

## Power MOSFET

**TO-220 FULLPAK**


N-Channel MOSFET

### FEATURES

- Isolated package
- High voltage isolation = 2.5 kV<sub>RMS</sub> (t = 60 s; f = 60 Hz)
- Sink to lead creepage distance = 4.8 mm
- 175 °C operating temperature
- Dynamic dV/dt rating
- Low thermal resistance
- Material categorization: for definitions of compliance please see [www.vishay.com/doc?99912](http://www.vishay.com/doc?99912)


**RoHS**  
COMPLIANT

| PRODUCT SUMMARY          |                              |
|--------------------------|------------------------------|
| V <sub>DS</sub> (V)      | 100                          |
| R <sub>DS(on)</sub> (Ω)  | V <sub>GS</sub> = 10 V 0.077 |
| Q <sub>g</sub> max. (nC) | 72                           |
| Q <sub>gs</sub> (nC)     | 11                           |
| Q <sub>gd</sub> (nC)     | 32                           |
| Configuration            | Single                       |

### DESCRIPTION

Third generation power MOSFETs from Vishay provide the designer with the best combination of fast switching, ruggedized device design, low on-resistance and cost-effectiveness.

The TO-220 FULLPAK eliminates the need for additional insulating hardware in commercial-industrial applications. The molding compound used provides a high isolation capability and a low thermal resistance between the tab and external heatsink. This isolation is equivalent to using a 100 micron mica barrier with standard TO-220 product. The FULLPAK is mounted to a heatsink using a single clip or by a single screw fixing.

| ORDERING INFORMATION |                |
|----------------------|----------------|
| Package              | TO-220 FULLPAK |
| Lead (Pb)-free       | IRFI540GPbF    |

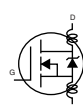
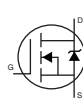
| ABSOLUTE MAXIMUM RATINGS (T <sub>C</sub> = 25 °C, unless otherwise noted) |                                   |                         |                |      |   |
|---|-----------------------------------|-------------------------|----------------|------|---|
| PARAMETER   | SYMBOL                            |                         | LIMIT          | UNIT |   |
| Drain-source voltage  | V <sub>DS</sub>                   |                         | 100            | V    |   |
| Gate-source voltage   | V <sub>GS</sub>                   |                         | ± 20           |      |   |
| Continuous drain current  | V <sub>GS</sub> at 10 V           | T <sub>C</sub> = 25 °C  | 17             | A    |   |
|   |                                   | T <sub>C</sub> = 100 °C | 12             |      |   |
| Pulsed drain current <sup>a</sup>   | I <sub>DM</sub>                   |                         | 68             |      |   |
| Linear derating factor  |                                   |                         | 0.32           | W/°C |   |
| Single pulse avalanche energy <sup>b</sup>                                | E <sub>AS</sub>                   |                         | 720            | mJ   |   |
| Repetitive avalanche current <sup>a</sup>                                 | I <sub>AR</sub>                   |                         | 17             | A    |   |
| Repetitive avalanche energy <sup>a</sup>                                  | E <sub>AR</sub>                   |                         | 4.8            | mJ   |   |
| Maximum power dissipation   | T <sub>C</sub> = 25 °C            |                         | P <sub>D</sub> | 48   | W |
| Peak diode recovery dV/dt <sup>c</sup>                                    | dV/dt                             |                         | 5.5            | V/ns |   |
| Operating junction and storage temperature range                          | T <sub>J</sub> , T <sub>stg</sub> |                         | -55 to +175    | °C   |   |
| Soldering recommendations (peak temperature) <sup>d</sup>                 | For 10 s                          |                         | 300            |      |   |
| Mounting torque   | M3 screw                          |                         | 0.6            | Nm   |   |

