

## BUK438-500-VB Datasheet

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

| PRODUCT SUMMARY                    |                 |      |
|------------------------------------|-----------------|------|
| $V_{DS}$ (V) at $T_J$ max.         | 650             |      |
| $R_{DS(on)}$ ( $\Omega$ ) at 25 °C | $V_{GS} = 10$ V | 0.34 |
| $Q_g$ max. (nC)                    | 106             |      |
| $Q_{gs}$ (nC)                      | 14              |      |
| $Q_{gd}$ (nC)                      | 33              |      |
| Configuration                      | Single          |      |

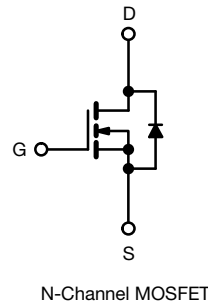
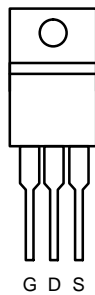
#### FEATURES

- Reduced  $t_{rr}$ ,  $Q_{rr}$ , and  $I_{RRM}$
- Low figure-of-merit (FOM)  $R_{on} \times Q_g$
- Low input capacitance ( $C_{iss}$ )
- Low switching losses due to reduced  $Q_{rr}$
- Ultra low gate charge ( $Q_g$ )
- Avalanche energy rated (UIS)



**RoHS**  
COMPLIANT

**TO-220AB**




| ABSOLUTE MAXIMUM RATINGS ( $T_C = 25$ °C, unless otherwise noted) |                  |                |      |      |
|---|------------------|----------------|------|------|
| PARAMETER   | SYMBOL           | LIMIT          | UNIT |      |
| Drain-Source Voltage  | $V_{DS}$         | 650            | V    |      |
| Gate-Source Voltage   | $V_{GS}$         | $\pm 30$       |      |      |
| Continuous Drain Current ( $T_J = 150$ °C)                        | $V_{GS}$ at 10 V | $T_C = 25$ °C  | 18   | A    |
|   |                  | $T_C = 100$ °C | 16   |      |
| Pulsed Drain Current <sup>a</sup>                                 | $I_{DM}$         | 53             |      |      |
| Linear Derating Factor  |                  | 1.7            | W/°C |      |
| Single Pulse Avalanche Energy <sup>b</sup>                        | $E_{AS}$         | 367            | mJ   |      |
| Maximum Power Dissipation   | $P_D$            | 208            | W    |      |
| Operating Junction and Storage Temperature Range                  | $T_J, T_{stg}$   | -55 to +150    | °C   |      |
| Drain-Source Voltage Slope  | $dV/dt$          | $T_J = 125$ °C | 37   | V/ns |
| Reverse Diode $dV/dt$ <sup>d</sup>                                |                  | 31             |      |      |
| 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,  $R_g = 25$   $\Omega$ ,  $I_{AS} = 5.1$  A.
- 1.6 mm from case.
- $I_{SD} \leq I_D$ ,  $dI/dt = 100$  A/ $\mu$ s, starting  $T_J = 25$  °C.

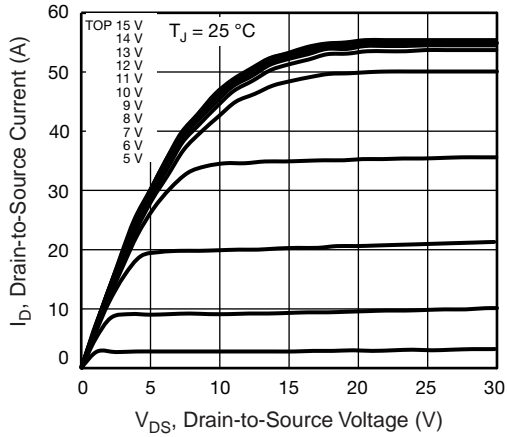
| <b>THERMAL RESISTANCE RATINGS</b> |            |      |      |      |
|-----------------------------------|------------|------|------|------|
| PARAMETER                         | SYMBOL     | TYP. | MAX. | UNIT |
| Maximum Junction-to-Ambient       | $R_{thJA}$ | -    | 62   | °C/W |
| Maximum Junction-to-Case (Drain)  | $R_{thJC}$ | -    | 0.5  |      |

