

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

### PRODUCT SUMMARY

|                           |                        |       |
|---------------------------|------------------------|-------|
| $V_{DS}$ (V)              | 60                     |       |
| $R_{DS(on)}$ ( $\Omega$ ) | $V_{GS} = 10\text{ V}$ | 0.072 |
| $Q_g$ max. (nC)           | 25                     |       |
| $Q_{gs}$ (nC)             | 5.8                    |       |
| $Q_{gd}$ (nC)             | 11                     |       |
| Configuration             | Single                 |       |

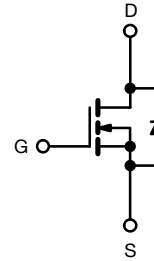
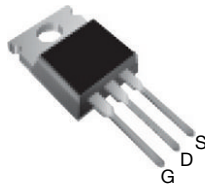
### FEATURES

- Dynamic dV/dt rating
  - Fast switching
  - Ease of paralleling
- Simple drive requirements



**RoHS**  
COMPLIANT

TO-220AB



N-Channel MOSFET

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

| PARAMETER                                                 |                                    |                                     | SYMBOL         | LIMIT       | UNIT                  |
|-----------------------------------------------------------|------------------------------------|-------------------------------------|----------------|-------------|-----------------------|
| Drain-Source Voltage                                      |                                    |                                     | $V_{DS}$       | 60          | V                     |
| Gate-Source Voltage                                       |                                    |                                     | $V_{GS}$       | $\pm 20$    |                       |
| Continuous Drain Current                                  | $V_{GS}$ at 10 V                   | $T_C = 25\text{ }^{\circ}\text{C}$  | $I_D$          | 20          | A                     |
|                                                           |                                    | $T_C = 100\text{ }^{\circ}\text{C}$ |                | 12          |                       |
| Pulsed Drain Current <sup>a</sup>                         |                                    |                                     | $I_{DM}$       | 68          |                       |
| Linear Derating Factor                                    |                                    |                                     |                | 0.40        | W/ $^{\circ}\text{C}$ |
| Single Pulse Avalanche Energy <sup>b</sup>                |                                    |                                     | $E_{AS}$       | 100         | mJ                    |
| Maximum Power Dissipation                                 | $T_C = 25\text{ }^{\circ}\text{C}$ |                                     | $P_D$          | 60          | W                     |
| 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 +175 | $^{\circ}\text{C}$    |
| Soldering Recommendations (Peak temperature) <sup>d</sup> | for 10 s                           |                                     |                | 300         |                       |
| Mounting Torque                                           | 6-32 or M3 screw                   |                                     |                | 10          | lbf · in              |
|                                                           |                                    |                                     |                | 1.1         | N · m                 |

### Notes

- a. Repetitive rating; pulse width limited by maximum junction temperature (see fig. 11).  
 b.  $V_{DD} = 25\text{ V}$ , starting  $T_J = 25\text{ }^{\circ}\text{C}$ ,  $L = 403\text{ }\mu\text{H}$ ,  $R_g = 25\text{ }\Omega$ ,  $I_{AS} = 17\text{ A}$  (see fig. 12).  
 c.  $I_{SD} \leq 17\text{ A}$ ,  $dI/dt \leq 140\text{ A}/\mu\text{s}$ ,  $V_{DD} \leq V_{DS}$ ,  $T_J \leq 175\text{ }^{\circ}\text{C}$ .  
 d. 1.6 mm from case.

