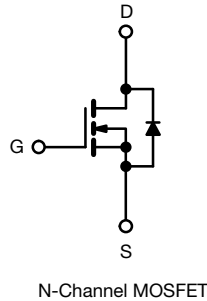
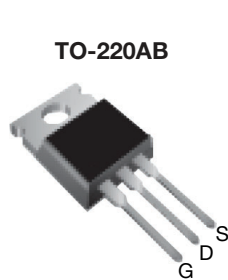


## EF Series Power MOSFET With Fast Body Diode



### FEATURES

- 4<sup>th</sup> generation E series technology
- Low figure-of-merit (FOM)  $R_{on} \times Q_g$
- Low effective capacitance ( $C_{o(er)}$ )
- Reduced switching and conduction losses
- 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**

### 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
  - Motor drives
  - Battery chargers
  - Solar (PV inverters)

### PRODUCT SUMMARY

|   |                 |       |
|---|-----------------|-------|
| $V_{DS}$ (V) at $T_J$ max.              | 650             |       |
| $R_{DS(on)}$ typ. ( $\Omega$ ) at 25 °C | $V_{GS} = 10$ V | 0.059 |
| $Q_g$ max. (nC)                         | 77              |       |
| $Q_{gs}$ (nC)                           | 19              |       |
| $Q_{gd}$ (nC)                           | 16              |       |
| Configuration                           | Single          |       |

### ORDERING INFORMATION

|                                 |                  |
|---------------------------------|------------------|
| Package                         | TO-220AB         |
| Lead (Pb)-free and halogen-free | SiHP068N60EF-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  | 41   | A |
|   |                  | $T_C = 100$ °C | 26   |   |
| Pulsed drain current <sup>a</sup>                         | $I_{DM}$         | 115            |      |   |
| Linear derating factor                                    |                  | 2              | W/°C |   |
| Single pulse avalanche energy <sup>b</sup>                | $E_{AS}$         | 226            | mJ   |   |
| Maximum power dissipation                                 | $P_D$            | 250            | W    |   |
| Operating junction and storage temperature range          | $T_J, T_{stg}$   | -55 to +150    | °C   |   |
| Drain-source voltage slope                                | $dV/dt$          | 100            | V/ns |   |
| Reverse diode $dV/dt$ <sup>d</sup>                        |                  |                |      |   |
| Soldering recommendations (peak temperature) <sup>c</sup> | For 10 s         | 260            | °C   |   |

#### Notes

- Repetitive rating; pulse width limited by maximum junction temperature
- $V_{DD} = 120$  V, starting  $T_J = 25$  °C,  $L = 28.2$  mH,  $R_g = 25$   $\Omega$ ,  $I_{AS} = 4$  A
- 1.6 mm from case
- $I_{SD} \leq I_D$ ,  $di/dt = 210$  A/ $\mu$ s, starting  $T_J = 25$  °C



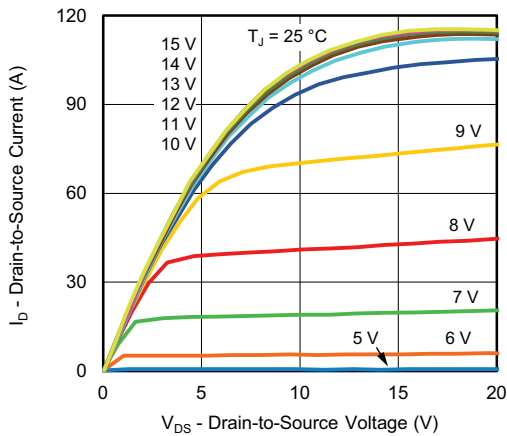
| THERMAL RESISTANCE RATINGS       |                   |       |      |
|----------------------------------|-------------------|-------|------|
| PARAMETER                        | SYMBOL            | LIMIT | UNIT |
| Maximum junction-to-ambient      | R <sub>thJA</sub> | 62    | °C/W |
| Maximum junction-to-case (drain) | R <sub>thJC</sub> | 0.5   |      |