| <b>SPECIFICATIONS</b> ( $T_J = 25\text{ }^\circ\text{C}$ , unless otherwise noted) |                     |   |  |      |      |           |               |
|--|---------------------|---|--|------|------|-----------|---------------|
| PARAMETER  | SYMBOL              | TEST CONDITIONS   |  | MIN. | TYP. | MAX.      | UNIT          |
| <b>Static</b>  |                     |   |  |      |      |           |               |
| Drain-Source Breakdown Voltage   | $V_{DS}$            | $V_{GS} = 0\text{ V}, I_D = 250\text{ }\mu\text{A}$   |  | 650  | -    | -         | V             |
| $V_{DS}$ Temperature Coefficient   | $\Delta V_{DS}/T_J$ | Reference to $25\text{ }^\circ\text{C}$ , $I_D = 1\text{ mA}$   |  | -    | 0.67 | -         | V/°C          |
| Gate-Source Threshold Voltage (N)  | $V_{GS(th)}$        | $V_{DS} = V_{GS}, I_D = 250\text{ }\mu\text{A}$   |  | 2.5  | -    | 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         | $\mu\text{A}$ |
|  |                     | $V_{DS} = 520\text{ V}, V_{GS} = 0\text{ V}, T_J = 125\text{ }^\circ\text{C}$   |  | -    | -    | 500       |               |
| Drain-Source On-State Resistance   | $R_{DS(on)}$        | $V_{GS} = 10\text{ V}$  | $I_D = 11\text{ A}$                        | -    | 0.34 | -         | $\Omega$      |
| Forward Transconductance   | $g_{fs}$            | $V_{DS} = 30\text{ V}, I_D = 11\text{ A}$   |  | -    | 7.0  | -         | S             |
| <b>Dynamic</b>   |                     |   |  |      |      |           |               |
| Input Capacitance  | $C_{iss}$           | $V_{GS} = 0\text{ V},$<br>$V_{DS} = 100\text{ V},$<br>$f = 1\text{ MHz}$  |  | -    | 4826 | -         | pF            |
| Output Capacitance   | $C_{oss}$           |   |  | -    | 456  | -         |               |
| Reverse Transfer Capacitance   | $C_{rss}$           |   |  | -    | 210  | -         |               |
| Effective Output Capacitance, Energy Related <sup>a</sup>                          | $C_{o(er)}$         | $V_{DS} = 0\text{ V to } 520\text{ V}, V_{GS} = 0\text{ V}$   |  | -    | 84   | -         | pF            |
| Effective Output Capacitance, Time Related <sup>b</sup>                            | $C_{o(tr)}$         |   |  | -    | 293  | -         |               |
| Total Gate Charge  | $Q_g$               | $V_{GS} = 10\text{ V}$  | $I_D = 11\text{ A}, V_{DS} = 520\text{ V}$ | -    | 71   | -         | nC            |
| Gate-Source Charge   | $Q_{gs}$            |   |  | -    | 14   | -         |               |
| Gate-Drain Charge  | $Q_{gd}$            |   |  | -    | 33   | -         |               |
| Turn-On Delay Time   | $t_{d(on)}$         | $V_{DD} = 520\text{ V}, I_D = 11\text{ A},$<br>$V_{GS} = 10\text{ V}, R_g = 9.1\text{ }\Omega$  |  | -    | 22   | -         | ns            |
| Rise Time  | $t_r$               |   |  | -    | 34   | -         |               |
| Turn-Off Delay Time  | $t_{d(off)}$        |   |  | -    | 68   | -         |               |
| Fall Time  | $t_f$               |   |  | -    | 42   | -         |               |
| Gate Input Resistance  | $R_g$               | $f = 1\text{ MHz}, \text{ open drain}$  |  | -    | 0.78 | -         | $\Omega$      |
| <b>Drain-Source Body Diode Characteristics</b>                                     |                     |   |  |      |      |           |               |
| Continuous Source-Drain Diode Current  | $I_S$               | MOSFET symbol showing the integral reverse p - n junction diode  |  | -    | -    | 21        | A             |
| Pulsed Diode Forward Current   | $I_{SM}$            |   |  | -    | -    | 53        |               |
| Diode Forward Voltage  | $V_{SD}$            | $T_J = 25\text{ }^\circ\text{C}, I_S = 11\text{ A}, V_{GS} = 0\text{ V}$  |  | -    | 0.9  | 1.2       | V             |
| Reverse Recovery Time  | $t_{rr}$            | $T_J = 25\text{ }^\circ\text{C}, I_F = I_S = 11\text{ A},$<br>$di/dt = 100\text{ A}/\mu\text{s}, V_R = 25\text{ V}$                                   |  | -    | 160  | -         | ns            |
| Reverse Recovery Charge  | $Q_{rr}$            |   |  | -    | 1.2  | -         | $\mu\text{C}$ |
| Reverse Recovery Current   | $I_{RRM}$           |   |  | -    | 14   | -         | A             |

