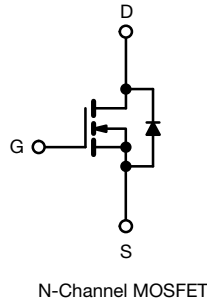
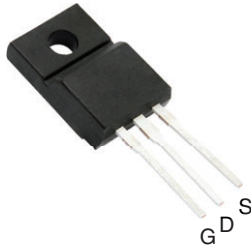


## EF Series Power MOSFET With Fast Body Diode

**TO-220 FULLPAK**


### 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-220 FULLPAK   |
| Lead (Pb)-free and halogen-free | SiHF068N60EF-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) <sup>e</sup>   | $V_{GS}$ at 10 V | $T_C = 25$ °C  | 16   | A |
|   |                  | $T_C = 100$ °C | 10   |   |
| Pulsed drain current <sup>a</sup>                         | $I_{DM}$         | 115            |      |   |
| Linear derating factor                                    |                  | 0.31           | W/°C |   |
| Single pulse avalanche energy <sup>b</sup>                | $E_{AS}$         | 226            | mJ   |   |
| Maximum power dissipation                                 | $P_D$            | 39             | 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   |   |
| Mounting torque, M3 screw                                 |                  | 0.6            | Nm   |   |

#### 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
- Limited by maximum junction temperature



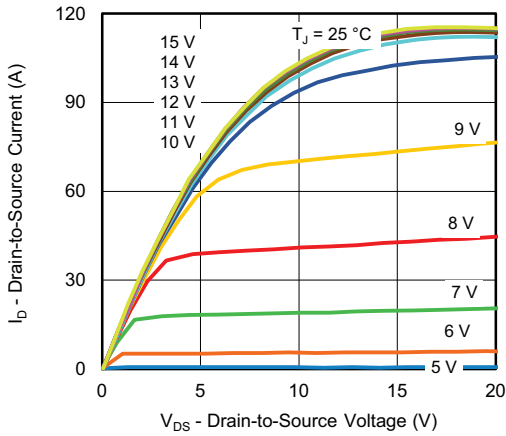
| THERMAL RESISTANCE RATINGS       |                   |       |      |
|----------------------------------|-------------------|-------|------|
| PARAMETER                        | SYMBOL            | LIMIT | UNIT |
| Maximum junction-to-ambient      | R <sub>thJA</sub> | 65    | °C/W |
| Maximum junction-to-case (drain) | R <sub>thJC</sub> | 3.2   |      |

| 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    |

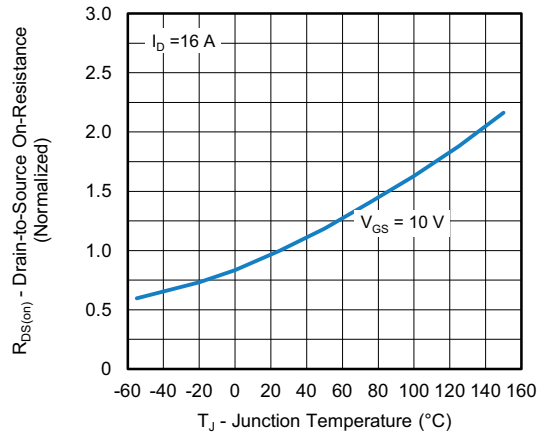
**Notes**

- 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>

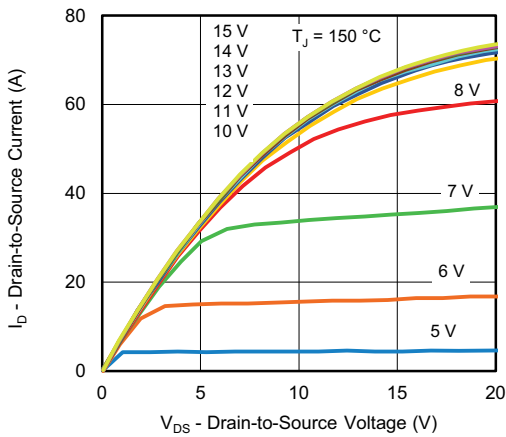
**TYPICAL CHARACTERISTICS** (25 °C, unless otherwise noted)



