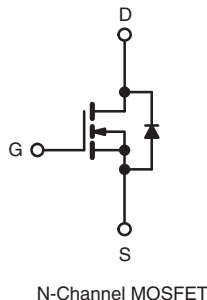
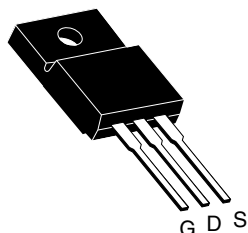


## D Series Power MOSFET

### PRODUCT SUMMARY

|                                         |                 |     |
|-----------------------------------------|-----------------|-----|
| $V_{DS}$ (V) at $T_J$ max.              | 450             |     |
| $R_{DS(on)}$ max. at 25 °C ( $\Omega$ ) | $V_{GS} = 10$ V | 0.6 |
| $Q_g$ max. (nC)                         | 30              |     |
| $Q_{gs}$ (nC)                           | 4               |     |
| $Q_{gd}$ (nC)                           | 7               |     |
| Configuration                           | Single          |     |

### TO-220 FULLPAK



### FEATURES

- Optimal Design
  - Low Area Specific On-Resistance
  - Low Input Capacitance ( $C_{iss}$ )
  - Reduced Capacitive Switching Losses
  - High Body Diode Ruggedness
  - Avalanche Energy Rated (UIS)
- Optimal Efficiency and Operation
  - Low Cost
  - Simple Gate Drive Circuitry
  - Low Figure-of-Merit (FOM):  $R_{on} \times Q_g$
  - Fast Switching
- Compliant to RoHS Directive 2011/65/EU

### Note

\* Pb containing terminations are not RoHS compliant, exemptions may apply

### APPLICATIONS

- Consumer Electronics
  - Displays (LCD or Plasma TV)
- Server and Telecom Power Supplies
  - SMPS
- Industrial
  - Welding
  - Induction Heating
  - Motor Drives
- Battery Chargers



**RoHS\***  
COMPLIANT

### ORDERING INFORMATION

|                |                |
|----------------|----------------|
| Package        | TO-220 FULLPAK |
| Lead (Pb)-free | SiHF10N40D-E3  |

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

| PARAMETER                                               | SYMBOL           | LIMIT          | UNIT |
|---------------------------------------------------------|------------------|----------------|------|
| Drain-Source Voltage                                    | $V_{DS}$         | 400            | V    |
| Gate-Source Voltage                                     | $V_{GS}$         | $\pm 30$       |      |
| Gate-Source Voltage AC ( $f > 1$ Hz)                    |                  | 30             |      |
| Continuous Drain Current ( $T_J = 150$ °C) <sup>e</sup> | $V_{GS}$ at 10 V | $T_C = 25$ °C  | A    |
|                                                         |                  | $T_C = 100$ °C |      |
| Pulsed Drain Current <sup>a</sup>                       | $I_{DM}$         | 23             |      |
| Linear Derating Factor                                  |                  | 0.26           | W/°C |
| Single Pulse Avalanche Energy <sup>b</sup>              | $E_{AS}$         | 194            | mJ   |
| Maximum Power Dissipation                               | $P_D$            | 33             | 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 | V/ns |
| Reverse Diode $dV/dt$ <sup>d</sup>                      |                  | 24             |      |
| Soldering Recommendations (Peak Temperature)            |                  | 300°           |      |
|                                                         |                  | for 10 s       | °C   |

### Notes

- Repetitive rating; pulse width limited by maximum junction temperature.
- $V_{DS} = 50$  V, starting  $T_J = 25$  °C,  $L = 2.3$  mH,  $R_g = 25$   $\Omega$ ,  $I_{AS} = 13$  A.
- 1.6 mm from case.
- $I_{SD} \leq I_D$ , starting  $T_J = 25$  °C.
- Limited by maximum junction temperature.

