

## E Series Power MOSFET

### PRODUCT SUMMARY

|   |                 |      |
|---|-----------------|------|
| $V_{DS}$ (V) at $T_J$ max.              | 650             |      |
| $R_{DS(on)}$ max. ( $\Omega$ ) at 25 °C | $V_{GS} = 10$ V | 0.18 |
| $Q_g$ max. (nC)                         | 86              |      |
| $Q_{gs}$ (nC)                           | 11              |      |
| $Q_{gd}$ (nC)                           | 24              |      |
| Configuration                           | Single          |      |

### FEATURES

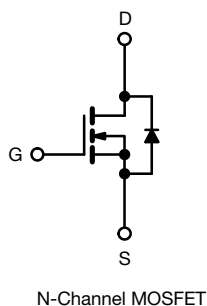
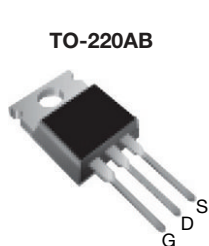
- Low figure-of-merit (FOM)  $R_{on} \times Q_g$
- Low input capacitance ( $C_{iss}$ )
- Reduced switching and conduction losses
- Ultra low gate charge ( $Q_g$ )
- Avalanche energy rated (UIS)
- Material categorization: for definitions of compliance please see [www.vishay.com/doc?99912](http://www.vishay.com/doc?99912)



**RoHS**  
COMPLIANT  
HALOGEN  
**FREE**  
Available

### 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
  - Welding
  - Induction heating
  - Motor drives
  - Battery chargers
  - Renewable energy
  - Solar (PV inverters)



### ORDERING INFORMATION

|                                 |                |
|---------------------------------|----------------|
| Package                         | TO-220AB       |
| Lead (Pb)-free                  | SiHP22N60E-E3  |
| Lead (Pb)-free and Halogen-free | SiHP22N60E-GE3 |

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

| PARAMETER   | SYMBOL           | LIMIT          | UNIT |
|---|------------------|----------------|------|
| Drain-Source Voltage                                      | $V_{DS}$         | 600            | V    |
| Gate-Source Voltage                                       | $V_{GS}$         | $\pm 30$       |      |
| Continuous Drain Current ( $T_J = 150$ °C)                | $V_{GS}$ at 10 V | $T_C = 25$ °C  | A    |
|   |                  | $T_C = 100$ °C |      |
| Pulsed Drain Current <sup>a</sup>                         | $I_{DM}$         | 56             |      |
| Linear Derating Factor                                    |                  | 1.8            | W/°C |
| Single Pulse Avalanche Energy <sup>b</sup>                | $E_{AS}$         | 367            | mJ   |
| Maximum Power Dissipation                                 | $P_D$            | 227            | W    |
| Operating Junction and Storage Temperature Range          | $T_J, T_{stg}$   | -55 to +150    | °C   |
| Drain-Source Voltage Slope                                | $dV/dt$          | 70             | V/ns |
| Reverse Diode $dV/dt$ <sup>d</sup>                        |                  | 11             |      |
| 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.