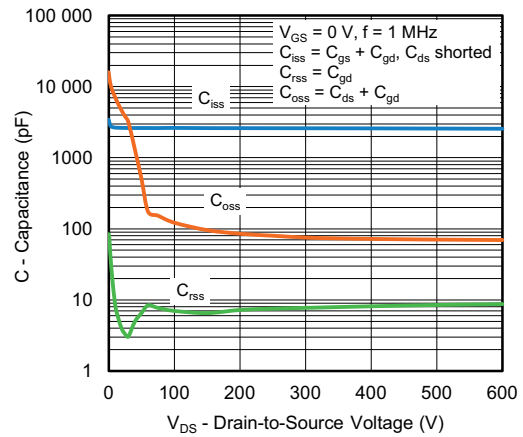
**Fig. 1 - Typical Output Characteristics**



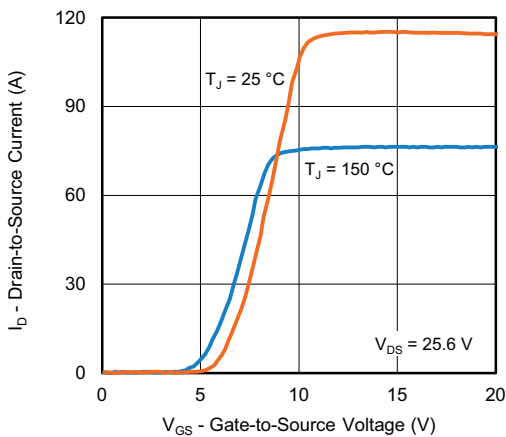
**Fig. 4 - Normalized On-Resistance vs. Temperature**



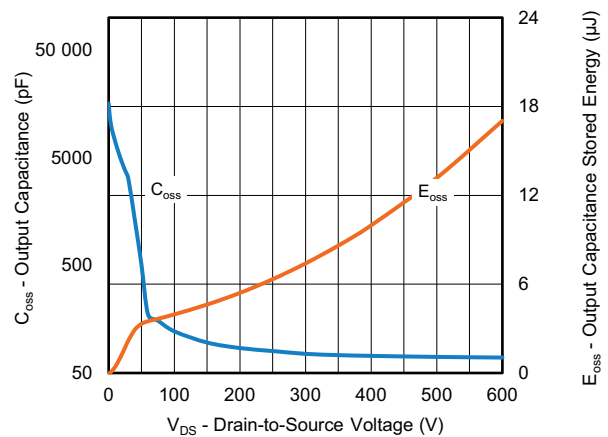
**Fig. 2 - Typical Output Characteristics**



