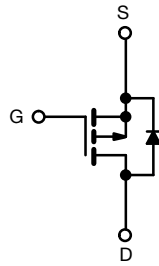


Power MOSFET

TO-220 FULLPAK


P-Channel MOSFET

FEATURES

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


RoHS
COMPLIANT

PRODUCT SUMMARY

| | | |
|----------------------------|-------------------------|------|
| V _{DS} (V) | -60 | |
| R _{DS(on)} (Ω) | V _{GS} = -10 V | 0.28 |
| Q _g (Max.) (nC) | 19 | |
| Q _{gs} (nC) | 5.4 | |
| Q _{gd} (nC) | 11 | |
| 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 | IRFI9Z24GPbF |

ABSOLUTE MAXIMUM RATINGS T_C = 25 °C, unless otherwise noted

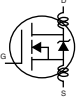

| PARAMETER | SYMBOL | LIMIT | UNIT |
|---|-----------------------------------|-------------------------|------|
| Drain-source voltage | V _{DS} | -60 | V |
| Gate-source voltage | V _{GS} | ± 20 | |
| Continuous drain current | V _{GS} at -10 V | T _C = 25 °C | A |
| | | T _C = 100 °C | |
| Pulsed drain current ^a | I _{DM} | -34 | |
| Linear derating factor | | 0.24 | W/°C |
| Single pulse avalanche energy ^b | E _{AS} | 200 | mJ |
| Repetitive avalanche current ^a | I _{AR} | -8.5 | A |
| Repetitive avalanche energy ^a | E _{AR} | 3.7 | mJ |
| Maximum power dissipation | P _D | 37 | W |
| Peak diode recovery dV/dt ^c | dV/dt | -4.5 | V/ns |
| Operating junction and storage temperature range | T _J , T _{stg} | -55 to +175 | °C |
| Soldering recommendations (peak temperature) ^d | For 10 s | 300 | |
| Mounting torque | M3 screw | 0.6 | |

Notes

- Repetitive rating; pulse width limited by maximum junction temperature (see fig. 11)
- V_{DD} = -25 V, starting T_J = 25 °C, L = 3.2 mH, R_G = 25 Ω, I_{AS} = -8.5 A (see fig. 12)
- I_{SD} ≤ -11 A, dI/dt ≤ 140 A/μs, V_{DD} ≤ V_{DS}, T_J ≤ 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} | - | 4.1 | |

| 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_{DS} | $V_{GS} = 0\text{ V}, I_D = -250\text{ }\mu\text{A}$ | | -60 | - | - | V |
| V_{DS} temperature coefficient | $\Delta V_{DS}/T_J$ | Reference to $25\text{ }^\circ\text{C}$, $I_D = -1\text{ mA}$ | | - | -0.056 | - | 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} | $V_{GS} = \pm 20\text{ V}$ | | - | - | ± 100 | nA |
| Zero gate voltage drain current | I_{DSS} | $V_{DS} = -60\text{ V}, V_{GS} = 0\text{ V}$ | | - | - | -100 | μA |
| | | $V_{DS} = -48\text{ V}, V_{GS} = 0\text{ V}, T_J = 150\text{ }^\circ\text{C}$ | | - | - | -500 | |
| Drain-source on-state resistance | $R_{DS(on)}$ | $V_{GS} = -10\text{ V}$ | $I_D = -5.1\text{ A}^b$ | - | - | 0.28 | Ω |
| Forward transconductance | g_{fs} | $V_{DS} = -25\text{ V}, I_D = -5.1\text{ A}^b$ | | 3.2 | - | - | S |
| Dynamic | | | | | | | |
| Input capacitance | C_{iss} | $V_{GS} = 0\text{ V}, V_{DS} = -25\text{ V}, f = 1.0\text{ MHz}$, see fig. 5 | | - | 570 | - | pF |
| Output capacitance | C_{oss} | | | - | 360 | - | |
| Reverse transfer capacitance | C_{rss} | | | - | 65 | - | |
| Drain to sink capacitance | C | $f = 1.0\text{ MHz}$ | | - | 12 | - | |
| Total gate charge | Q_g | $V_{GS} = -10\text{ V}$ | $I_D = -11\text{ A}, V_{DS} = -48\text{ V}$, see fig. 6 and 13 ^b | - | - | 19 | nC |
| Gate-source charge | Q_{gs} | | | - | - | 5.4 | |
| Gate-drain charge | Q_{gd} | | | - | - | 11 | |
| Turn-on delay time | $t_{d(on)}$ | $V_{DD} = -30\text{ V}, I_D = -11\text{ A}, R_G = 18\text{ }\Omega, R_D = 2.5\text{ }\Omega$, see fig. 10 ^b | | - | 13 | - | ns |
| Rise time | t_r | | | - | 68 | - | |
| Turn-off delay time | $t_{d(off)}$ | | | - | 15 | - | |
| Fall time | t_f | | | - | 29 | - | |
| 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 | - | |
| Drain-Source Body Diode Characteristics | | | | | | | |
| Continuous source-drain diode current | I_S | MOSFET symbol showing the integral reverse p-n junction diode  | | - | - | -8.5 | A |
| Pulsed diode forward current ^a | I_{SM} | | | - | - | -34 | |
| Body diode voltage | V_{SD} | $T_J = 25\text{ }^\circ\text{C}, I_S = -8.5\text{ A}, V_{GS} = 0\text{ V}^b$ | | - | - | -6.3 | V |
| Body diode reverse recovery time | t_{rr} | $T_J = 25\text{ }^\circ\text{C}, I_F = -11\text{ A}, dI/dt = 100\text{ A}/\mu\text{s}^b$ | | - | 100 | 200 | ns |
| Body diode reverse recovery charge | Q_{rr} | | | - | 0.32 | 0.64 | μC |
| 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