| SPECIFICATIONS (T <sub>J</sub> = 25 °C, unless otherwise noted) |                                  |   |                       |       |       |      |
|---|----------------------------------|---|-----------------------|-------|-------|------|
| PARAMETER   | SYMBOL                           | TEST CONDITIONS   | MIN.                  | TYP.  | MAX.  | UNIT |
| <b>Static</b>   |                                  |   |                       |       |       |      |
| Drain-source breakdown voltage                                  | V <sub>DS</sub>                  | V <sub>GS</sub> = 0 V, I <sub>D</sub> = 250 μA  | 600                   | -     | -     | 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   | -                     | 0.63  | -     | V/°C |
| Gate-source threshold voltage (N)                               | V <sub>GS(th)</sub>              | V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 250 μA   | 3                     | -     | 5     | V    |
| Gate-source leakage   | I <sub>GSS</sub>                 | V <sub>GS</sub> = ± 20 V  | -                     | -     | ± 100 | nA   |
|   |                                  | V <sub>GS</sub> = ± 30 V  | -                     | -     | ± 1   | μA   |
| Zero gate voltage drain current                                 | I <sub>DSS</sub>                 | V <sub>DS</sub> = 480 V, V <sub>GS</sub> = 0 V  | -                     | -     | 1     | μA   |
|   |                                  | V <sub>DS</sub> = 480 V, V <sub>GS</sub> = 0 V, T <sub>J</sub> = 125 °C   | -                     | -     | 2     | mA   |
| Drain-source on-state resistance                                | R <sub>DS(on)</sub>              | V <sub>GS</sub> = 10 V, I <sub>D</sub> = 16 A   | -                     | 0.059 | 0.068 | Ω    |
| Forward transconductance  | g <sub>fs</sub>                  | V <sub>DS</sub> = 30 V, I <sub>D</sub> = 16 A   | -                     | 9     | -     | S    |
| <b>Dynamic</b>  |                                  |   |                       |       |       |      |
| Input capacitance   | C <sub>iSS</sub>                 | V <sub>GS</sub> = 0 V,<br>V <sub>DS</sub> = 100 V,<br>f = 1 MHz   | -                     | 2628  | -     | pF   |
| Output capacitance  | C <sub>oss</sub>                 |   | -                     | 122   | -     |      |
| Reverse transfer capacitance                                    | C <sub>rSS</sub>                 |   | -                     | 7     | -     |      |
| Effective output capacitance, energy related <sup>a</sup>       | C <sub>o(er)</sub>               |   | -                     | 87    | -     |      |
| Effective output capacitance, time related <sup>b</sup>         | C <sub>o(tr)</sub>               | V <sub>DS</sub> = 0 V to 480 V, V <sub>GS</sub> = 0 V   | -                     | 543   | -     |      |
| Total gate charge   | Q <sub>g</sub>                   | V <sub>GS</sub> = 10 V, I <sub>D</sub> = 16 A, V <sub>DS</sub> = 480 V  | -                     | 51    | 77    | nC   |
| Gate-source charge  | Q <sub>gs</sub>                  |   | -                     | 19    | -     |      |
| Gate-drain charge   | Q <sub>gd</sub>                  |   | -                     | 16    | -     |      |
| Turn-on delay time  | t <sub>d(on)</sub>               | V <sub>DD</sub> = 480 V, I <sub>D</sub> = 16 A,<br>V <sub>GS</sub> = 10 V, R <sub>g</sub> = 9.1 Ω   | -                     | 27    | 54    | ns   |
| Rise time   | t <sub>r</sub>                   |   | -                     | 55    | 83    |      |
| Turn-off delay time   | t <sub>d(off)</sub>              |   | -                     | 53    | 80    |      |
| Fall time   | t <sub>f</sub>                   |   | -                     | 35    | 70    |      |
| Gate input resistance   | R <sub>g</sub>                   |   | f = 1 MHz, open drain | 0.3   | 0.7   |      |
| <b>Drain-Source Body Diode Characteristics</b>                  |                                  |   |                       |       |       |      |
| Continuous source-drain diode current                           | I <sub>S</sub>                   | MOSFET symbol showing the integral reverse p - n junction diode  | -                     | -     | 41    | A    |
| Pulsed diode forward current                                    | I <sub>SM</sub>                  |   | -                     | -     | 115   |      |
| Diode forward voltage   | V <sub>SD</sub>                  | T <sub>J</sub> = 25 °C, I <sub>S</sub> = 16 A, V <sub>GS</sub> = 0 V  | -                     | -     | 1.2   | V    |
| Reverse recovery time   | t <sub>rr</sub>                  | T <sub>J</sub> = 25 °C, I <sub>F</sub> = I <sub>S</sub> = 16 A,<br>di/dt = 100 A/μs, V <sub>R</sub> = 400 V   | -                     | 152   | 304   | ns   |
| Reverse recovery charge   | Q <sub>rr</sub>                  |   | -                     | 1     | 2     | μC   |
| Reverse recovery current  | I <sub>RRM</sub>                 |   | -                     | 14    | -     | A    |