#### Notes

- Repetitive rating; pulse width limited by maximum junction temperature (see fig. 11)
- V<sub>DD</sub> = 25 V, starting T<sub>J</sub> = 25 °C, L = 3.7 mH, R<sub>g</sub> = 25 Ω, I<sub>AS</sub> = 17 A (see fig. 12)
- I<sub>SD</sub> ≤ 17 A, dI/dt ≤ 200 A/μs, V<sub>DD</sub> ≤ V<sub>DS</sub>, T<sub>J</sub> ≤ 175 °C
- 1.6 mm from case



| THERMAL RESISTANCE RATINGS       |            |      |      |      |
|----------------------------------|------------|------|------|------|
| PARAMETER                        | SYMBOL     | TYP. | MAX. | UNIT |
| Maximum junction-to-ambient      | $R_{thJA}$ | -    | 65   | °C/W |
| Maximum junction-to-case (drain) | $R_{thJC}$ | -    | 3.1  |      |

| 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  | $V_{DS}$            | $V_{GS} = 0\text{ V}, I_D = 250\text{ }\mu\text{A}$   |  | 100  | -    | -         | V             |
| $V_{DS}$ temperature coefficient  | $\Delta V_{DS}/T_J$ | Reference to $25\text{ }^\circ\text{C}$ , $I_D = 1\text{ mA}$   |  | -    | 0.13 | -         | V/°C          |
| Gate-source threshold voltage   | $V_{GS(th)}$        | $V_{DS} = V_{GS}, I_D = 250\text{ }\mu\text{A}$   |  | 2.0  | -    | 4.0       | V             |
| Gate-source leakage   | $I_{GSS}$           | $V_{GS} = \pm 20\text{ V}$  |  | -    | -    | $\pm 100$ | nA            |
| Zero gate voltage drain current   | $I_{DSS}$           | $V_{DS} = 100\text{ V}, V_{GS} = 0\text{ V}$  |  | -    | -    | 25        | $\mu\text{A}$ |
|   |                     | $V_{DS} = 80\text{ V}, V_{GS} = 0\text{ V}, T_J = 150\text{ }^\circ\text{C}$  |  | -    | -    | 250       |               |
| Drain-source on-state resistance  | $R_{DS(on)}$        | $V_{GS} = 10\text{ V}$  | $I_D = 10\text{ A}^b$  | -    | -    | 0.077     | $\Omega$      |
| Forward transconductance  | $g_{fs}$            | $V_{DS} = 50\text{ V}, I_D = 10\text{ A}^b$   |  | 9.1  | -    | -         | S             |
| <b>Dynamic</b>  |                     |   |  |      |      |           |               |
| Input capacitance   | $C_{iss}$           | $V_{GS} = 0\text{ V}, V_{DS} = 25\text{ V}, f = 1.0\text{ MHz}$ , see fig. 5  |  | -    | 1700 | -         | pF            |
| Output capacitance  | $C_{oss}$           |   |  | -    | 560  | -         |               |
| Reverse transfer capacitance  | $C_{rss}$           |   |  | -    | 120  | -         |               |
| Drain to sink capacitance   | $C$                 | $f = 1.0\text{ MHz}$  |  | -    | 12   | -         |               |
| Total gate charge   | $Q_g$               | $V_{GS} = 10\text{ V}$  | $I_D = 17\text{ A}, V_{DS} = 80\text{ V}$ , see fig. 6 and 13 <sup>b</sup> | -    | -    | 72        | nC            |
| Gate-source charge  | $Q_{gs}$            |   |  | -    | -    | 11        |               |
| Gate-drain charge   | $Q_{gd}$            |   |  | -    | -    | 32        |               |
| Turn-on delay time  | $t_{d(on)}$         | $V_{DD} = 50\text{ V}, I_D = 17\text{ A}, R_g = 9.1\text{ }\Omega, R_D = 2.9\text{ }\Omega$ , see fig. 10 <sup>b</sup>                                  |  | -    | 11   | -         | ns            |
| Rise time   | $t_r$               |   |  | -    | 44   | -         |               |
| Turn-off delay time   | $t_{d(off)}$        |   |  | -    | 53   | -         |               |
| Fall time   | $t_f$               |   |  | -    | 43   | -         |               |
| Gate input resistance   | $R_g$               | $f = 1\text{ MHz}$ , open drain   |  | 0.3  | -    | 1.6       | $\Omega$      |
| Internal drain inductance   | $L_D$               | Between lead, 6 mm (0.25") from package and center of die contact  |  | -    | 4.5  | -         | nH            |
| Internal source inductance  | $L_S$               |   |  | -    | 7.5  | -         |               |
| <b>Drain-Source Body Diode Characteristics</b>                              |                     |   |  |      |      |           |               |
| Continuous source-drain diode current                                       | $I_S$               | MOSFET symbol showing the integral reverse p - n junction diode    |  | -    | -    | 17        | A             |
| Pulsed diode forward current <sup>a</sup>                                   | $I_{SM}$            |   |  | -    | -    | 68        |               |
| Body diode voltage  | $V_{SD}$            | $T_J = 25\text{ }^\circ\text{C}, I_S = 17\text{ A}, V_{GS} = 0\text{ V}^b$  |  | -    | -    | 2.5       | V             |
| Body diode reverse recovery time  | $t_{rr}$            | $T_J = 25\text{ }^\circ\text{C}, I_F = 17\text{ A}, di/dt = 100\text{ A}/\mu\text{s}^b$   |  | -    | 180  | 360       | ns            |
| Body diode reverse recovery charge  | $Q_{rr}$            |   |  | -    | 1.3  | 2.6       | $\mu\text{C}$ |
| 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)