**THERMAL RESISTANCE RATINGS**

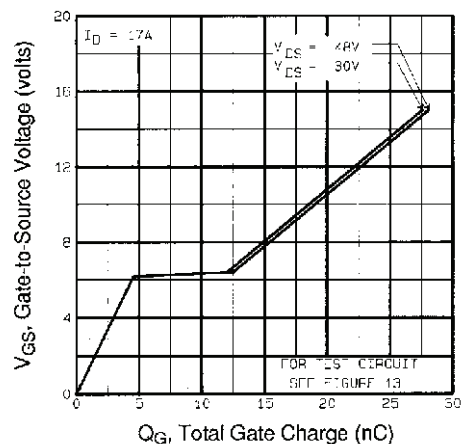
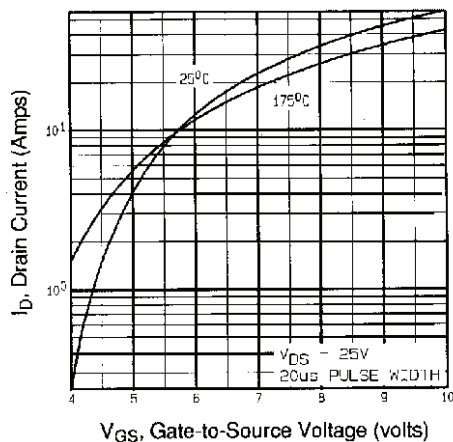
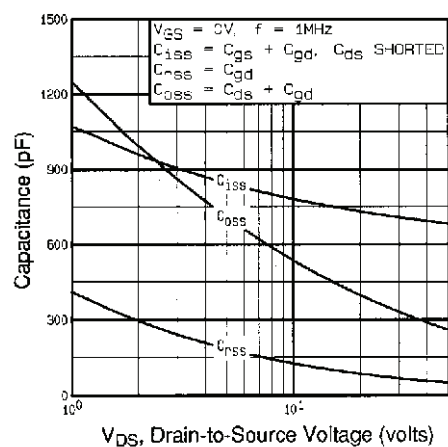
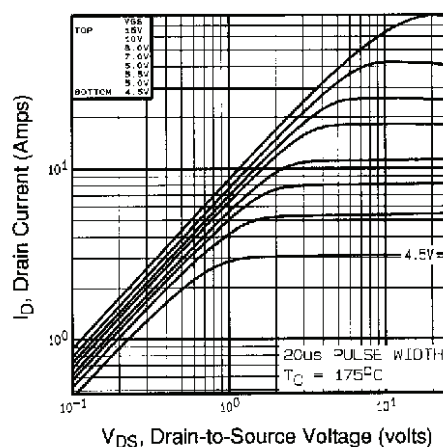
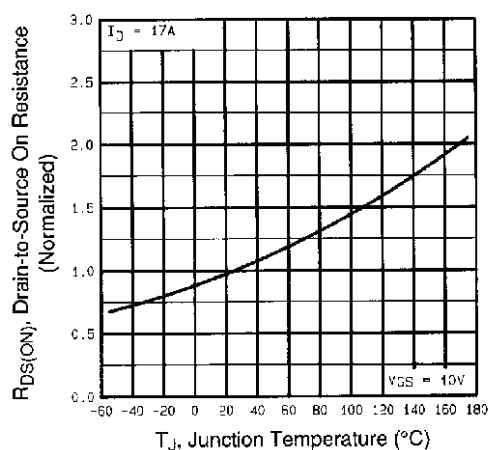
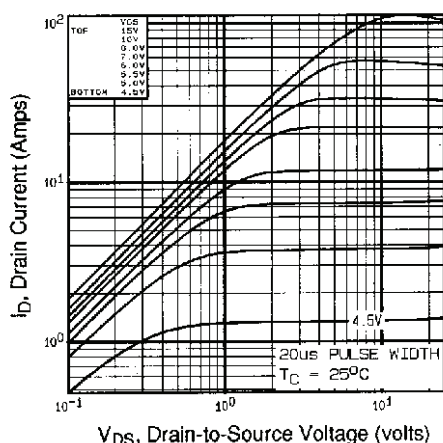
| PARAMETER                           | SYMBOL     | TYP. | MAX. | UNIT |
|-------------------------------------|------------|------|------|------|
| Maximum Junction-to-Ambient         | $R_{thJA}$ | -    | 62   | °C/W |
| Case-to-Sink, Flat, Greased Surface | $R_{thCS}$ | 0.50 | -    |      |
| Maximum Junction-to-Case (Drain)    | $R_{thJC}$ | -    | 2.5  |      |