**THERMAL RESISTANCE RATINGS**

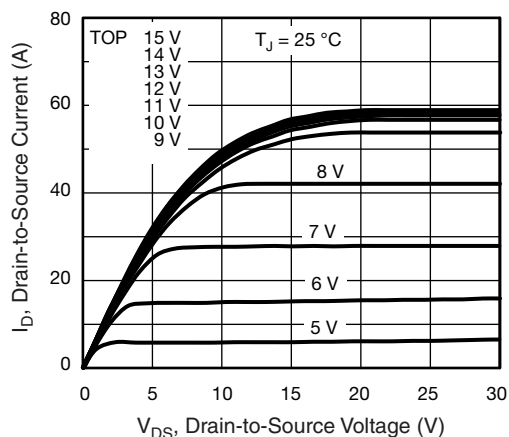
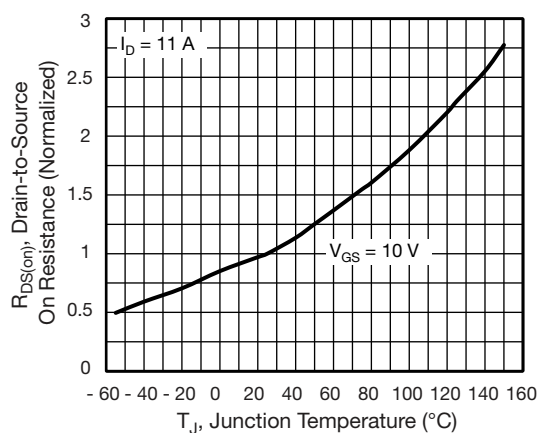
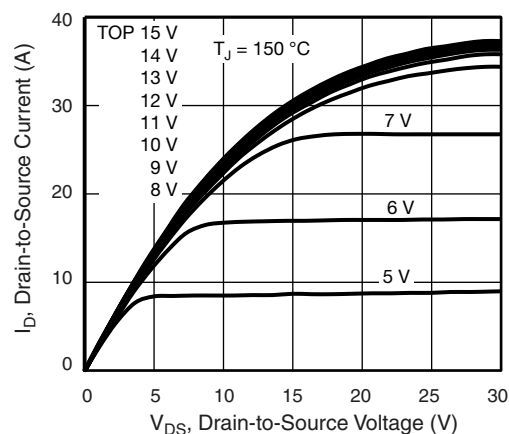
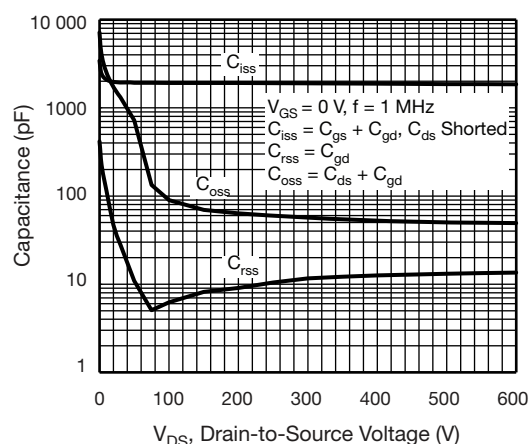
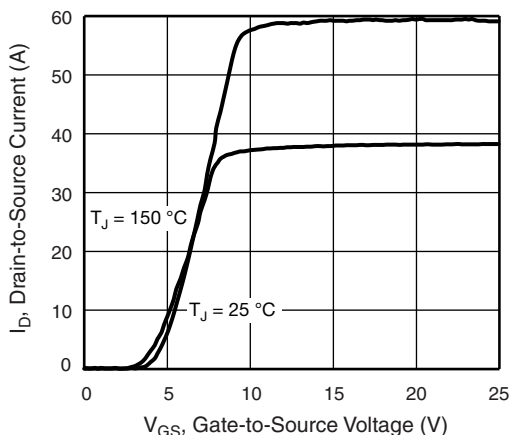
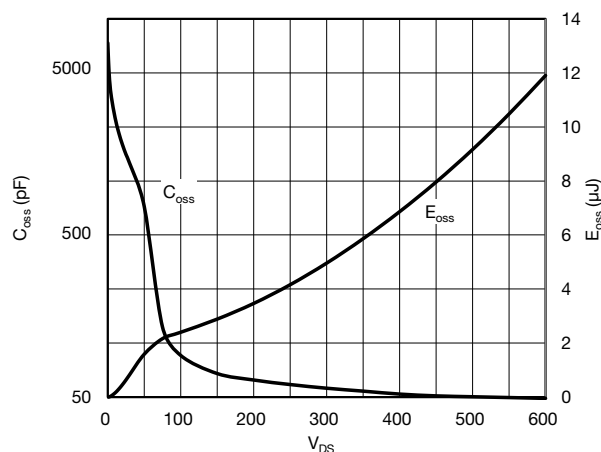
| PARAMETER                        | SYMBOL     | TYP. | MAX. | UNIT |
|----------------------------------|------------|------|------|------|
| Maximum Junction-to-Ambient      | $R_{thJA}$ | -    | 62   | °C/W |
| Maximum Junction-to-Case (Drain) | $R_{thJC}$ | -    | 0.55 |      |