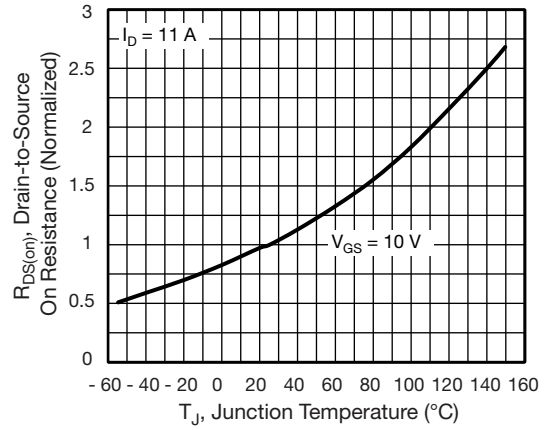
**Notes**

- 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 %  $V_{DSS}$ .

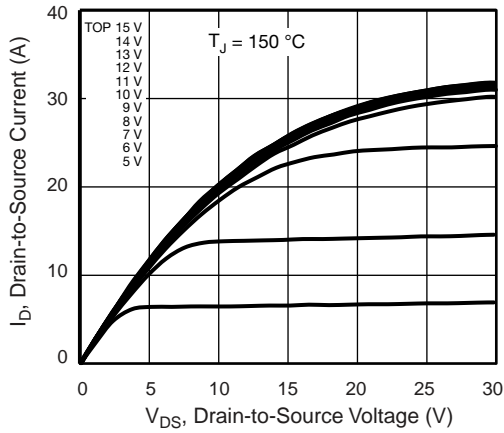
**TYPICAL CHARACTERISTICS** (25 °C, unless otherwise noted)



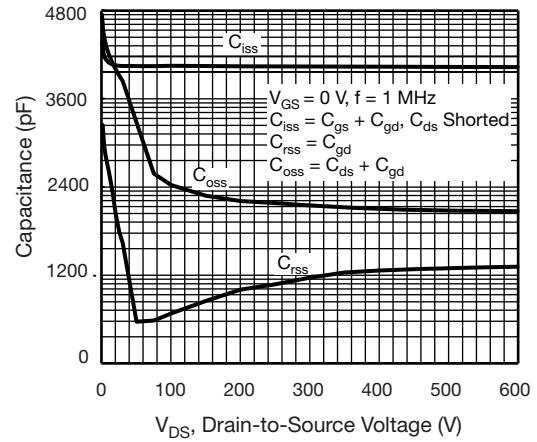
**Fig. 1 - Typical Output Characteristics**



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



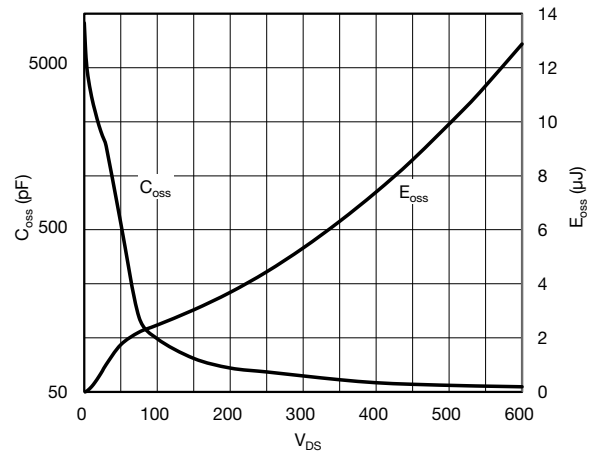
**Fig. 2 - Typical Output Characteristics**