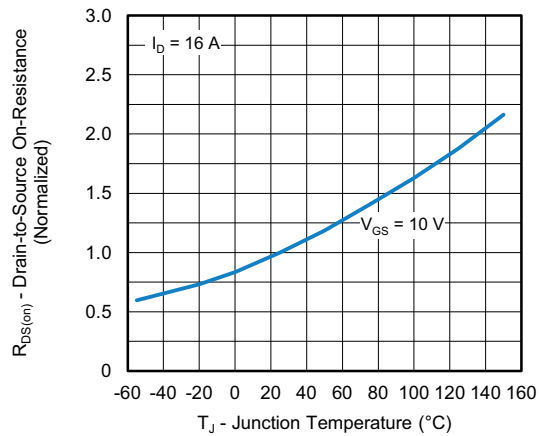
**Notes**

- a. C<sub>oss(er)</sub> is a fixed capacitance that gives the same energy as C<sub>oss</sub> while V<sub>DS</sub> is rising from 0 % to 80 % V<sub>DSS</sub>
- b. C<sub>oss(tr)</sub> is a fixed capacitance that gives the same charging time as C<sub>oss</sub> while V<sub>DS</sub> is rising from 0 % to 80 % V<sub>DSS</sub>

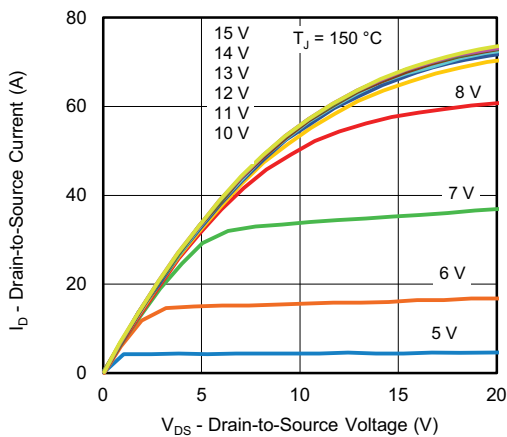
**TYPICAL CHARACTERISTICS** (25 °C, unless otherwise noted)