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

| PARAMETER                                 | SYMBOL              | TEST CONDITIONS                                                                                                                   |                                                                                  | MIN. | TYP.  | MAX.      | UNIT                |
|-------------------------------------------|---------------------|-----------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------|------|-------|-----------|---------------------|
| Static                                    |                     |                                                                                                                                   |                                                                                  |      |       |           |                     |
| Drain-Source Breakdown Voltage            | $V_{DS}$            | $V_{GS} = 0\text{ V}$ , $I_D = 250\text{ }\mu\text{A}$                                                                            |                                                                                  | 60   | -     | -         | V                   |
| $V_{DS}$ Temperature Coefficient          | $\Delta V_{DS}/T_J$ | Reference to $25\text{ }^\circ\text{C}$ , $I_D = 1\text{ mA}$                                                                     |                                                                                  | -    | 0.061 | -         | V/ $^\circ\text{C}$ |
| Gate-Source Threshold Voltage             | $V_{GS(th)}$        | $V_{DS} = V_{GS}$ , $I_D = 250\text{ }\mu\text{A}$                                                                                |                                                                                  | 1.0  | -     | 3.0       | V                   |
| Gate-Source Leakage                       | $I_{GSS}$           | $V_{GS} = \pm 20\text{ V}$                                                                                                        |                                                                                  | -    | -     | $\pm 100$ | nA                  |
| Zero Gate Voltage Drain Current           | $I_{DSS}$           | $V_{DS} = 60\text{ V}$ , $V_{GS} = 0\text{ V}$                                                                                    |                                                                                  | -    | -     | 25        | $\mu\text{A}$       |
|                                           |                     | $V_{DS} = 48\text{ V}$ , $V_{GS} = 0\text{ V}$ , $T_J = 150\text{ }^\circ\text{C}$                                                |                                                                                  | -    | -     | 250       |                     |
| Drain-Source On-State Resistance          | $R_{DS(on)}$        | $V_{GS} = 10\text{ V}$                                                                                                            | $I_D = 10\text{ A}^b$                                                            | -    | 0.072 | -         | $\Omega$            |
| Forward Transconductance                  | $g_{fs}$            | $V_{DS} = 25\text{ V}$ , $I_D = 10\text{ A}$                                                                                      |                                                                                  | 5.5  | -     | -         | S                   |
| Dynamic                                   |                     |                                                                                                                                   |                                                                                  |      |       |           |                     |
| Input Capacitance                         | $C_{iss}$           | $V_{GS} = 0\text{ V}$ ,<br>$V_{DS} = 25\text{ V}$ ,<br>$f = 1.0\text{ MHz}$ , see fig. 5                                          |                                                                                  | -    | 640   | -         | pF                  |
| Output Capacitance                        | $C_{oss}$           |                                                                                                                                   |                                                                                  | -    | 360   | -         |                     |
| Reverse Transfer Capacitance              | $C_{rss}$           |                                                                                                                                   |                                                                                  | -    | 79    | -         |                     |
| Total Gate Charge                         | $Q_g$               | $V_{GS} = 10\text{ V}$                                                                                                            | $I_D = 17\text{ A}$ , $V_{DS} = 48\text{ V}$ ,<br>see fig. 6 and 13 <sup>b</sup> | -    | -     | 25        | nC                  |
| Gate-Source Charge                        | $Q_{gs}$            |                                                                                                                                   |                                                                                  | -    | -     | 5.8       |                     |
| Gate-Drain Charge                         | $Q_{gd}$            |                                                                                                                                   |                                                                                  | -    | -     | 11        |                     |
| Turn-On Delay Time                        | $t_{d(on)}$         | $V_{DD} = 30\text{ V}$ , $I_D = 17\text{ A}$ ,<br>$R_g = 18\text{ }\Omega$ , $R_D = 1.7\text{ }\Omega$ , see fig. 10 <sup>b</sup> |                                                                                  | -    | 13    | -         | ns                  |
| Rise Time                                 | $t_r$               |                                                                                                                                   |                                                                                  | -    | 58    | -         |                     |
| Turn-Off Delay Time                       | $t_{d(off)}$        |                                                                                                                                   |                                                                                  | -    | 25    | -         |                     |
| Fall Time                                 | $t_f$               |                                                                                                                                   |                                                                                  | -    | 42    | -         |                     |
| Internal Drain Inductance                 | $L_D$               | Between lead,<br>6 mm (0.25") from<br>package and center of<br>die contact                                                        |                                                                                  | -    | 4.5   | -         | nH                  |
| Internal Source Inductance                | $L_S$               |                                                                                                                                   |                                                                                  | -    | 7.5   | -         |                     |
| Drain-Source Body Diode Characteristics   |                     |                                                                                                                                   |                                                                                  |      |       |           |                     |
| Continuous Source-Drain Diode Current     | $I_S$               | MOSFET symbol<br>showing the<br>integral reverse<br>p - n junction diode                                                          |                                                                                  | -    | -     | 20        | A                   |
| Pulsed Diode Forward Current <sup>a</sup> | $I_{SM}$            |                                                                                                                                   |                                                                                  | -    | -     | 68        |                     |
| Body Diode Voltage                        | $V_{SD}$            | $T_J = 25\text{ }^\circ\text{C}$ , $I_S = 17\text{ A}$ , $V_{GS} = 0\text{ V}^b$                                                  |                                                                                  | -    | -     | 1.5       | V                   |
| Body Diode Reverse Recovery Time          | $t_{rr}$            | $T_J = 25\text{ }^\circ\text{C}$ , $I_F = 17\text{ A}$ , $dI/dt = 100\text{ A}/\mu\text{s}$                                       |                                                                                  | -    | 88    | 180       | ns                  |
| Body Diode Reverse Recovery Charge        | $Q_{rr}$            |                                                                                                                                   |                                                                                  | -    | 0.29  | 0.64      | $\mu\text{C}$       |
| 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)


