DS</sub>                  | V <sub>GS</sub> = 0, I <sub>D</sub> = 250 μA                                                                                |                                                                                  | 60   | -     | -               | V    |
| V <sub>DS</sub> Temperature Coefficient   | ΔV <sub>DS</sub> /T <sub>J</sub> | Reference to 25 °C, I <sub>D</sub> = 1 mA                                                                                   |                                                                                  | -    | 0.070 | -               | V/°C |
| Gate-Source Threshold Voltage             | V <sub>GS(th)</sub>              | V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 250 μA                                                                 |                                                                                  | 1.0  | -     | 2.5             |      |
| Gate-Source Leakage                       | I <sub>GSS</sub>                 | V <sub>GS</sub> = ± 10 V                                                                                                    |                                                                                  | -    | -     | ± 100           | nA   |
| Zero Gate Voltage Drain Current           | I <sub>DSS</sub>                 | V <sub>DS</sub> = 60 V, V <sub>GS</sub> = 0 V                                                                               |                                                                                  | -    | -     | 25              | μA   |
|                                           |                                  | V <sub>DS</sub> = 48 V, V <sub>GS</sub> = 0 V, T <sub>J</sub> = 150 °C                                                      |                                                                                  | -    | -     | 250             |      |
| Drain-Source On-State Resistance          | R <sub>DS(on)</sub>              | V <sub>GS</sub> = 10 V                                                                                                      | I <sub>D</sub> = 21 A <sup>b</sup>                                               | -    | 0.024 | -               | Ω    |
|                                           |                                  | V <sub>GS</sub> = 4.5 V                                                                                                     | I <sub>D</sub> = 15 A <sup>b</sup>                                               | -    | 0.028 | -               |      |
| Forward Transconductance                  | g <sub>fs</sub>                  | V <sub>DS</sub> = 25 V, I <sub>D</sub> = 21A <sup>b</sup>                                                                   |                                                                                  | 23   | -     | -               | S    |
| Dynamic                                   |                                  |                                                                                                                             |                                                                                  |      |       |                 |      |
| Input Capacitance                         | C <sub>iss</sub>                 | V <sub>GS</sub> = 0 V,<br>V <sub>DS</sub> = 25 V,<br>f = 1.0 MHz, see fig. 5                                                |                                                                                  | -    | 190   |                 | pF   |
| Output Capacitance                        | C <sub>oss</sub>                 |                                                                                                                             |                                                                                  | -    | 920   | -               |      |
| Reverse Transfer Capacitance              | C <sub>rss</sub>                 |                                                                                                                             |                                                                                  | -    | 170   | -               |      |
| Total Gate Charge                         | Q <sub>g</sub>                   | V <sub>GS</sub> = 5.0 V                                                                                                     | I <sub>D</sub> = 51 A, V <sub>DS</sub> = 48 V,<br>see fig. 6 and 13 <sup>b</sup> | -    | -     | 66              | nC   |
| Gate-Source Charge                        | Q <sub>gs</sub>                  |                                                                                                                             |                                                                                  | -    | -     | 12              |      |
| Gate-Drain Charge                         | Q <sub>gd</sub>                  |                                                                                                                             |                                                                                  | -    | -     | 43              |      |
| Turn-On Delay Time                        | t <sub>d(on)</sub>               | V <sub>DD</sub> = 30 V, I <sub>D</sub> = 51 A,<br>R <sub>g</sub> = 4.6 Ω, R <sub>D</sub> = 0.56 Ω, see fig. 10 <sup>b</sup> |                                                                                  | -    | 17    | -               | ns   |
| Rise Time                                 | t <sub>r</sub>                   |                                                                                                                             |                                                                                  | -    | 230   | -               |      |
| Turn-Off Delay Time                       | t <sub>d(off)</sub>              |                                                                                                                             |                                                                                  | -    | 2     | -               |      |
| Fall Time                                 | t <sub>f</sub>                   |                                                                                                                             |                                                                                  | -    | 110   | -               |      |
| Internal Drain Inductance                 | L <sub>D</sub>                   | Between lead,<br>6 mm (0.25") from<br>package and center of<br>die contact                                                  |                                                                                  | -    | 4.5   | -               | nH   |
| Internal Source Inductance                | L <sub>S</sub>                   |                                                                                                                             |                                                                                  | -    | 7.5   | -               |      |
| Drain-Source Body Diode Characteristics   |                                  |                                                                                                                             |                                                                                  |      |       |                 |      |
| Continuous Source-Drain Diode Current     | I <sub>S</sub>                   | MOSFET symbol<br>showing the<br>integral reverse<br>p - n junction diode                                                    |                                                                                  | -    | -     | 50 <sup>c</sup> | A    |
| Pulsed Diode Forward Current <sup>a</sup> | I <sub>SM</sub>                  |                                                                                                                             |                                                                                  | -    | -     | 200             |      |
| Body Diode Voltage                        | V <sub>SD</sub>                  | T <sub>J</sub> = 25 °C, I <sub>S</sub> = 51 A, V <sub>GS</sub> = 0 V <sup>b</sup>                                           |                                                                                  | -    | -     | 2.5             | V    |
| Body Diode Reverse Recovery Time          | t <sub>rr</sub>                  | T <sub>J</sub> = 25 °C, I <sub>F</sub> = 51 A, dI/dt = 100 A/μs <sup>b</sup>                                                |                                                                                  | -    | 130   | 180             | ns   |
| Body Diode Reverse Recovery Charge        | Q <sub>rr</sub>                  |                                                                                                                             |                                                                                  | -    | 0.84  | 1.3             | μC   |
| Forward Turn-On Time                      | t <sub>on</sub>                  | Intrinsic turn-on time is negligible (turn-on is dominated by L <sub>S</sub> and L <sub>D</sub> )                           |                                                                                  |      |       |                 |      |