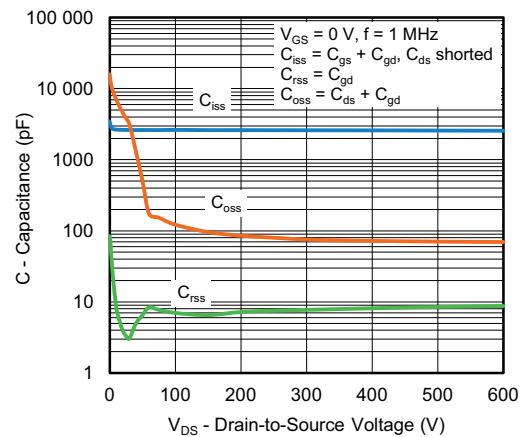
**Fig. 1 - Typical Output Characteristics**



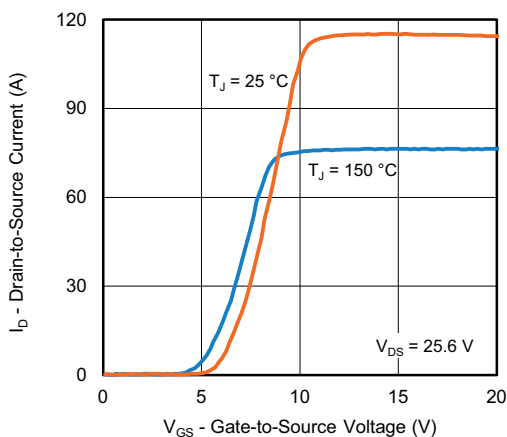
**Fig. 4 - Normalized On-Resistance vs. Temperature**



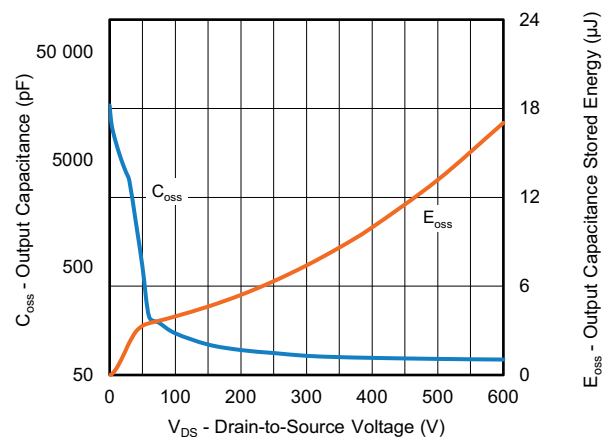
**Fig. 2 - Typical Output Characteristics**