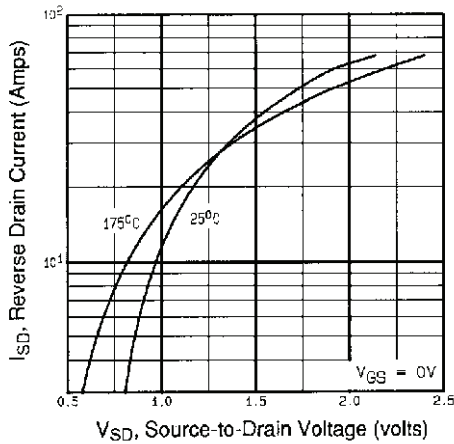


Fig. 7 - Typical Source-Drain Diode Forward Voltage

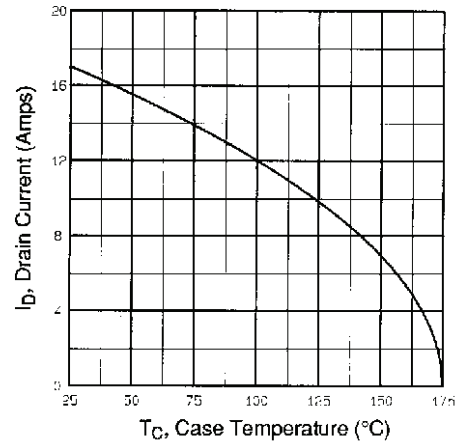


Fig. 9 - Maximum Drain Current vs. Case Temperature



Fig. 8 - Maximum Safe Operating Area

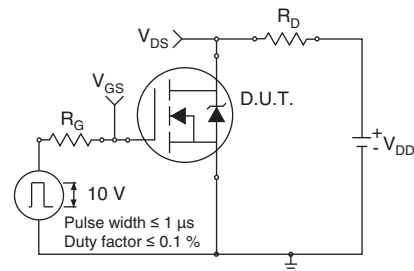


Fig. 10a - Switching Time Test Circuit

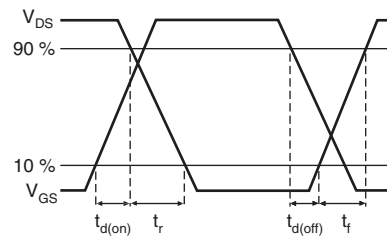


Fig. 10b - Switching Time Waveforms

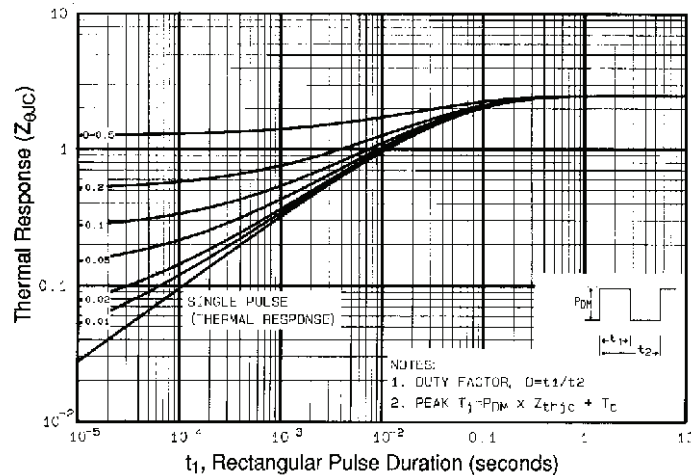


Fig. 11 - Maximum Effective Transient Thermal Impedance, Junction-to-Case

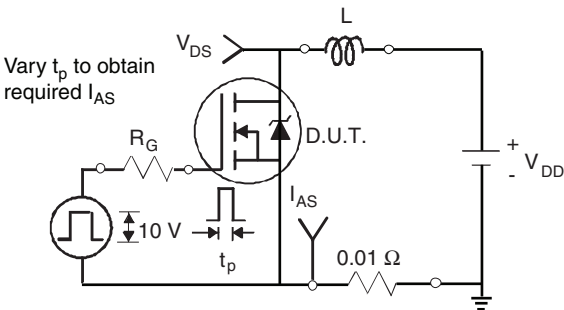


Fig. 12a - Unclamped Inductive Test Circuit

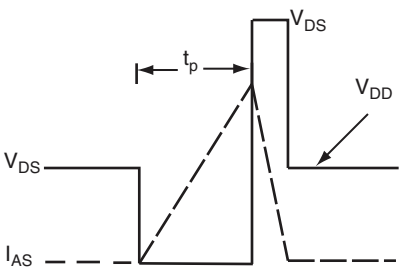


Fig. 12b - Unclamped Inductive Waveforms