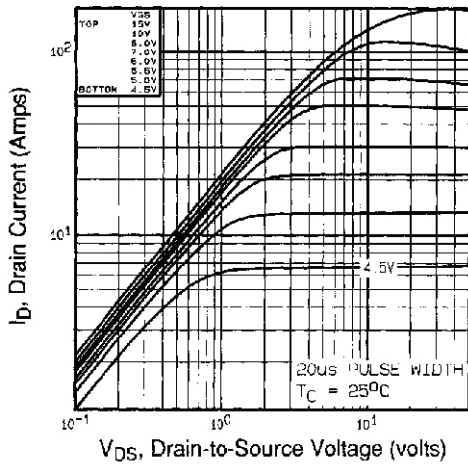


Fig. 1 - Typical Output Characteristics,  $T_C = 25^\circ\text{C}$

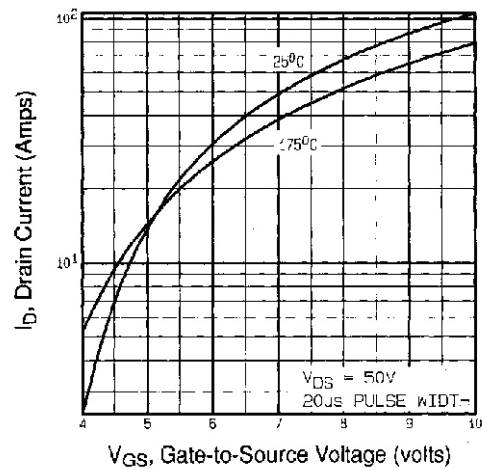


Fig. 3 - Typical Transfer Characteristics

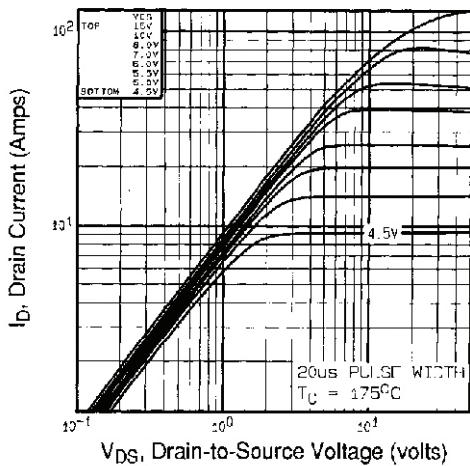


Fig. 2 - Typical Output Characteristics,  $T_C = 175^\circ\text{C}$

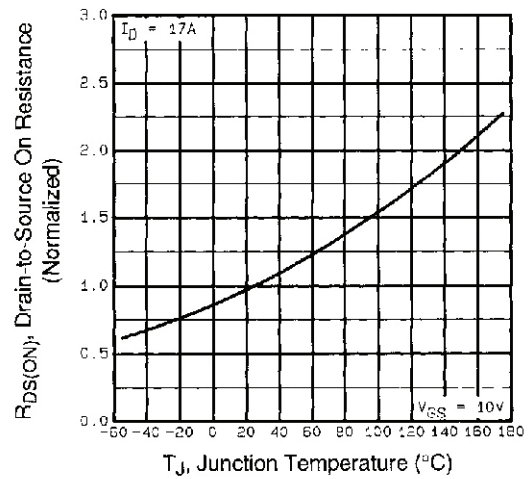


Fig. 4 - Normalized On-Resistance vs. Temperature

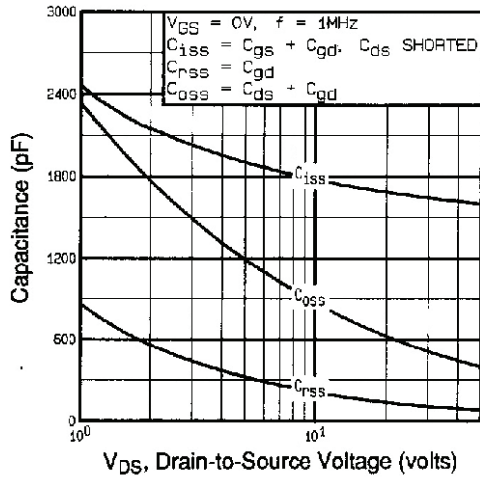