**Notes**

- a. Repetitive rating; pulse width limited by maximum junction temperature (see fig. 11).  
 b. Pulse width  $\leq 300\ \mu\text{s}$ ; duty cycle  $\leq 2\%$ .  
 c. Current limited by the package, (Die Current = 51 A).

**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**

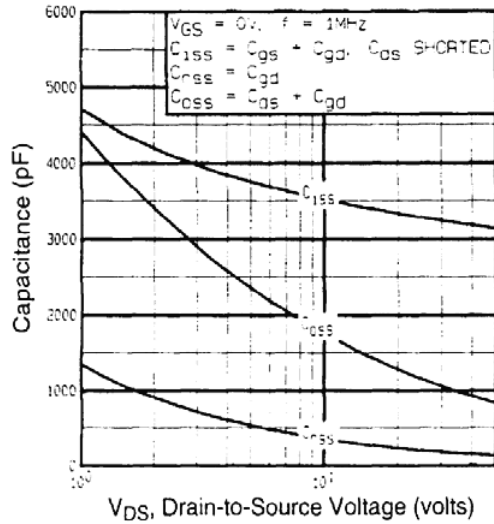


Fig. 5 - Typical Capacitance vs. Drain-to-Source Voltage

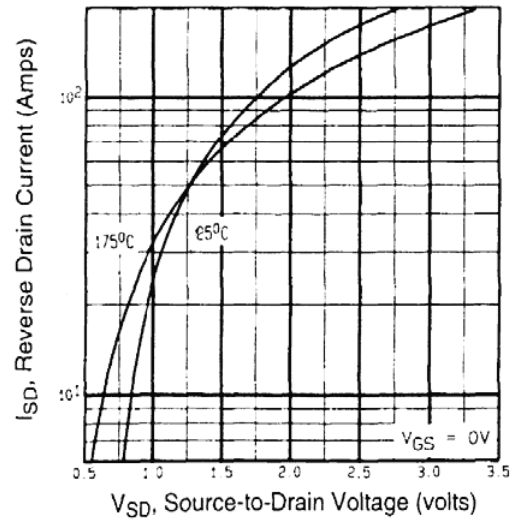


Fig. 7 - Typical Source-Drain Diode Forward Voltage