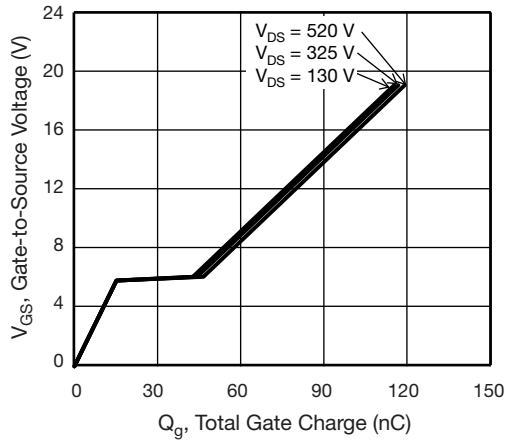
**Fig. 5 - Typical Capacitance vs. Drain-to-Source Voltage**



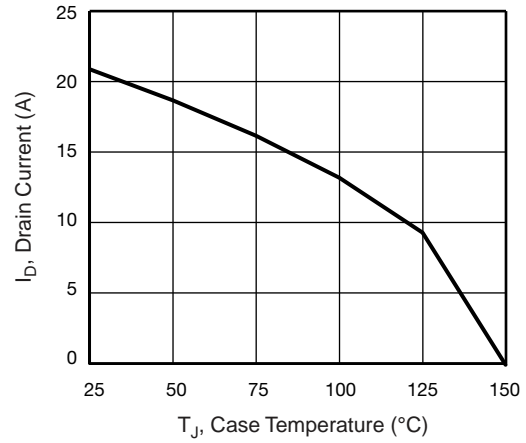
**Fig. 3 - Typical Transfer Characteristics**



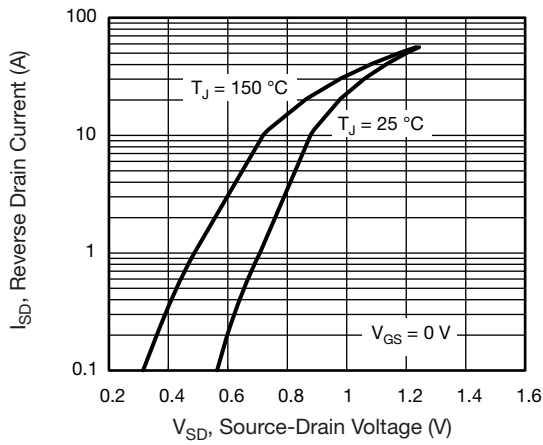
**Fig. 6 -  $C_{oss}$  and  $E_{oss}$  vs.  $V_{DS}$**



**Fig. 7 - Typical Gate Charge vs. Gate-to-Source Voltage**



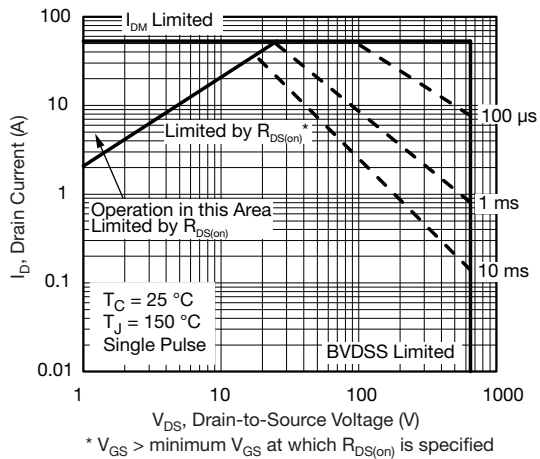
**Fig. 10 - Maximum Drain Current vs. Case Temperature**