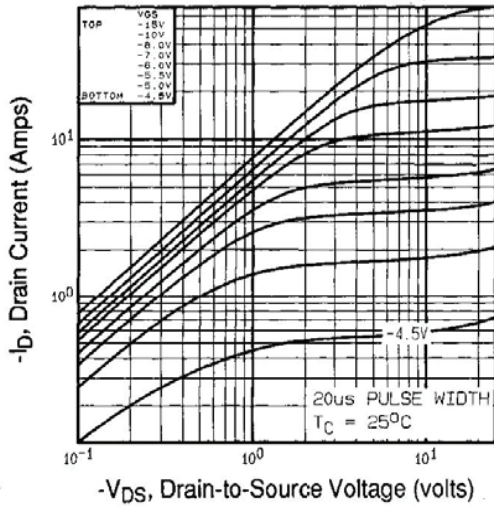


Fig. 1 - Typical Output Characteristics, $T_C = 25^\circ\text{C}$

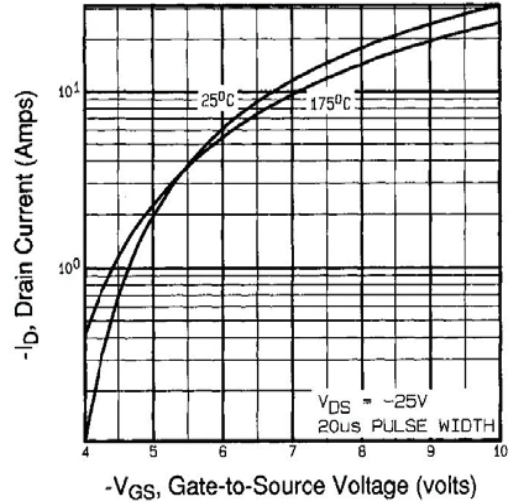


Fig. 3 - Typical Transfer Characteristics

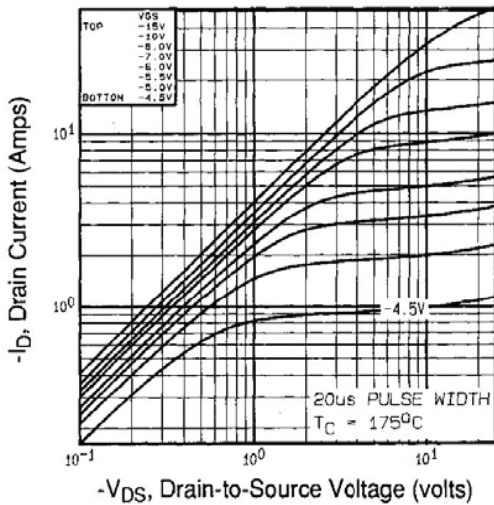


Fig. 2 - Typical Output Characteristics, $T_C = 175^\circ\text{C}$

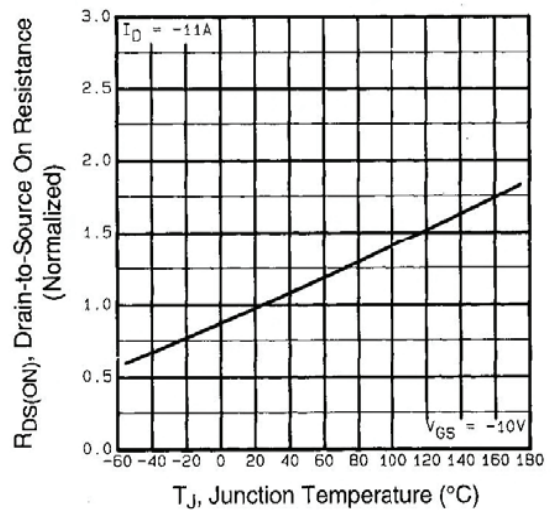


Fig. 4 - Normalized On-Resistance vs. Temperature

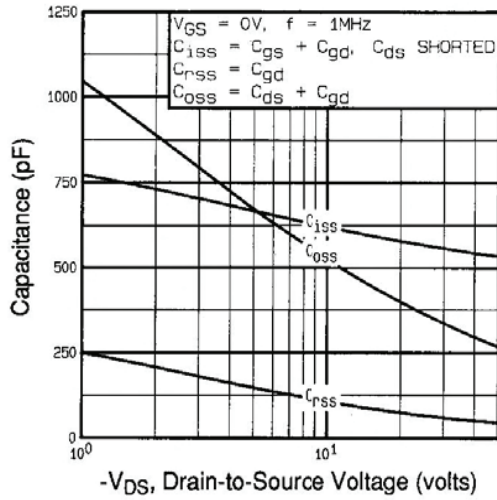


Fig. 5 - Typical Capacitance vs. Drain-to-Source Voltage

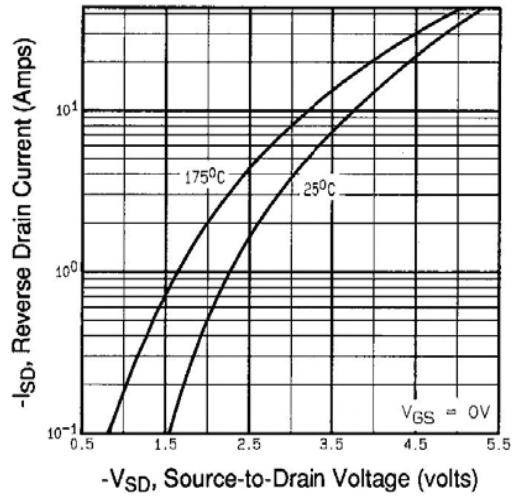