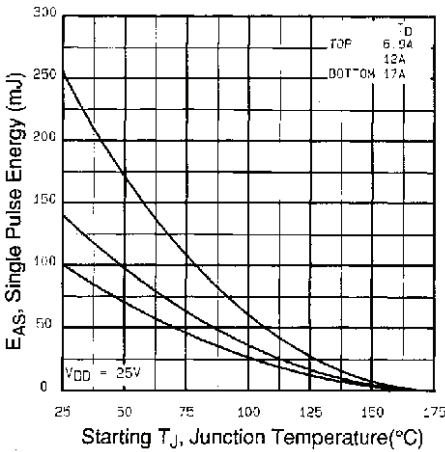


Fig. 12c - Maximum Avalanche Energy vs. Drain Current

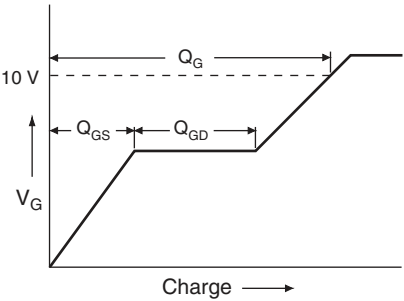


Fig. 13a - Basic Gate Charge Waveform

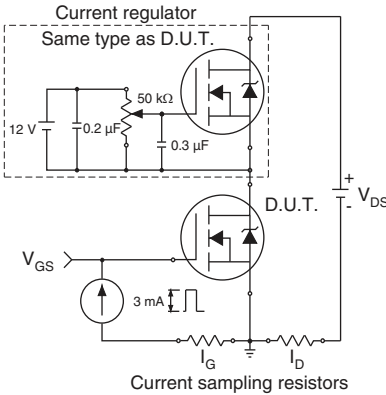
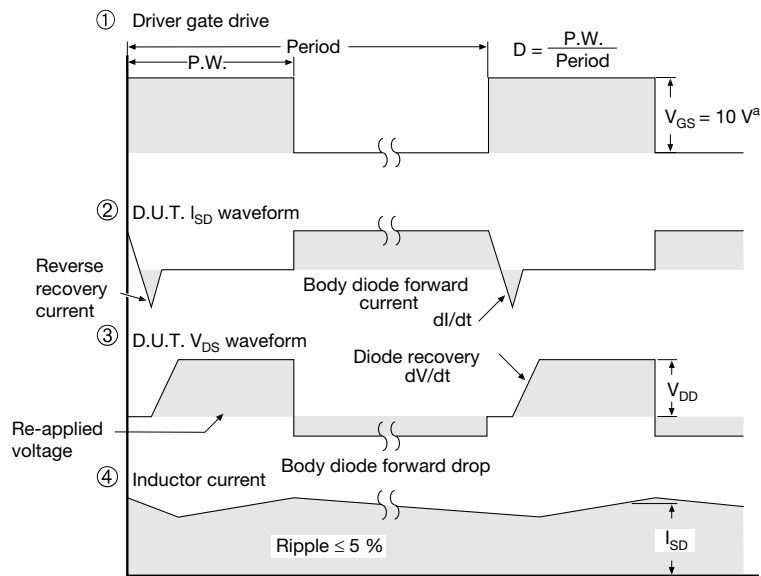
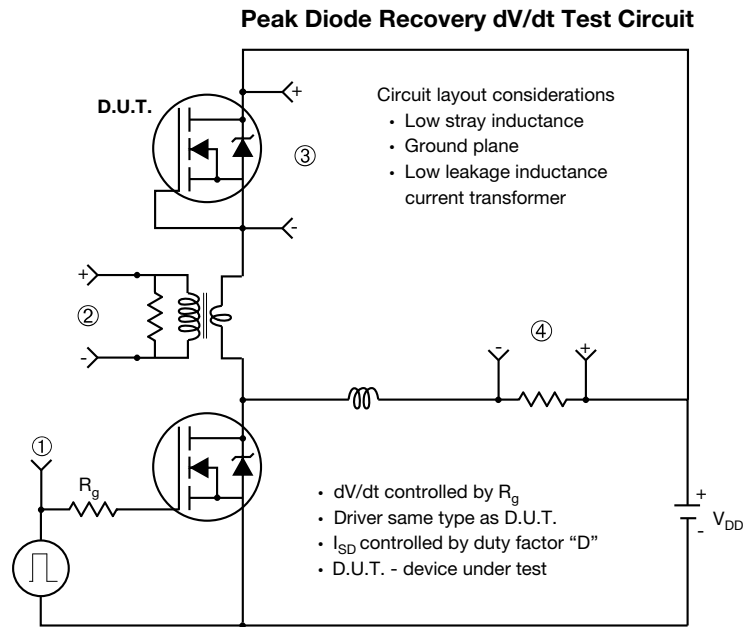


Fig. 13b - Gate Charge Test



**Note**

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

**Fig. 14 - For N-Channel**

## TO-220



| DIM. | MILLIMETERS |       | INCHES |       |
|------|-------------|-------|--------|-------|
|      | MIN.        | MAX.  | MIN.   | MAX.  |
| A    | 4.24        | 4.65  | 0.167  | 0.183 |
| b    | 0.69        | 1.02  | 0.027  | 0.040 |
| b(1) | 1.14        | 1.78  | 0.045  | 0.070 |
| c    | 0.36        | 0.61  | 0.014  | 0.024 |
| D    | 14.33       | 15.85 | 0.564  | 0.624 |
| E    | 9.96        | 10.52 | 0.392  | 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) | 6.10        | 6.71  | 0.240  | 0.264 |
| J(1) | 2.41        | 2.92  | 0.095  | 0.115 |
| L    | 13.36       | 14.40 | 0.526  | 0.567 |
| L(1) | 3.33        | 4.04  | 0.131  | 0.159 |
| Ø P  | 3.53        | 3.94  | 0.139  | 0.155 |
| Q    | 2.54        | 3.00  | 0.100  | 0.118 |

ECN: X15-0364-Rev. C, 14-Dec-15  
DWG: 6031

**Note**

- M\* = 0.052 inches to 0.064 inches (dimension including protrusion), heatsink hole for HVM

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