**THERMAL RESISTANCE RATINGS**

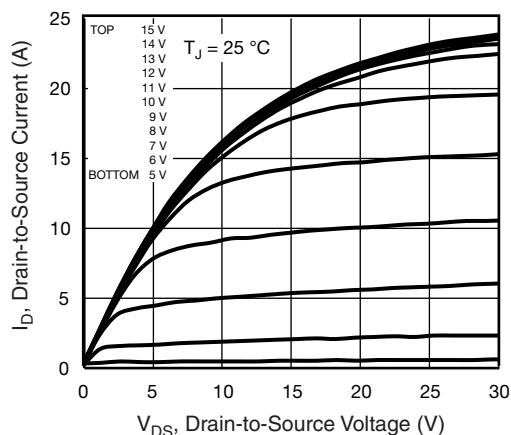
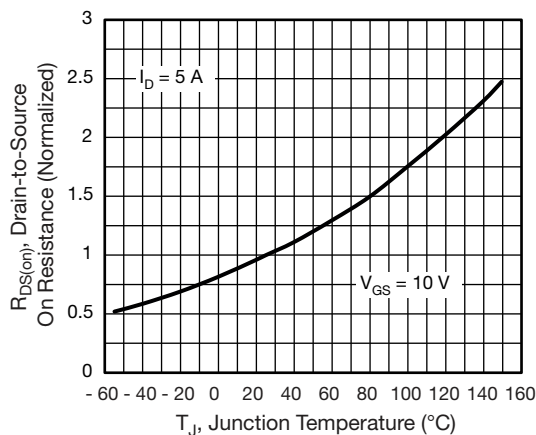
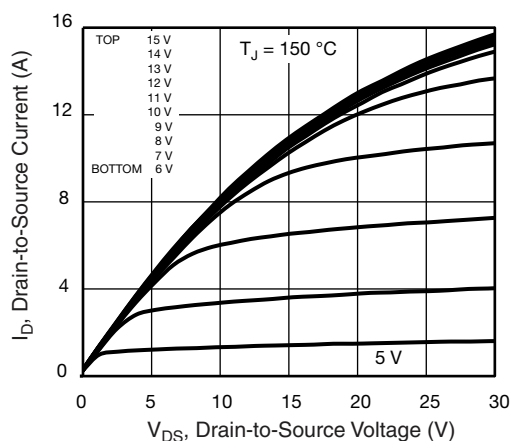
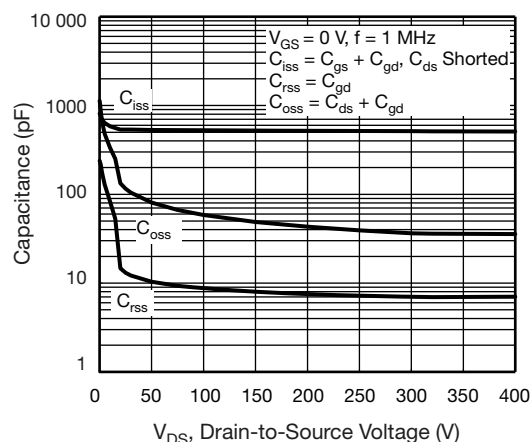
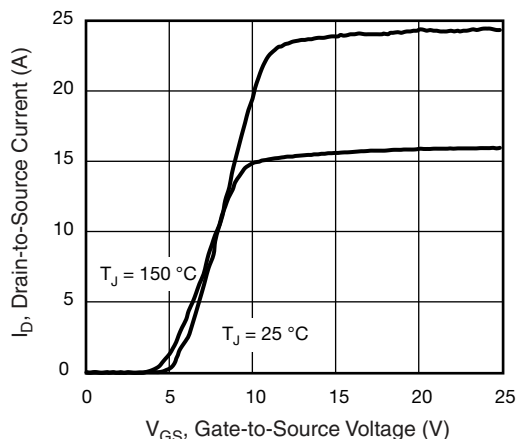
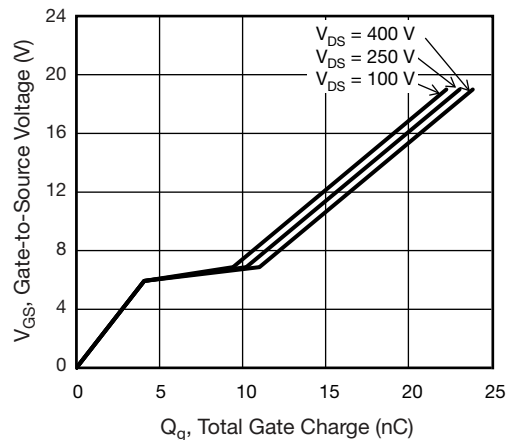
| PARAMETER                        | SYMBOL     | TYP. | MAX. | UNIT |
|----------------------------------|------------|------|------|------|
| Maximum Junction-to-Ambient      | $R_{thJA}$ | -    | 65   | °C/W |
| Maximum Junction-to-Case (Drain) | $R_{thJC}$ | -    | 3.8  |      |