Fig. 7 - Typical Source-Drain Diode Forward Voltage

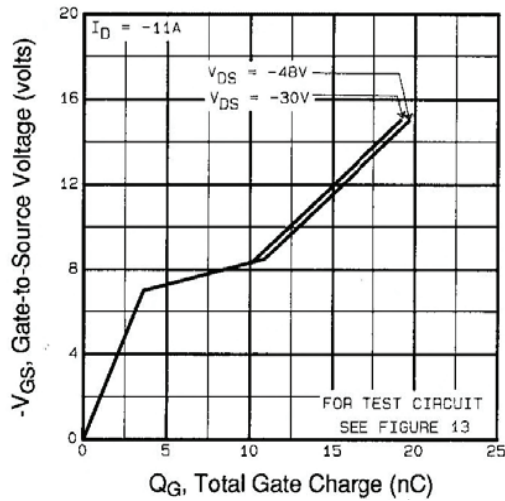


Fig. 6 - Typical Gate Charge vs. Gate-to-Source Voltage

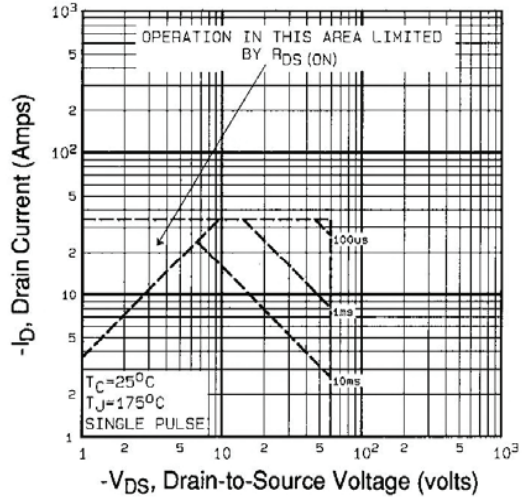


Fig. 8 - Maximum Safe Operating Area

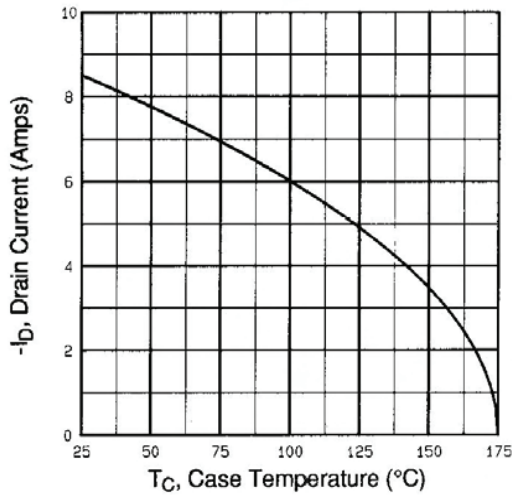


Fig. 9 - Maximum Drain Current vs. Case Temperature

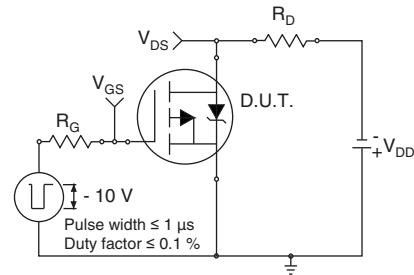


Fig. 10a - Switching Time Test Circuit

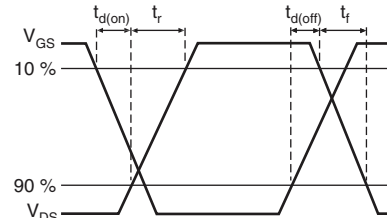


Fig. 10b - Switching Time Waveforms

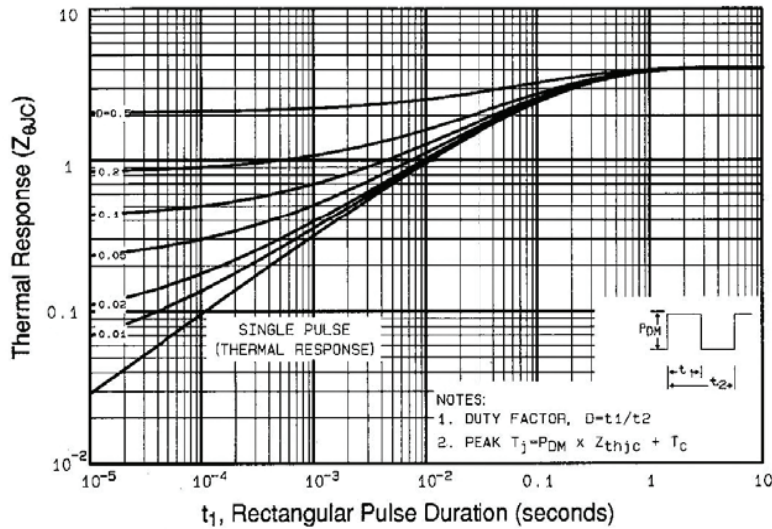