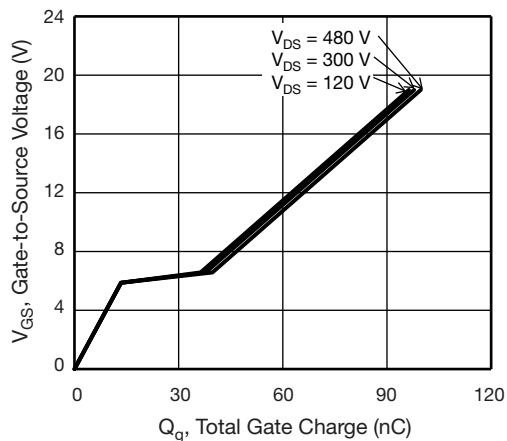
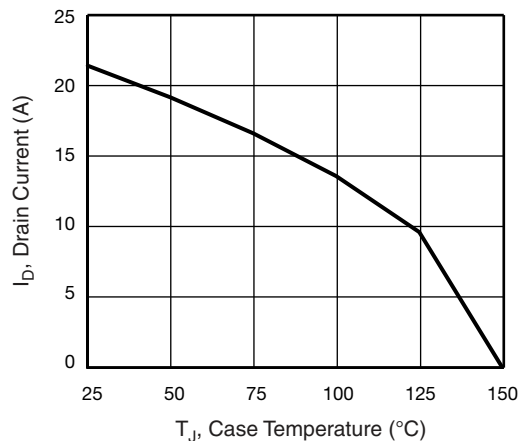
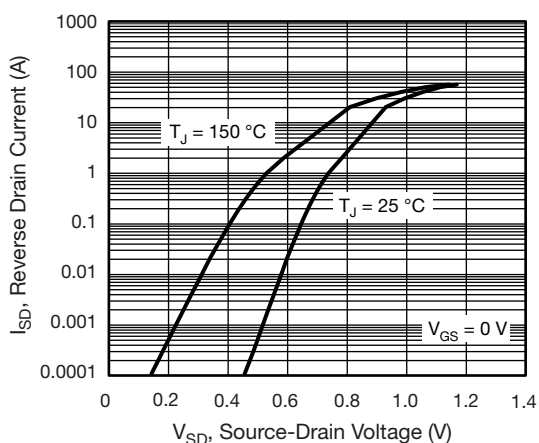
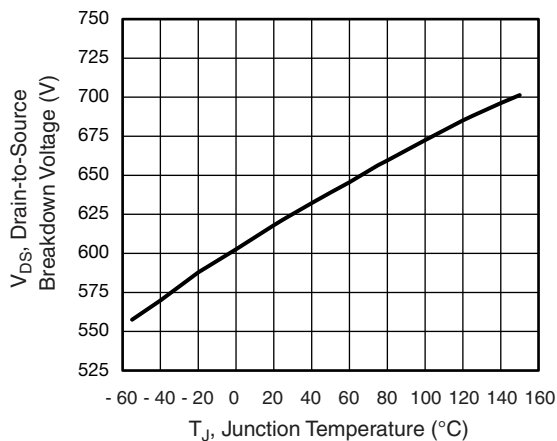
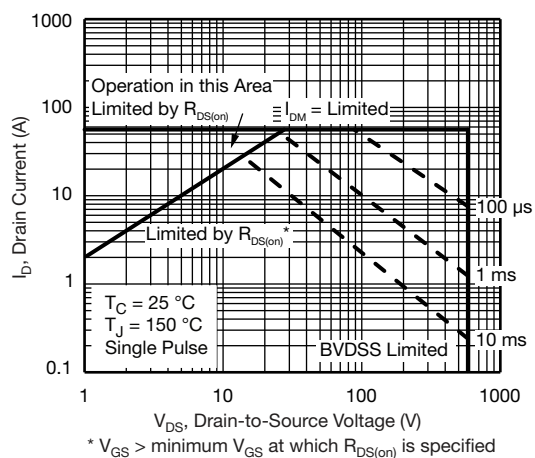
**SPECIFICATIONS** ( $T_J = 25\text{ }^{\circ}\text{C}$ , unless otherwise noted)