**Fig. 8 - Typical Source-Drain Diode Forward Voltage**



**Fig. 11 - Temperature vs. Drain-to-Source Voltage**



**Fig. 9 - Maximum Safe Operating Area**

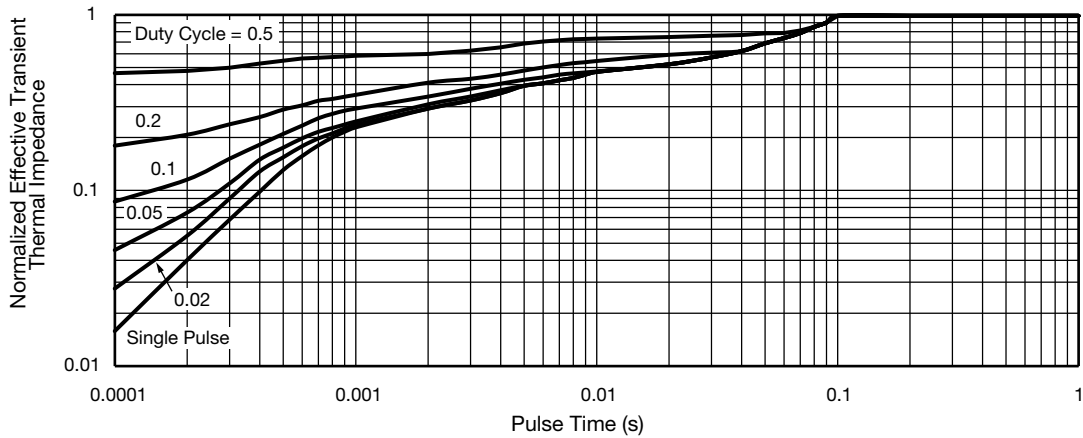


Fig. 12 - Normalized Thermal Transient Impedance, Junction-to-Case

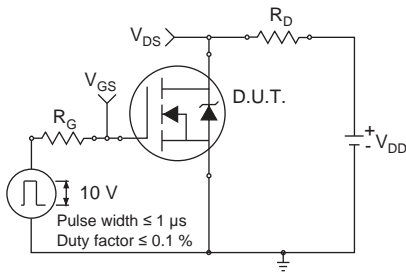


Fig. 13 - Switching Time Test Circuit

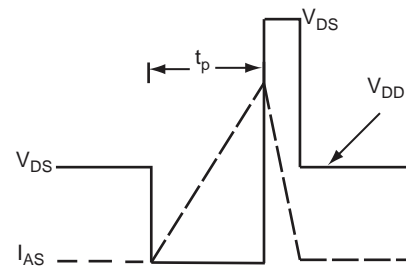


Fig. 16 - Unclamped Inductive Waveforms

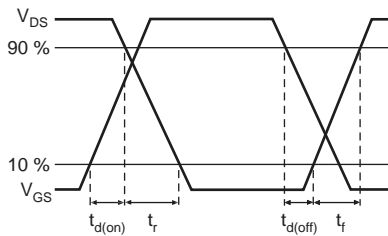


Fig. 14 - Switching Time Waveforms

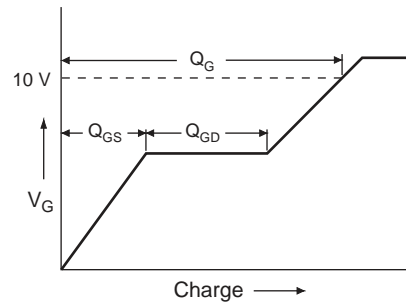


Fig. 17 - Basic Gate Charge Waveform