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



**Fig. 3 - Typical Transfer Characteristics**



**Fig. 6 - C<sub>oss</sub> and E<sub>oss</sub> vs. V<sub>DS</sub>**

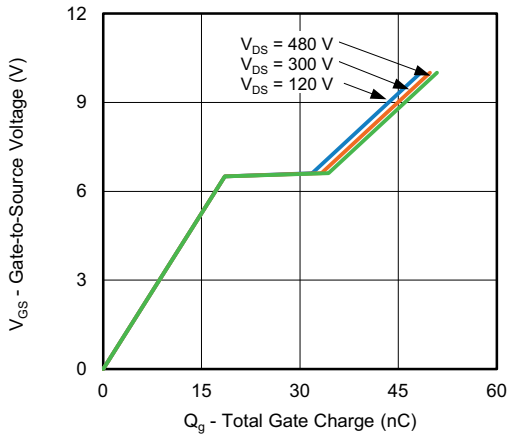


Fig. 7 - Typical Gate Charge vs. Gate-to-Source Voltage

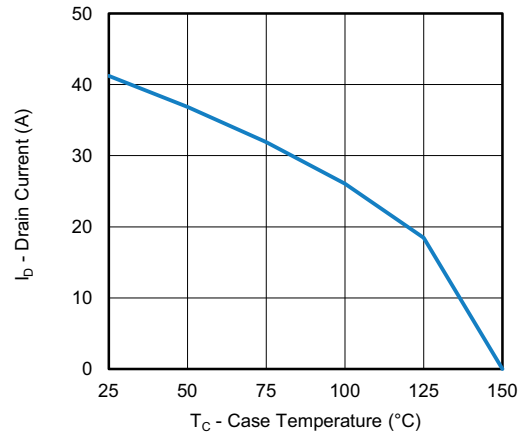


Fig. 10 - Maximum Drain Current vs. Case Temperature

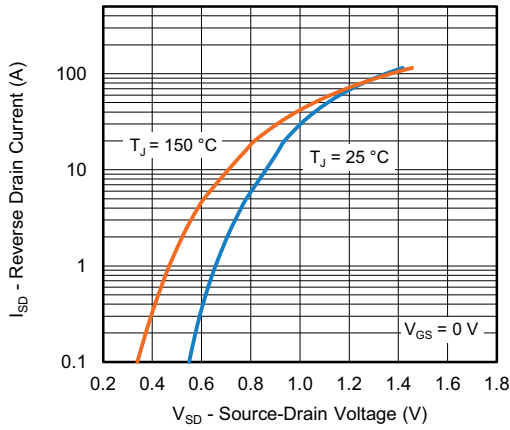


Fig. 8 - Typical Source-Drain Diode Forward Voltage

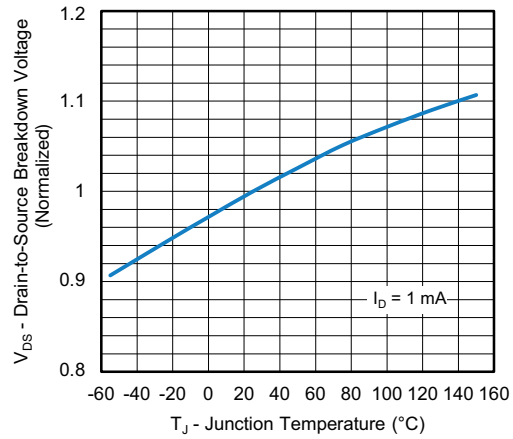


Fig. 11 - Temperature vs. Drain-to-Source Voltage

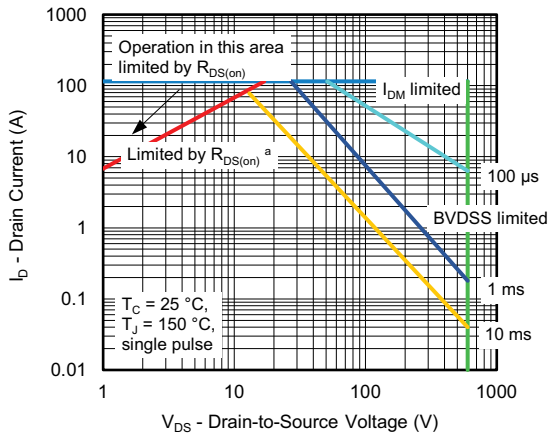


Fig. 9 - Maximum Safe Operating Area

**Note**

a.  $V_{GS} >$  minimum  $V_{GS}$  at which  $R_{DS(on)}$  is specified

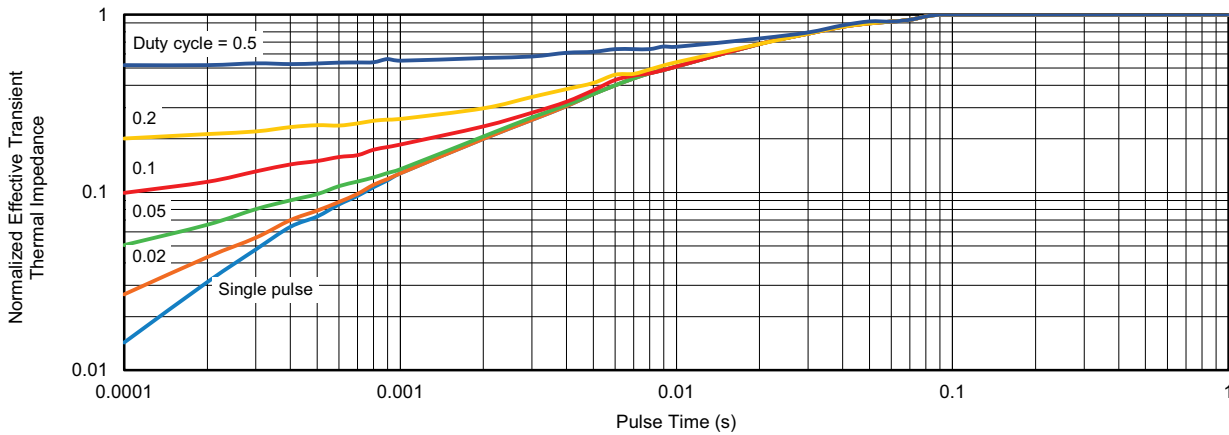