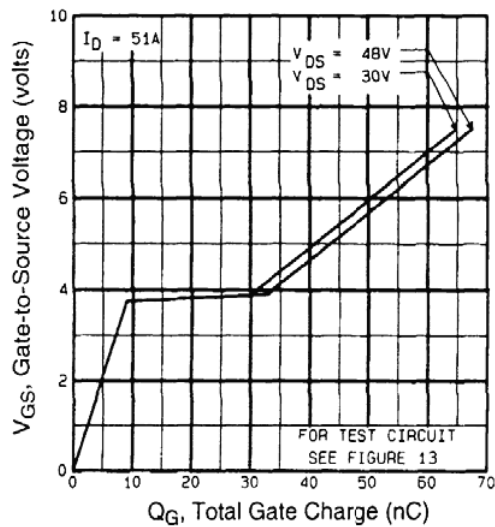


Fig. 6 - Typical Gate Charge vs. Gate-to-Source Voltage

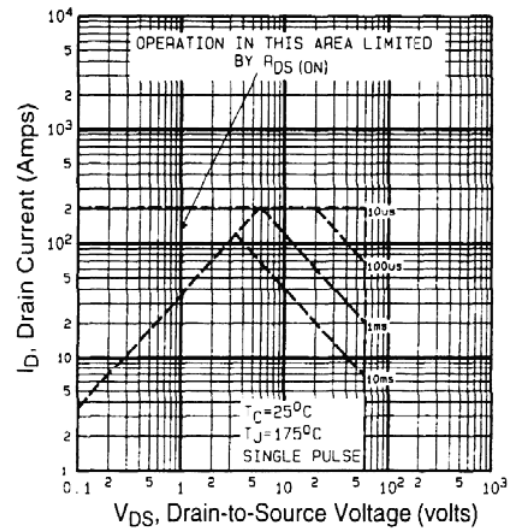


Fig. 8 - Maximum Safe Operating Area

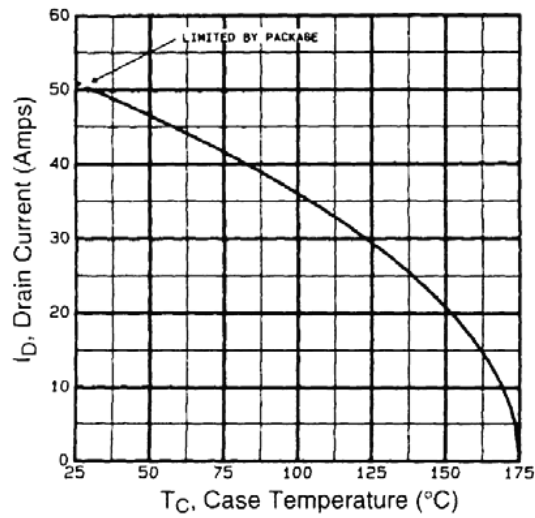


Fig. 9 - Maximum Drain Current vs. Case Temperature

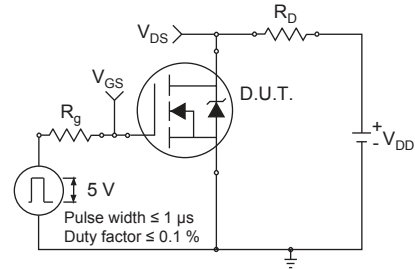


Fig. 10a - Switching Time Test Circuit

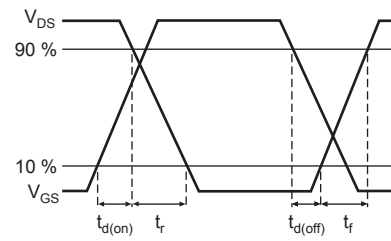


Fig. 10b - Switching Time Waveforms

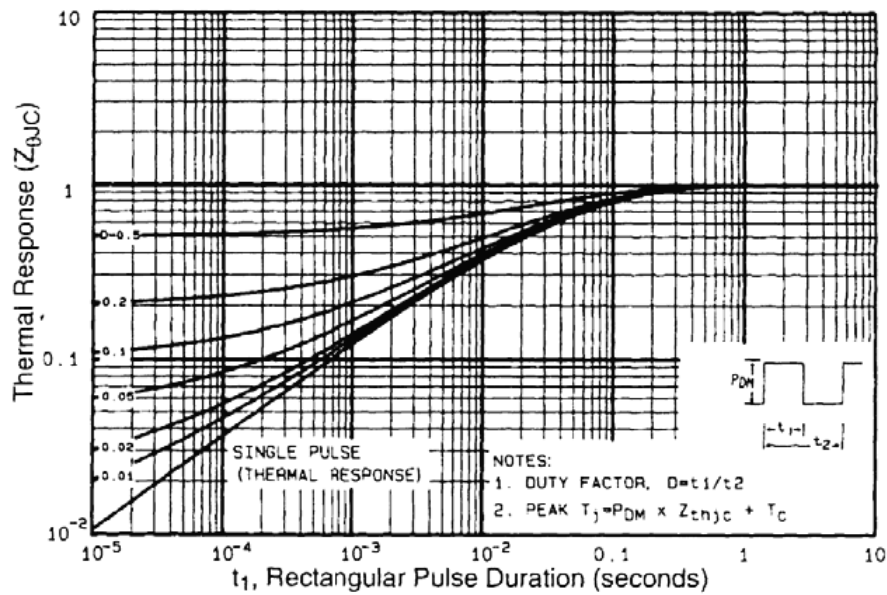