**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>**

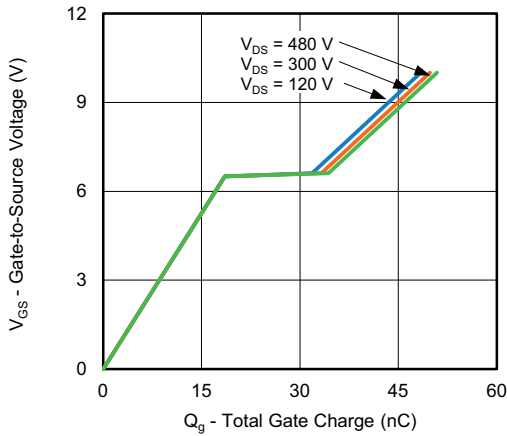


Fig. 7 - Typical Gate Charge vs. Gate-to-Source Voltage

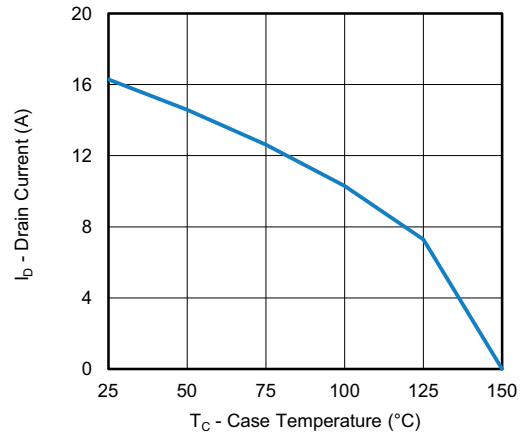


Fig. 10 - Maximum Drain Current vs. Case Temperature

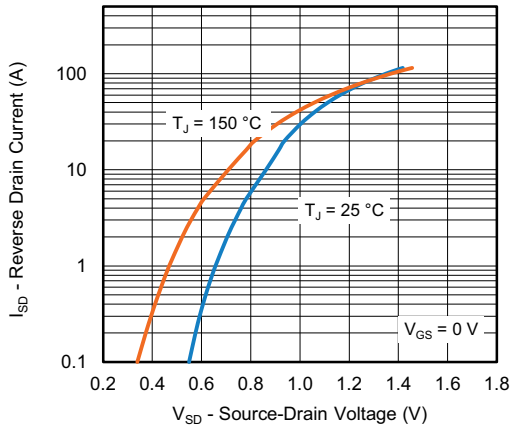


Fig. 8 - Typical Source-Drain Diode Forward Voltage

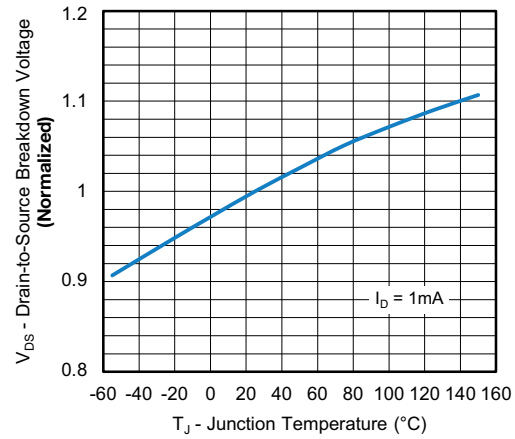


Fig. 11 - Temperature vs. Drain-to-Source Voltage

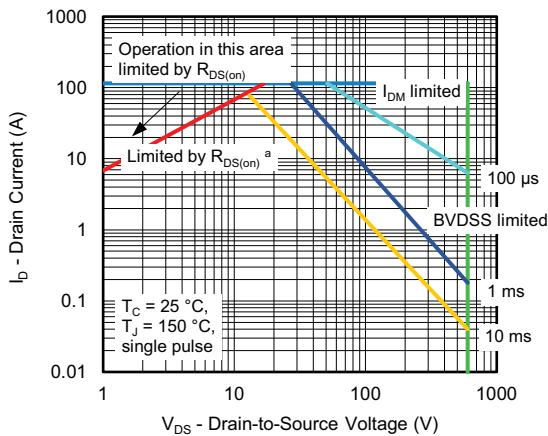


Fig. 9 - Maximum Safe Operating Area

**Note**

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

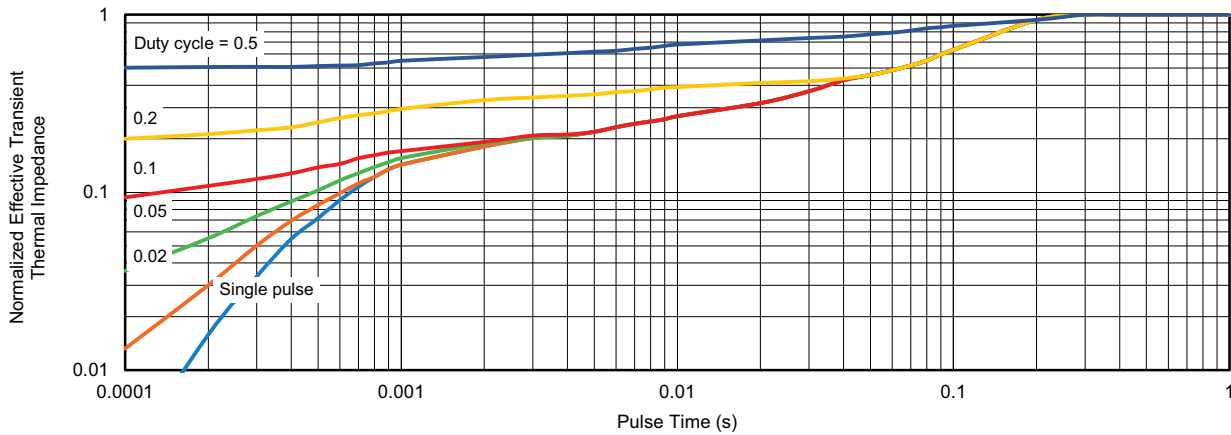


Fig. 12 - Normalized Thermal Transient Impedance, Junction-to-Case