Fig. 5 - Typical Capacitance vs. Drain-to-Source Voltage

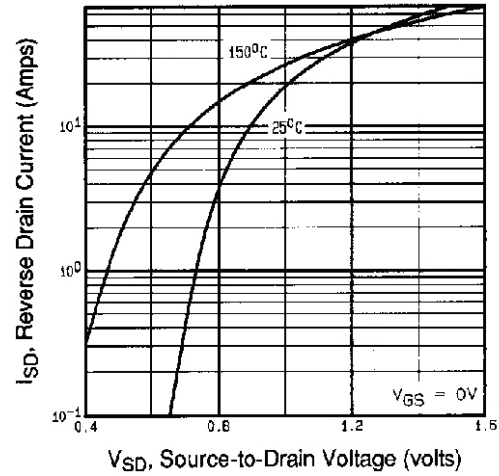


Fig. 7 - Typical Source-Drain Diode Forward Voltage

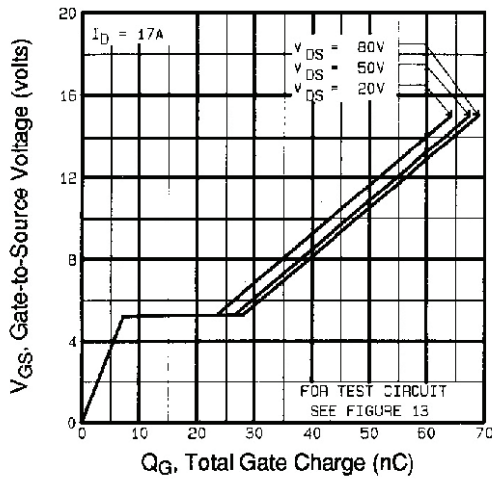


Fig. 6 - Typical Gate Charge vs. Gate-to-Source Voltage

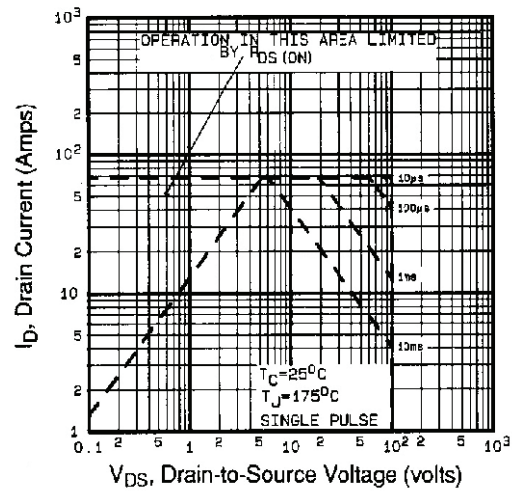


Fig. 8 - Maximum Safe Operating Area

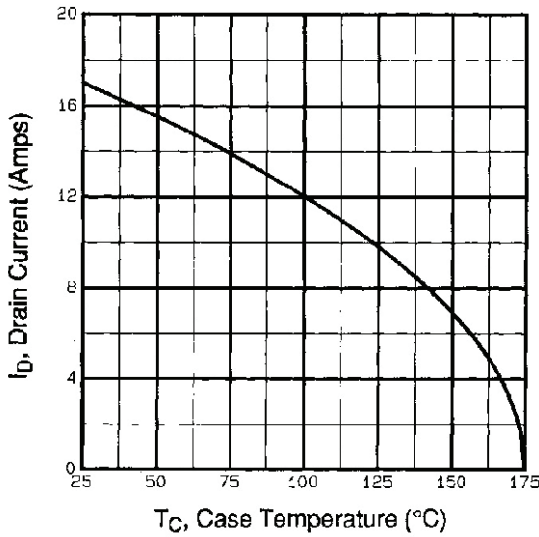


Fig. 9 - Maximum Drain Current vs. Case Temperature



Fig. 10a - Switching Time Test Circuit



Fig. 10b - Switching Time Waveforms