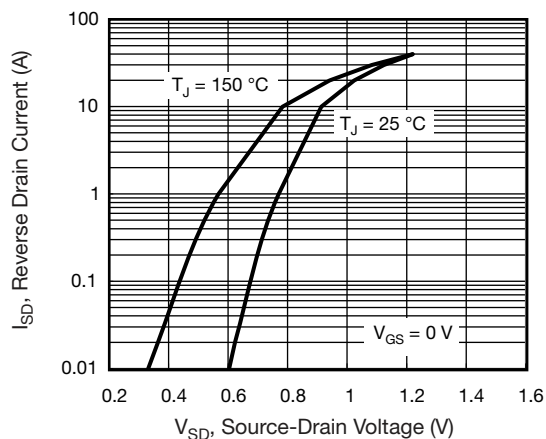
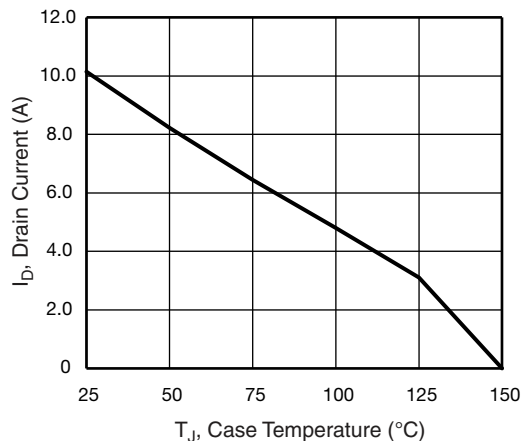
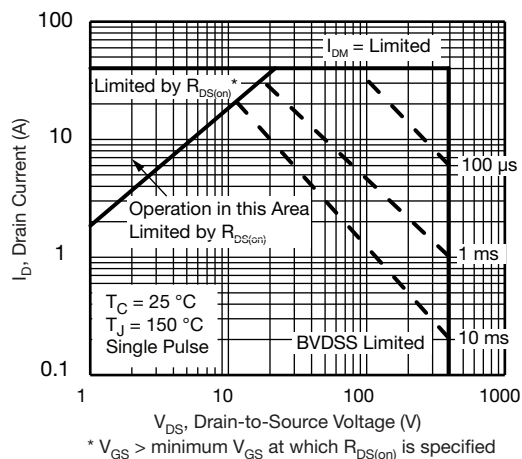
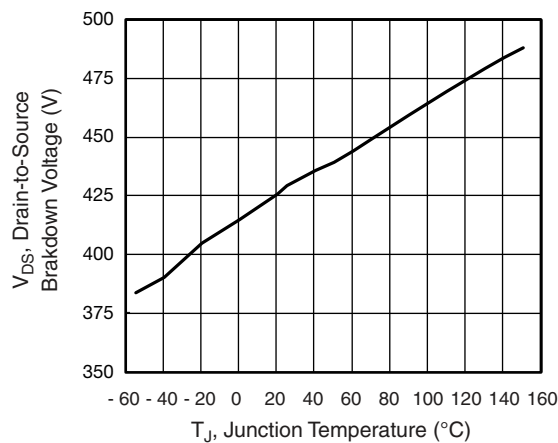
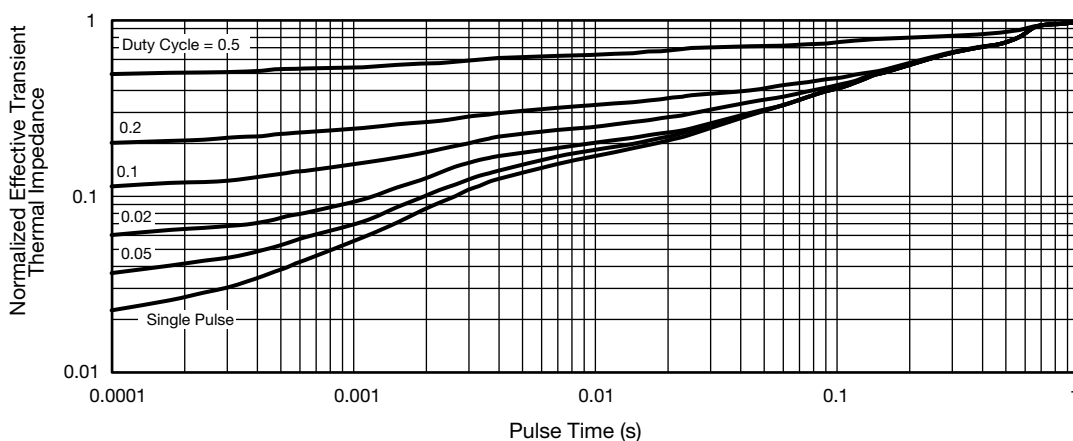
**SPECIFICATIONS** ( $T_J = 25\text{ }^{\circ}\text{C}$ , unless otherwise noted)