Fig. 11 - Maximum Effective Transient Thermal Impedance, Junction-to-Case

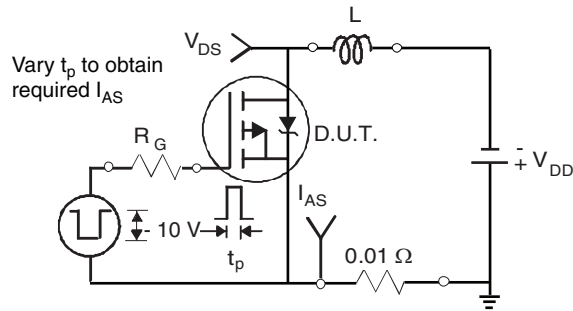


Fig. 12a - Unclamped Inductive Test Circuit

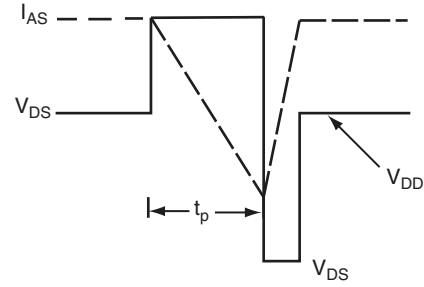


Fig. 12b - Unclamped Inductive Waveforms

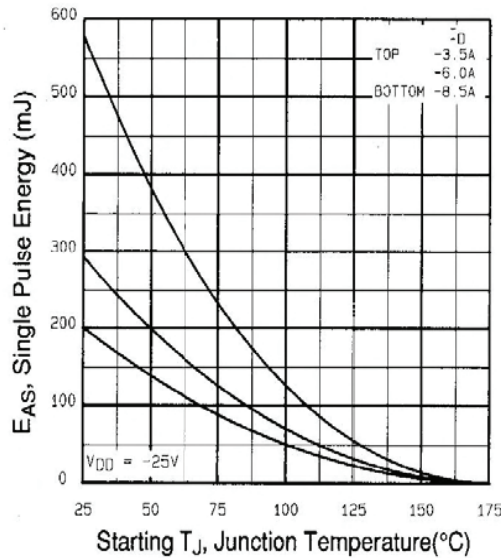


Fig. 12c - Maximum Avalanche Energy vs. Drain Current

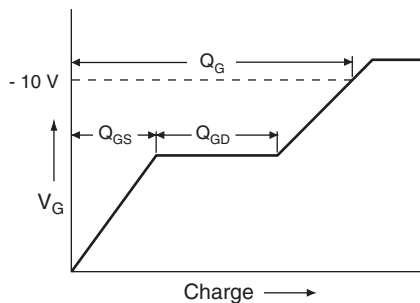


Fig. 13a - Basic Gate Charge Waveform

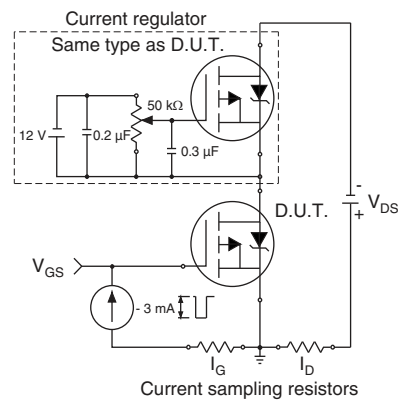
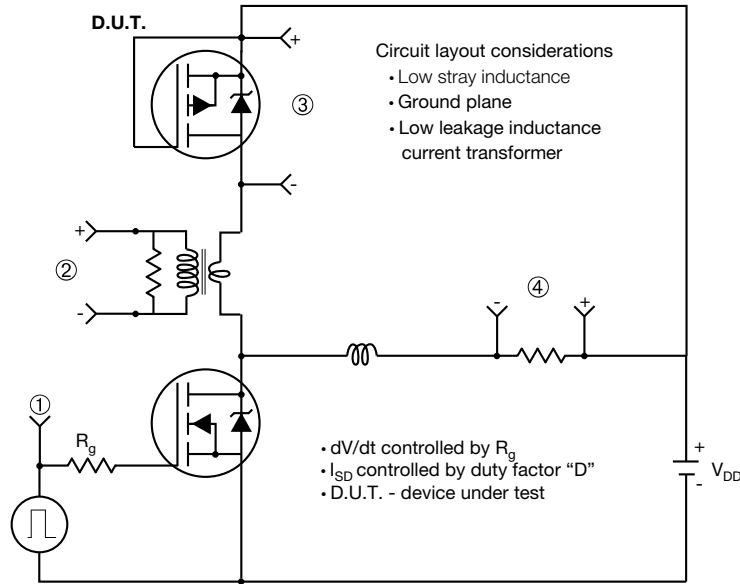


Fig. 13b - Gate Charge Test Circuit

Peak Diode Recovery dV/dt Test Circuit