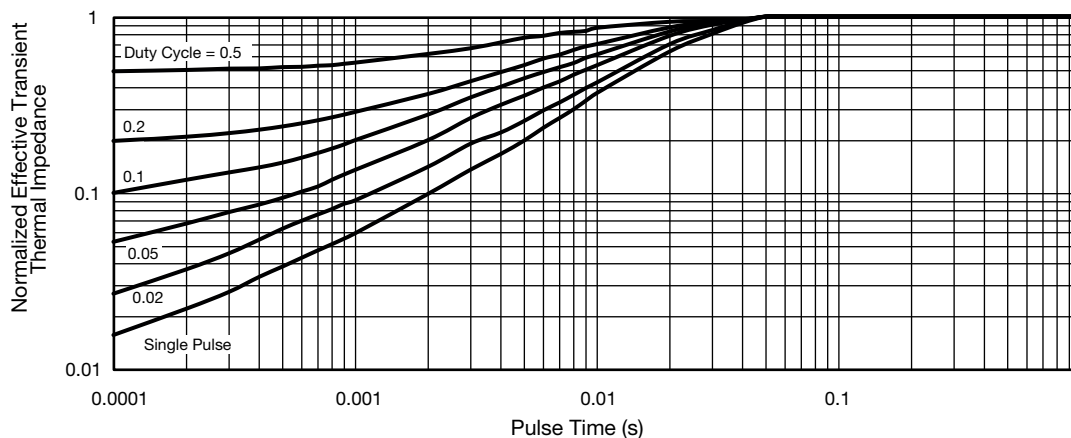
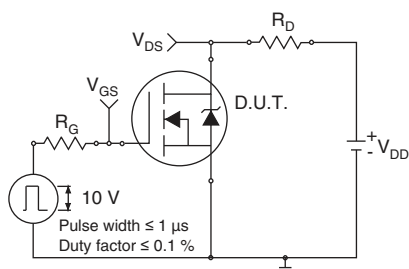
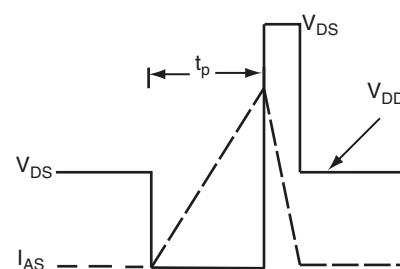
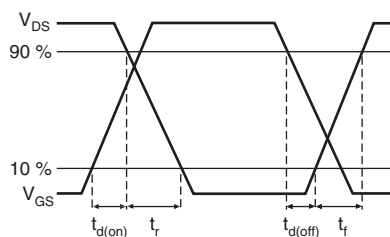
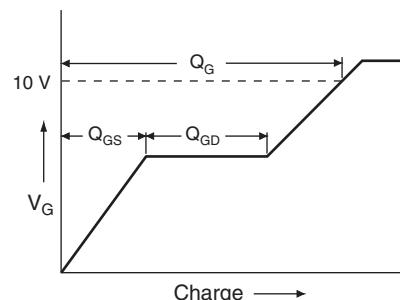
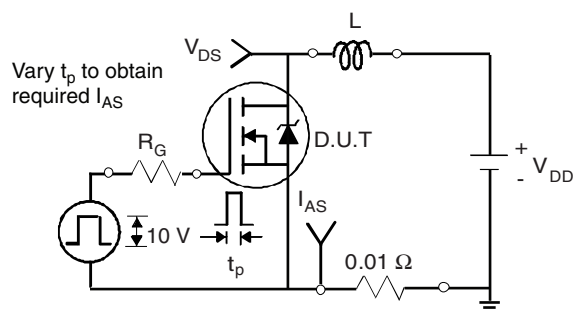
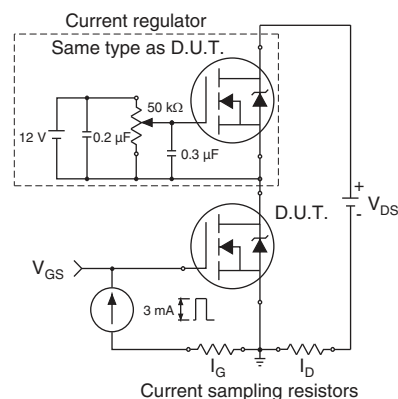
| PARAMETER   | SYMBOL              | TEST CONDITIONS   | MIN. | TYP. | MAX.      | UNIT          |
|---|---------------------|---|------|------|-----------|---------------|
| <b>Static</b>   |                     |   |      |      |           |               |
| Drain-Source Breakdown Voltage                            | $V_{DS}$            | $V_{GS} = 0\text{ V}$ , $I_D = 250\text{ }\mu\text{A}$  | 600  | -    | -         | V             |
| $V_{DS}$ Temperature Coefficient                          | $\Delta V_{DS}/T_J$ | Reference to $25\text{ }^{\circ}\text{C}$ , $I_D = 250\text{ }\mu\text{A}$  | -    | 0.71 | -         | 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                                       | $I_{GSS}$           | $V_{GS} = \pm 20\text{ V}$  | -    | -    | $\pm 100$ | nA            |
|   |                     | $V_{GS} = \pm 30\text{ V}$  | -    | -    | $\pm 1$   | $\mu\text{A}$ |
| Zero Gate Voltage Drain Current                           | $I_{DSS}$           | $V_{DS} = 600\text{ V}$ , $V_{GS} = 0\text{ V}$   | -    | -    | 1         | $\mu\text{A}$ |
|   |                     | $V_{DS} = 480\text{ V}$ , $V_{GS} = 0\text{ V}$ , $T_J = 125\text{ }^{\circ}\text{C}$   | -    | -    | 10        |               |
| Drain-Source On-State Resistance                          | $R_{DS(on)}$        | $V_{GS} = 10\text{ V}$ , $I_D = 11\text{ A}$  | -    | 0.15 | 0.18      | $\Omega$      |
| Forward Transconductance                                  | $g_{fs}$            | $V_{DS} = 8\text{ V}$ , $I_D = 5\text{ A}$  | -    | 6.4  | -         | S             |
| <b>Dynamic</b>  |                     |   |      |      |           |               |
| Input Capacitance   | $C_{iss}$           | $V_{GS} = 0\text{ V}$ ,<br>$V_{DS} = 100\text{ V}$ ,<br>$f = 1\text{ MHz}$  | -    | 1920 | -         | pF            |
| Output Capacitance  | $C_{oss}$           |   | -    | 90   | -         |               |
| Reverse Transfer Capacitance                              | $C_{rss}$           |   | -    | 6    | -         |               |