| PARAMETER                                                 | SYMBOL                           | TEST CONDITIONS                                                                                                                                          |                                               | MIN. | TYP. | MAX.  | UNIT |
|-----------------------------------------------------------|----------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------|------|------|-------|------|
| Static                                                    |                                  |                                                                                                                                                          |                                               |      |      |       |      |
| Drain-Source Breakdown Voltage                            | V <sub>DS</sub>                  | V <sub>GS</sub> = 0 V, I <sub>D</sub> = 250 μA                                                                                                           |                                               | 400  | -    | -     | V    |
| V <sub>DS</sub> Temperature Coefficient                   | ΔV <sub>DS</sub> /T <sub>J</sub> | Reference to 25 °C, I <sub>D</sub> = 250 μA                                                                                                              |                                               | -    | 0.53 | -     | 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> = ± 30 V                                                                                                                                 |                                               | -    | -    | ± 100 | nA   |
| Zero Gate Voltage Drain Current                           | I <sub>DSS</sub>                 | V <sub>DS</sub> = 400 V, V <sub>GS</sub> = 0 V                                                                                                           |                                               | -    | -    | 1     | μA   |
|                                                           |                                  | V <sub>DS</sub> = 320 V, V <sub>GS</sub> = 0 V, T <sub>J</sub> = 125 °C                                                                                  |                                               | -    | -    | 10    |      |
| Drain-Source On-State Resistance                          | R <sub>DS(on)</sub>              | V <sub>GS</sub> = 10 V                                                                                                                                   | I <sub>D</sub> = 5 A                          | -    | 0.5  | 0.6   | Ω    |
| Forward Transconductance                                  | g <sub>fs</sub>                  | V <sub>DS</sub> = 50 V, I <sub>D</sub> = 5 A                                                                                                             |                                               | -    | 2.7  | -     | S    |
| Dynamic                                                   |                                  |                                                                                                                                                          |                                               |      |      |       |      |
| Input Capacitance                                         | C <sub>iss</sub>                 | V <sub>GS</sub> = 0 V,<br>V <sub>DS</sub> = 100 V,<br>f = 1 MHz                                                                                          |                                               | -    | 526  | -     | pF   |
| Output Capacitance                                        | C <sub>oss</sub>                 |                                                                                                                                                          |                                               | -    | 59   | -     |      |
| Reverse Transfer Capacitance                              | C <sub>rss</sub>                 |                                                                                                                                                          |                                               | -    | 9    | -     |      |
| Effective output capacitance, energy related <sup>a</sup> | C <sub>o(er)</sub>               | V <sub>GS</sub> = 0 V,<br>V <sub>DS</sub> = 0 V to 320 V                                                                                                 |                                               | -    | 66   | -     |      |
| Effective output capacitance, time related <sup>b</sup>   | C <sub>o(tr)</sub>               |                                                                                                                                                          |                                               | -    | 84   | -     |      |
| Total Gate Charge                                         | Q <sub>g</sub>                   | V <sub>GS</sub> = 10 V                                                                                                                                   | I <sub>D</sub> = 5 A, V <sub>DS</sub> = 320 V | -    | 15   | 30    | nC   |
| Gate-Source Charge                                        | Q <sub>gs</sub>                  |                                                                                                                                                          |                                               | -    | 4    | -     |      |
| Gate-Drain Charge                                         | Q <sub>gd</sub>                  |                                                                                                                                                          |                                               | -    | 7    | -     |      |
| Turn-On Delay Time                                        | t <sub>d(on)</sub>               | V <sub>DD</sub> = 400 V, I <sub>D</sub> = 10 A,<br>V <sub>GS</sub> = 10 V, R <sub>g</sub> = 9.1 Ω                                                        |                                               | -    | 12   | 24    | ns   |
| Rise Time                                                 | t <sub>r</sub>                   |                                                                                                                                                          |                                               | -    | 18   | 36    |      |
| Turn-Off Delay Time                                       | t <sub>d(off)</sub>              |                                                                                                                                                          |                                               | -    | 18   | 36    |      |
| Fall Time                                                 | t <sub>f</sub>                   |                                                                                                                                                          |                                               | -    | 14   | 28    |      |
| Gate Input Resistance                                     | R <sub>g</sub>                   | f = 1 MHz, open drain                                                                                                                                    |                                               | -    | 1.8  | -     | Ω    |
| Drain-Source Body Diode Characteristics                   |                                  |                                                                                                                                                          |                                               |      |      |       |      |
| Continuous Source-Drain Diode Current                     | I <sub>S</sub>                   | MOSFET symbol showing the integral reverse p - n junction diode<br> |                                               | -    | -    | 10    | A    |
| Pulsed Diode Forward Current                              | I <sub>SM</sub>                  |                                                                                                                                                          |                                               | -    | -    | 40    |      |
| Diode Forward Voltage                                     | V <sub>SD</sub>                  | T <sub>J</sub> = 25 °C, I <sub>S</sub> = 5 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> = 5 A,<br>dI/dt = 100 A/μs, V <sub>R</sub> = 25 V                                                |                                               | -    | 230  | -     | ns   |
| Reverse Recovery Charge                                   | Q <sub>rr</sub>                  |                                                                                                                                                          |                                               | -    | 1.6  | -     | μC   |
| Reverse Recovery Current                                  | I <sub>RRM</sub>                 |                                                                                                                                                          |                                               | -    | 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 %  $V_{DS}$ .  
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 %  $V_{DS}$ .