Note
• Compliment N-Channel of D.U.T. for driver

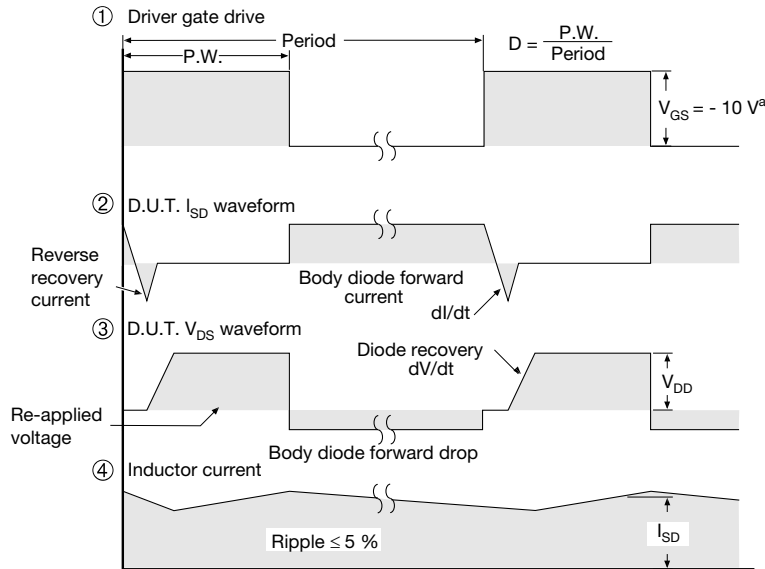


Fig. 14 - For P-Channel

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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 1st character located at the 2nd 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

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2. These dimensions apply to all TO-220 FULLPAK leadframe versions 3 leads
3. All critical dimensions should C meet $C_{pk} > 1.33$
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