



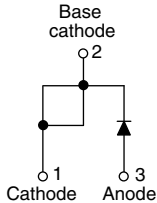
## Ultralow $V_F$ Hyperfast Rectifier for Discontinuous Mode PFC, 15 A FRED Pt®



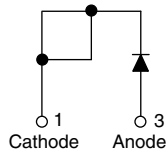
TO-220AC



TO-220 FULL-PAK



VS-15ETL06PbF  
VS-15ETL06-N3



VS-15ETL06FPPbF  
VS-15ETL06FP-N3

### FEATURES

- Hyperfast recovery time
- Benchmark ultralow forward voltage drop
- 175 °C operating junction temperature
- Low leakage current
- Fully isolated package ( $V_{INS} = 2500 V_{RMS}$ )
- UL E78996 pending
- Compliant to RoHS Directive 2002/95/EC
- Designed and qualified according to JEDEC-JESD47
- Halogen-free according to IEC 61249-2-21 definition (-N3 only)



### DESCRIPTION

State of the art, ultralow  $V_F$ , soft-switching hyperfast rectifiers optimized for Discontinuous (Critical) Mode (DCM) Power Factor Correction (PFC).

The minimized conduction loss, optimized stored charge and low recovery current minimize the switching losses and reduce over dissipation in the switching element and snubbers.

The device is also intended for use as a freewheeling diode in power supplies and other power switching applications.

### APPLICATIONS

AC/DC SMPS 70 W to 400 W

e.g. laptop and printer AC adaptors, desktop PC, TV and monitor, games units and DVD AC/DC power supplies.

| PRODUCT SUMMARY |                    |
|-----------------|--------------------|
| Package         | TO-220AC, TO-220FP |
| $I_{F(AV)}$     | 15 A               |
| $V_R$           | 600 V              |
| $V_F$ at $I_F$  | 1.05 V             |
| $t_{rr}$ typ.   | 60 ns              |
| $T_J$ max.      | 175 °C             |
| Diode variation | Single die         |

| ABSOLUTE MAXIMUM RATINGS                    |                |                                  |             |       |
|---|----------------|----------------------------------|-------------|-------|
| PARAMETER                                   | SYMBOL         | TEST CONDITIONS                  | VALUES      | UNITS |
| Peak repetitive reverse voltage             | $V_{RRM}$      |                                  | 600         | V     |
| Average rectified forward current           | $I_{F(AV)}$    | $T_C = 154\text{ °C}$            | 15          | A     |
|   |                | $T_C = 120\text{ °C (FULL-PAK)}$ |             |       |
| Non-repetitive peak surge current           | $I_{FSM}$      | $T_J = 25\text{ °C}$             | 250         |       |
| Peak repetitive forward current             | $I_{FM}$       |                                  | 30          |       |
| Operating junction and storage temperatures | $T_J, T_{Stg}$ |                                  | - 65 to 175 | °C    |

| ELECTRICAL SPECIFICATIONS ( $T_J = 25\text{ °C}$ unless otherwise specified) |               |  |      |      |      |         |
|--|---------------|--|------|------|------|---------|
| PARAMETER  | SYMBOL        | TEST CONDITIONS                              | MIN. | TYP. | MAX. | UNITS   |
| Breakdown voltage, blocking voltage  | $V_{BR}, V_R$ | $I_R = 100\ \mu A$                           | 600  | -    | -    | V       |
| Forward voltage  | $V_F$         | $I_F = 15\text{ A}$                          | -    | 0.99 | 1.05 |         |
|  |               | $I_F = 15\text{ A}, T_J = 150\text{ °C}$     | -    | 0.85 | 0.92 |         |
| Reverse leakage current  | $I_R$         | $V_R = V_R$ rated                            | -    | 0.1  | 10   | $\mu A$ |
|  |               | $T_J = 150\text{ °C}, V_R = V_R$ rated       | -    | 15   | 120  |         |
| Junction capacitance   | $C_T$         | $V_R = 600\text{ V}$                         | -    | 20   | -    | pF      |
| Series inductance  | $L_S$         | Measured lead to lead 5 mm from package body | -    | 8.0  | -    | nH      |



| DYNAMIC RECOVERY CHARACTERISTICS (T <sub>C</sub> = 25 °C unless otherwise specified) |                  |  |      |      |      |       |
|--|------------------|--|------|------|------|-------|
| PARAMETER  | SYMBOL           | TEST CONDITIONS  | MIN. | TYP. | MAX. | UNITS |
| Reverse recovery time  | t <sub>rr</sub>  | I <sub>F</sub> = 1 A, di <sub>F</sub> /dt = 100 A/μs, V <sub>R</sub> = 30 V  | -    | 60   | 120  | ns    |
|  |                  | I <sub>F</sub> = 15 A, di <sub>F</sub> /dt = 100 A/μs, V <sub>R</sub> = 30 V | -    | 190  | 270  |       |
|  |                  | T <sub>J</sub> = 25 °C   | -    | 220  | -    |       |
|  |                  | T <sub>J</sub> = 125 °C  | -    | 320  | -    |       |
| Peak recovery current  | I <sub>RRM</sub> | T <sub>J</sub> = 25 °C   | -    | 19   | -    | A     |
|  |                  | T <sub>J</sub> = 125 °C  | -    | 26   | -    |       |
| Reverse recovery charge  | Q <sub>rr</sub>  | T <sub>J</sub> = 25 °C   | -    | 2.2  | -    | μC    |
|  |                  | T <sub>J</sub> = 125 °C  | -    | 4.3  | -    |       |