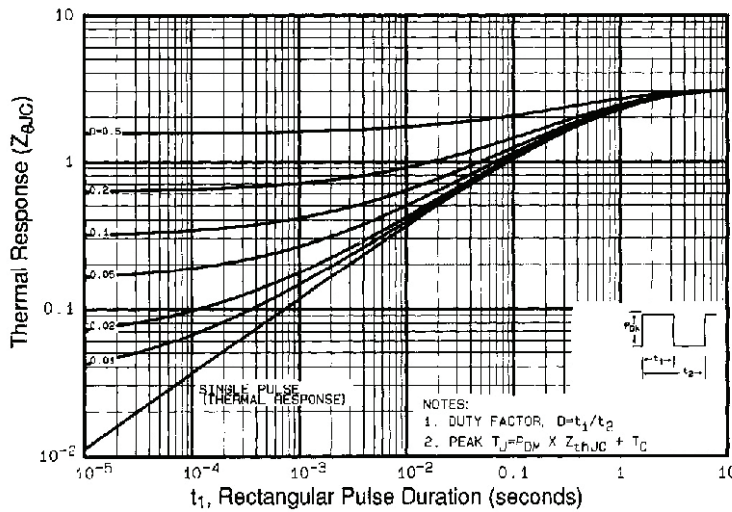


Fig. 11 - Maximum Effective Transient Thermal Impedance, Junction-to-Case

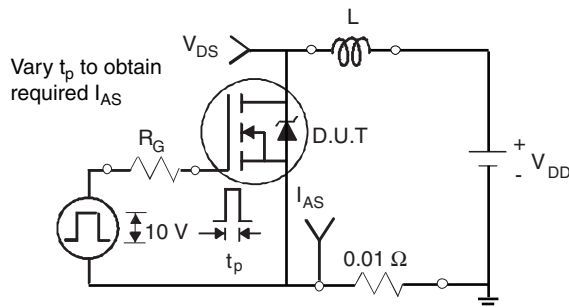


Fig. 12a - Unclamped Inductive Test Circuit

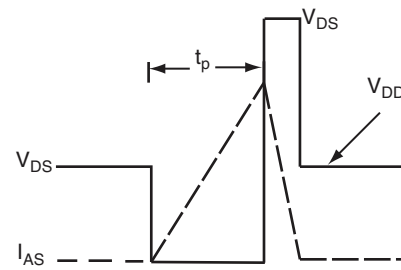
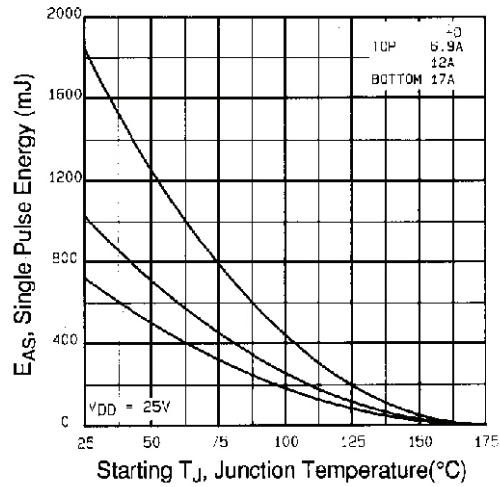
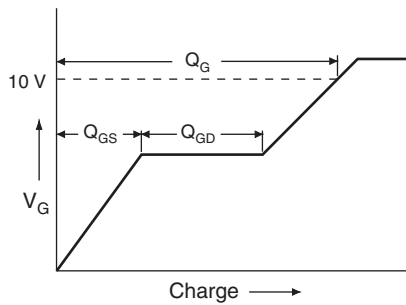


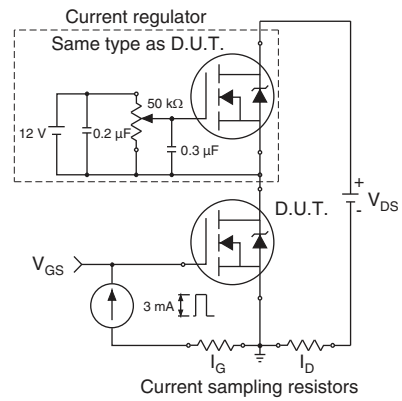
Fig. 12b - Unclamped Inductive Waveforms



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