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

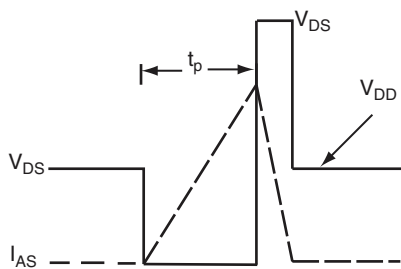

**Fig. 7 - Typical Source-Drain Diode Forward Voltage**

**Fig. 9 - Maximum Drain Current vs. Case Temperature**

**Fig. 8 - Maximum Safe Operating Area**

**Fig. 10 - Temperature vs. Drain-to-Source Voltage**

**Fig. 11 - Normalized Thermal Transient Impedance, Junction-to-Case**


**Fig. 12 - Switching Time Test Circuit**

**Fig. 16 - Basic Gate Charge Waveform**

**Fig. 13 - Switching Time Waveforms**

**Fig. 17 - Gate Charge Test Circuit**

**Fig. 14 - Unclamped Inductive Test Circuit**

**Fig. 15 - Unclamped Inductive Waveforms**

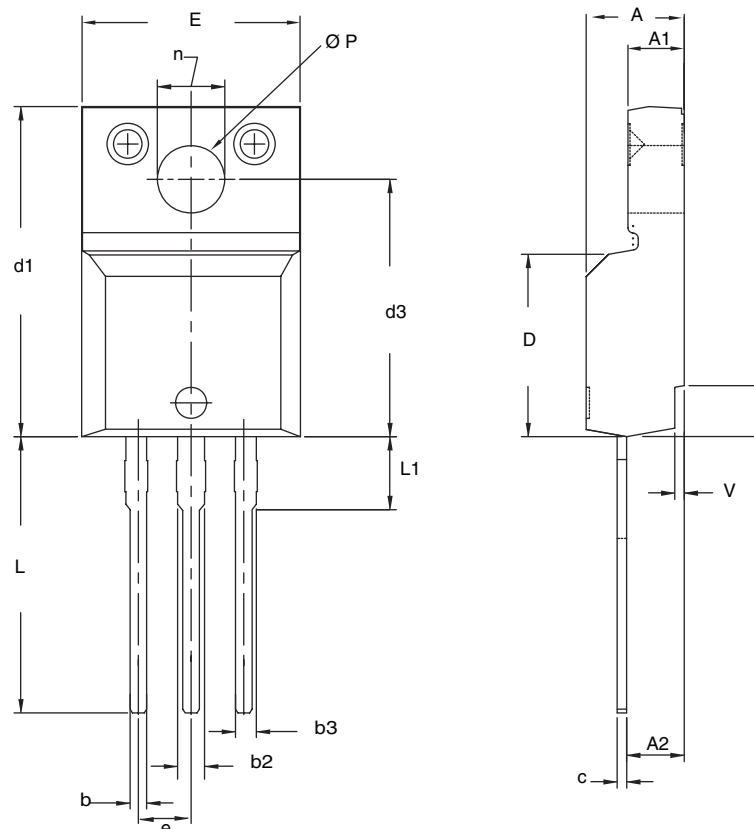

**Note**

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

**Fig. 18 - For N-Channel**

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## TO-220 FULLPAK (HIGH VOLTAGE)



| 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: X09-0126-Rev. B, 26-Oct-09  
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.



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