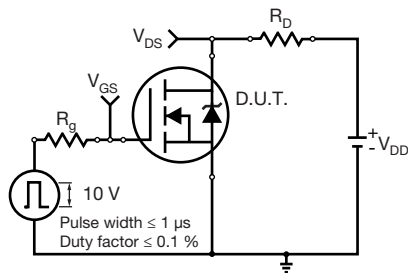


Fig. 13 - Switching Time Test Circuit

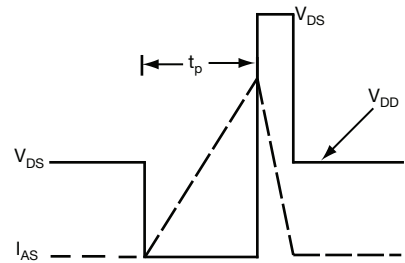


Fig. 16 - Unclamped Inductive Waveforms

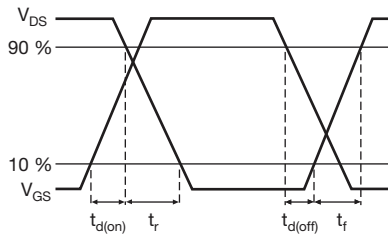


Fig. 14 - Switching Time Waveforms

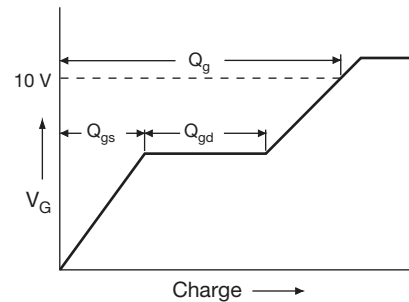


Fig. 17 - Basic Gate Charge Waveform

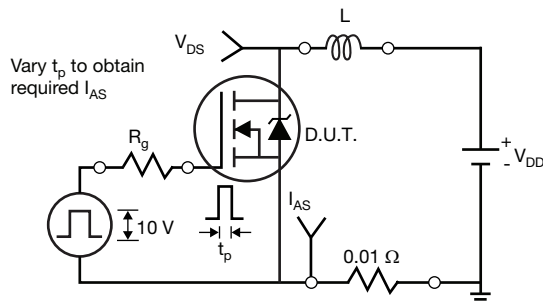


Fig. 15 - Unclamped Inductive Test Circuit

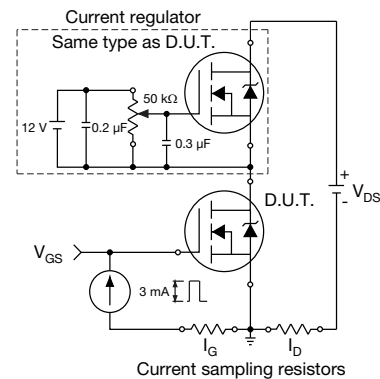


Fig. 18 - Gate Charge Test Circuit



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

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

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# TO-220 FULLPAK (High Voltage)