| Effective Output Capacitance, Energy Related <sup>a</sup> | $C_{o(er)}$         | $V_{DS} = 0\text{ V to } 480\text{ V}$ , $V_{GS} = 0\text{ V}$  | -    | 73   | -         |               |
| Effective Output Capacitance, Time Related <sup>b</sup>   | $C_{o(tr)}$         |   | -    | 263  | -         |               |
| Total Gate Charge   | $Q_g$               | $V_{GS} = 10\text{ V}$ , $I_D = 11\text{ A}$ , $V_{DS} = 480\text{ V}$  | -    | 57   | 86        | nC            |
| Gate-Source Charge  | $Q_{gs}$            |   | -    | 11   | -         |               |
| Gate-Drain Charge   | $Q_{gd}$            |   | -    | 24   | -         |               |
| Turn-On Delay Time  | $t_{d(on)}$         | $V_{DD} = 380\text{ V}$ , $I_D = 11\text{ A}$ ,<br>$V_{GS} = 10\text{ V}$ , $R_g = 4.7\text{ }\Omega$   | -    | 18   | 36        | ns            |
| Rise Time   | $t_r$               |   | -    | 27   | 54        |               |
| Turn-Off Delay Time                                       | $t_{d(off)}$        |   | -    | 66   | 99        |               |
| Fall Time   | $t_f$               |   | -    | 35   | 70        |               |
| Gate Input Resistance                                     | $R_g$               | $f = 1\text{ MHz}$ , open drain   | 0.3  | 0.77 | 1.2       | $\Omega$      |
| <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                              | $I_{SM}$            |   | -    | -    | 56        |               |
| Diode Forward Voltage                                     | $V_{SD}$            | $T_J = 25\text{ }^{\circ}\text{C}$ , $I_S = 11\text{ A}$ , $V_{GS} = 0\text{ V}$  | -    | -    | 1.2       | V             |
| Reverse Recovery Time                                     | $t_{rr}$            | $T_J = 25\text{ }^{\circ}\text{C}$ , $I_F = I_S = 11\text{ A}$ ,<br>$dI/dt = 100\text{ A}/\mu\text{s}$ , $V_R = 25\text{ V}$                          | -    | 344  | -         | ns            |
| Reverse Recovery Charge                                   | $Q_{rr}$            |   | -    | 5.3  | -         | $\mu\text{C}$ |
| Reverse Recovery Current                                  | $I_{RRM}$           |   | -    | 28   | -         | 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**



**Fig. 19 - For N-Channel**

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## TO-220-1



| 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

## Package Picture





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