Fig. 11 - Maximum Effective Transient Thermal Impedance, Junction-to-Case

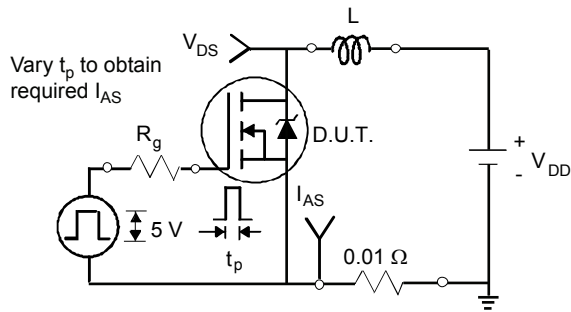


Fig. 12a - Unclamped Inductive Test Circuit

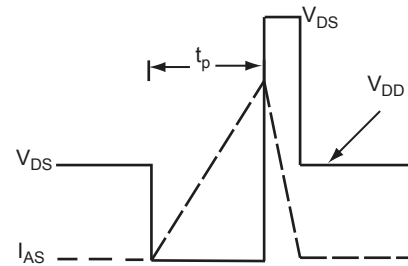


Fig. 12b - Unclamped Inductive Waveforms

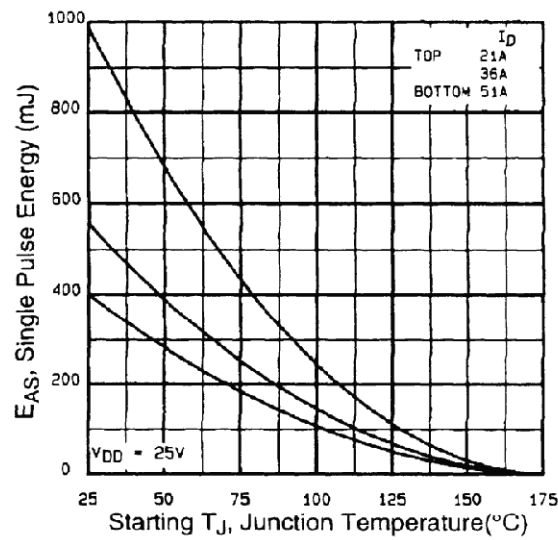


Fig. 12c - Maximum Avalanche Energy vs. Drain Current

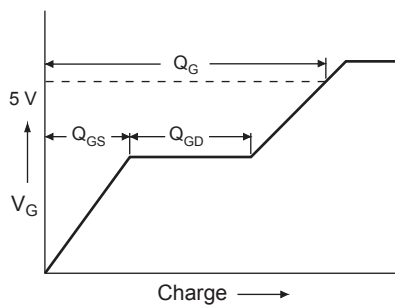


Fig. 13a - Basic Gate Charge Waveform

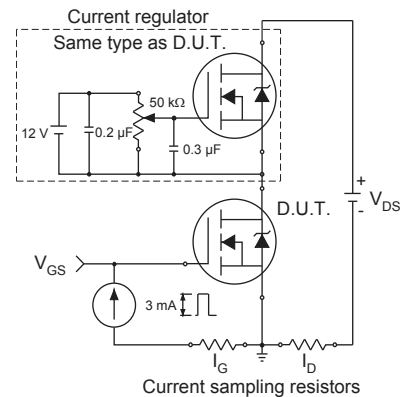
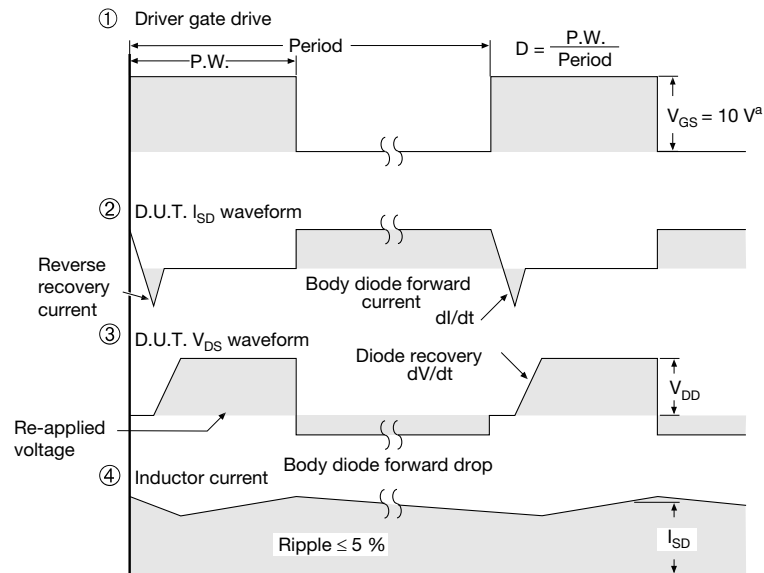
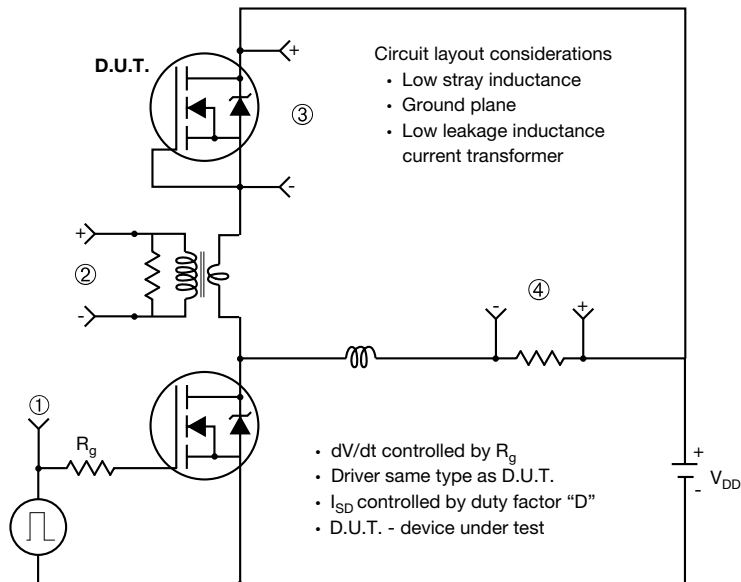