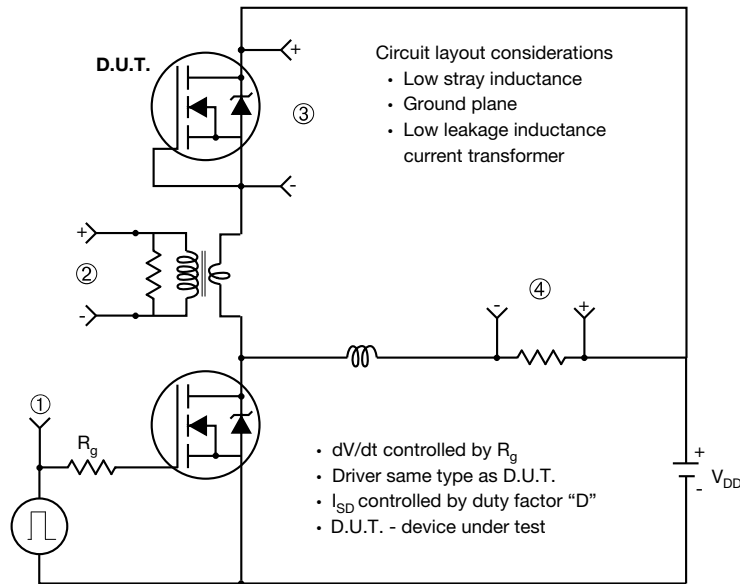


**Fig. 13a - Basic Gate Charge Waveform**



**Fig. 13b - Gate Charge Test Circuit**

**Peak Diode Recovery dV/dt Test Circuit**



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

**Fig. 14 - 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

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3. All critical dimensions should C meet  $C_{pk} > 1.33$
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