Fig. 12 - Normalized Thermal Transient Impedance, Junction-to-Case

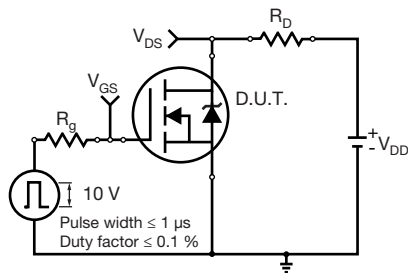


Fig. 13 - Switching Time Test Circuit

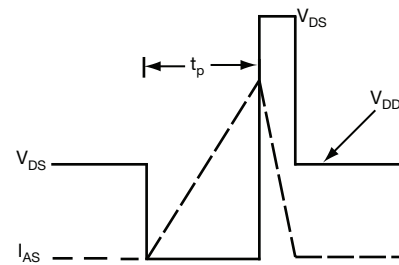


Fig. 16 - Unclamped Inductive Waveforms

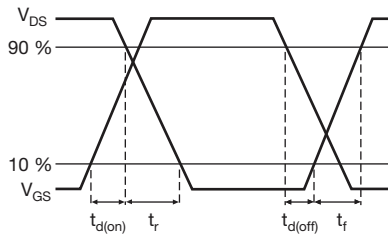


Fig. 14 - Switching Time Waveforms

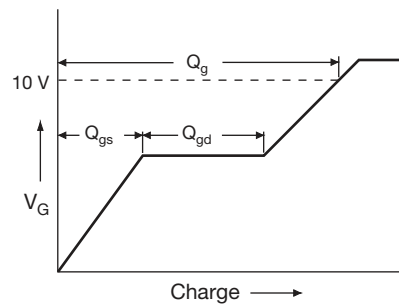


Fig. 17 - Basic Gate Charge Waveform

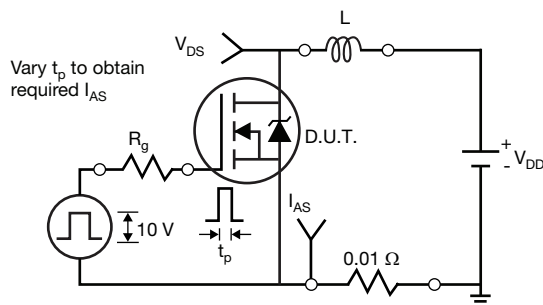


Fig. 15 - Unclamped Inductive Test Circuit

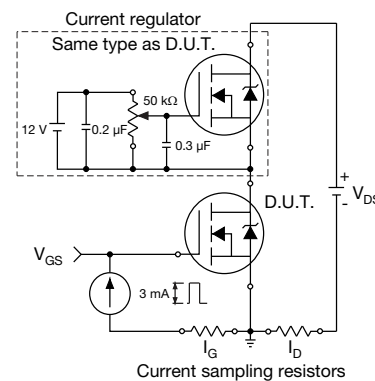


Fig. 18 - Gate Charge Test Circuit



**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: E21-0621-Rev. D, 04-Nov-2021  
DWG: 6031

**Note**

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



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