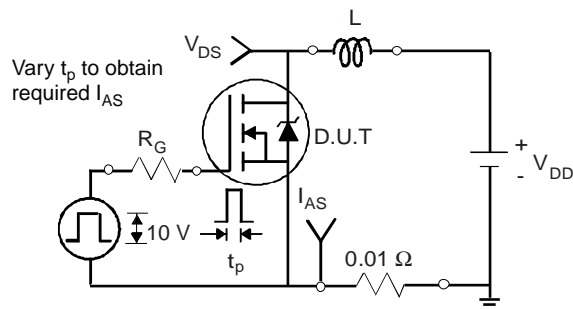


Fig. 15 - Unclamped Inductive Test Circuit

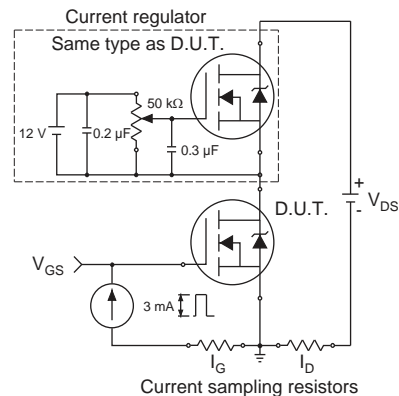
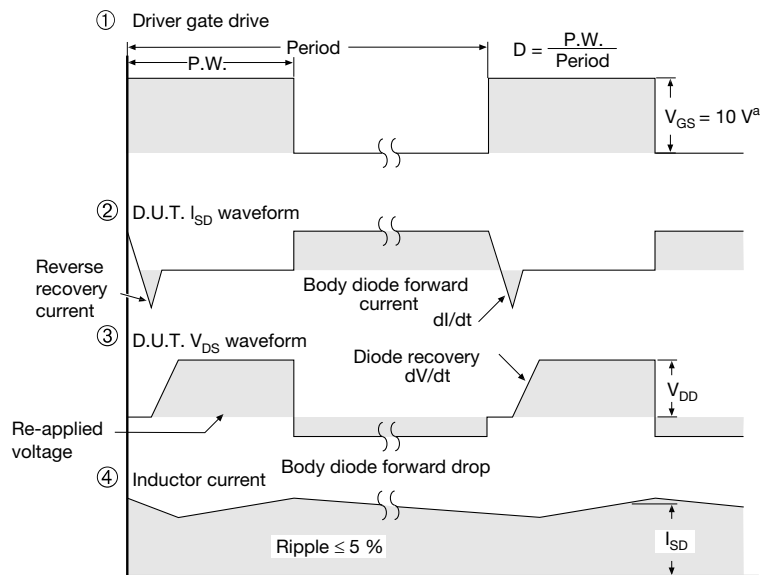
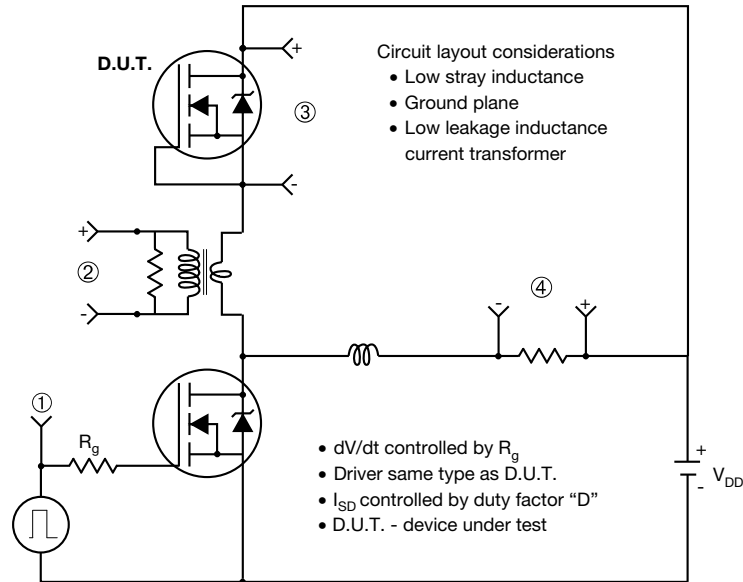


Fig. 18 - Gate Charge Test Circuit

Peak Diode Recovery dV/dt Test Circuit

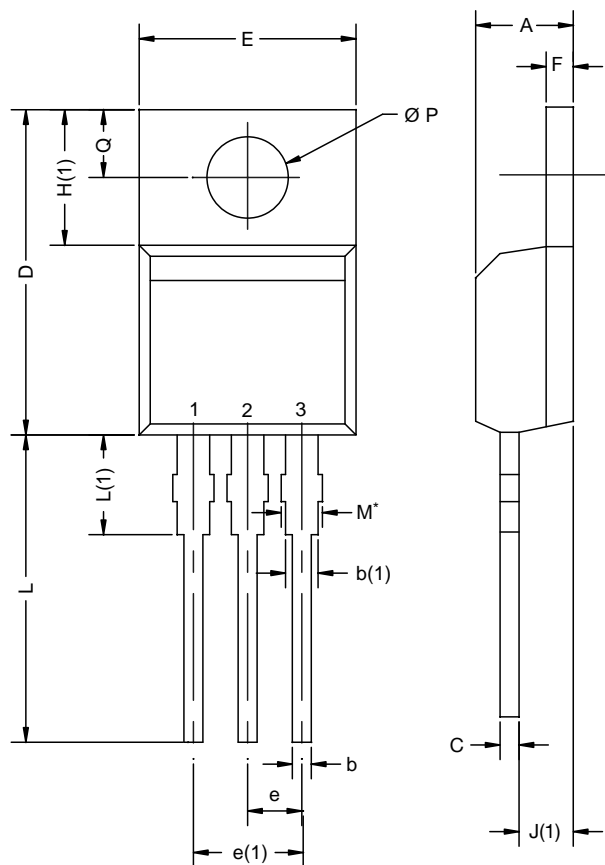


**Note**

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

Fig. 19 - 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  
DWG: 5471

**Notes**

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

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