## OPTION 1: FACILITY CODE = 9



| DIM.            | MILLIMETERS |       |       |
|-----------------|-------------|-------|-------|
|                 | MIN.        | NOM.  | MAX.  |
| A               | 4.60        | 4.70  | 4.80  |
| b               | 0.70        | 0.80  | 0.91  |
| b1              | 1.20        | 1.30  | 1.47  |
| b2              | 1.10        | 1.20  | 1.30  |
| C               | 0.45        | 0.50  | 0.63  |
| D               | 15.80       | 15.87 | 15.97 |
| e               | 2.54 BSC    |       |       |
| E               | 10.00       | 10.10 | 10.30 |
| F               | 2.44        | 2.54  | 2.64  |
| G               | 6.50        | 6.70  | 6.90  |
| L               | 12.90       | 13.10 | 13.30 |
| L1              | 3.13        | 3.23  | 3.33  |
| Q               | 2.65        | 2.75  | 2.85  |
| Q1              | 3.20        | 3.30  | 3.40  |
| $\varnothing R$ | 3.08        | 3.18  | 3.28  |

### Notes

1. To be used only for process drawing
2. These dimensions apply to all TO-220 FULLPAK leadframe versions 3 leads
3. All critical dimensions should C meet  $C_{pk} > 1.33$
4. All dimensions include burrs and plating thickness
5. No chipping or package damage
6. Facility code will be the 1<sup>st</sup> character located at the 2<sup>nd</sup> row of the unit marking



OPTION 2: FACILITY CODE = Y



| DIM. | MILLIMETERS |        | INCHES    |       |
|------|-------------|--------|-----------|-------|
|      | MIN.        | MAX.   | MIN.      | MAX.  |
| A    | 4.570       | 4.830  | 0.180     | 0.190 |
| A1   | 2.570       | 2.830  | 0.101     | 0.111 |
| A2   | 2.510       | 2.850  | 0.099     | 0.112 |
| b    | 0.622       | 0.890  | 0.024     | 0.035 |
| b2   | 1.229       | 1.400  | 0.048     | 0.055 |
| b3   | 1.229       | 1.400  | 0.048     | 0.055 |
| c    | 0.440       | 0.629  | 0.017     | 0.025 |
| D    | 8.650       | 9.800  | 0.341     | 0.386 |
| d1   | 15.88       | 16.120 | 0.622     | 0.635 |
| d3   | 12.300      | 12.920 | 0.484     | 0.509 |
| E    | 10.360      | 10.630 | 0.408     | 0.419 |
| e    | 2.54 BSC    |        | 0.100 BSC |       |
| L    | 13.200      | 13.730 | 0.520     | 0.541 |
| L1   | 3.100       | 3.500  | 0.122     | 0.138 |
| n    | 6.050       | 6.150  | 0.238     | 0.242 |
| Ø P  | 3.050       | 3.450  | 0.120     | 0.136 |
| u    | 2.400       | 2.500  | 0.094     | 0.098 |
| V    | 0.400       | 0.500  | 0.016     | 0.020 |

ECN: E19-0180-Rev. D, 08-Apr-2019  
DWG: 5972

Notes

1. To be used only for process drawing
2. These dimensions apply to all TO-220 FULLPAK leadframe versions 3 leads
3. All critical dimensions should C meet  $C_{pk} > 1.33$
4. All dimensions include burrs and plating thickness
5. No chipping or package damage
6. Facility code will be the 1<sup>st</sup> character located at the 2<sup>nd</sup> row of the unit marking





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