Fig. 13b - Gate Charge Test Circuit

### Peak Diode Recovery dV/dt Test Circuit

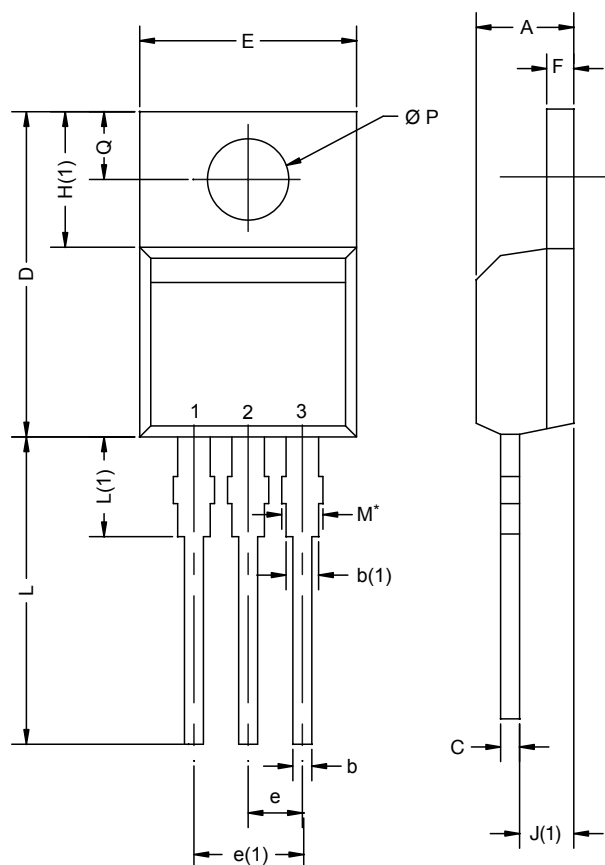


#### Note

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

**Fig. 14 - 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 |
| Ø 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<br>DWG: 5471 |             |       |        |       |

### Notes

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



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