| THERMAL - MECHANICAL SPECIFICATIONS             |                                   |  |           |      |         |                     |
|---|-----------------------------------|--|-----------|------|---------|---------------------|
| PARAMETER                                       | SYMBOL                            | TEST CONDITIONS                            | MIN.      | TYP. | MAX.    | UNITS               |
| Maximum junction and storage temperature range  | T <sub>J</sub> , T <sub>Stg</sub> |  | - 65      | -    | 175     | °C                  |
| Thermal resistance, junction to case (FULL-PAK) | R <sub>thJC</sub>                 |  | -         | 1.0  | 1.3     | °C/W                |
|   |                                   |  | -         | 3.0  | 3.5     |                     |
| Thermal resistance, junction to ambient per leg | R <sub>thJA</sub>                 | Typical socket mount                       | -         | -    | 70      | °C/W                |
| Thermal resistance, case to heatsink            | R <sub>thCS</sub>                 | Mounting surface, flat, smooth and greased | -         | 0.5  | -       |                     |
| Weight  |                                   |  | -         | 2.0  | -       | g                   |
|   |                                   |  | -         | 0.07 | -       | oz.                 |
| Mounting torque                                 |                                   |  | 6.0 (5.0) | -    | 12 (10) | kgf · cm (lbf · in) |
| Marking device                                  |                                   | Case style TO-220AC                        | 15ETL06   |      |         |                     |
|   |                                   | Case style TO-220AC FULL-PAK               | 15ETL06FP |      |         |                     |

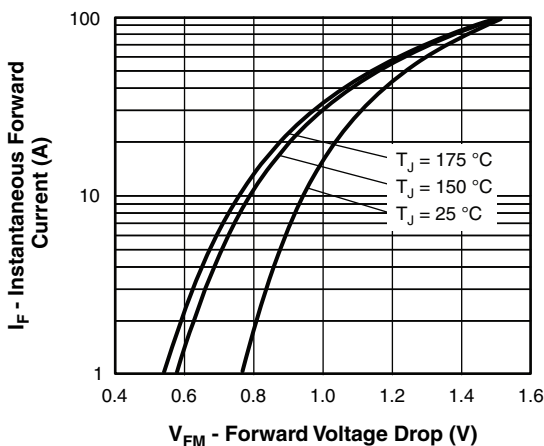


Fig. 1 - Maximum Forward Voltage Drop Characteristics

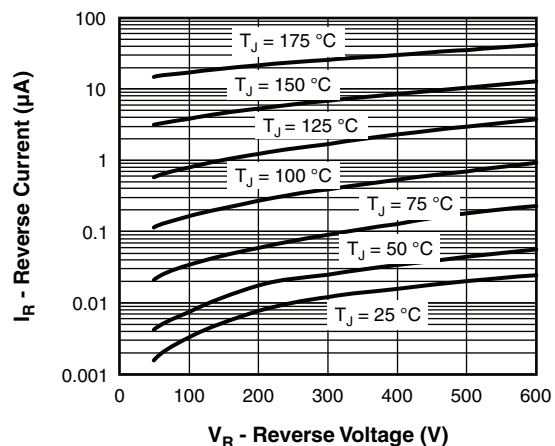


Fig. 2 - Typical Values of Reverse Current vs. Reverse Voltage

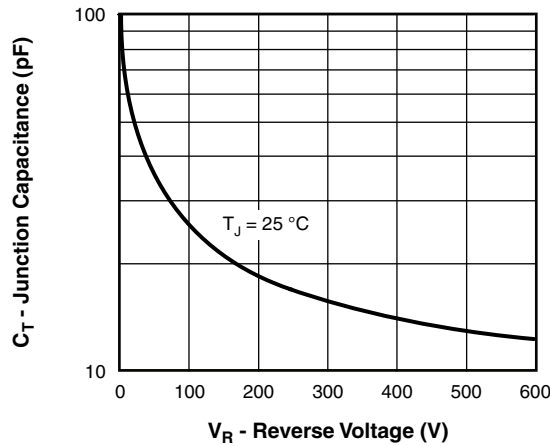


Fig. 3 - Typical Junction Capacitance vs. Reverse Voltage

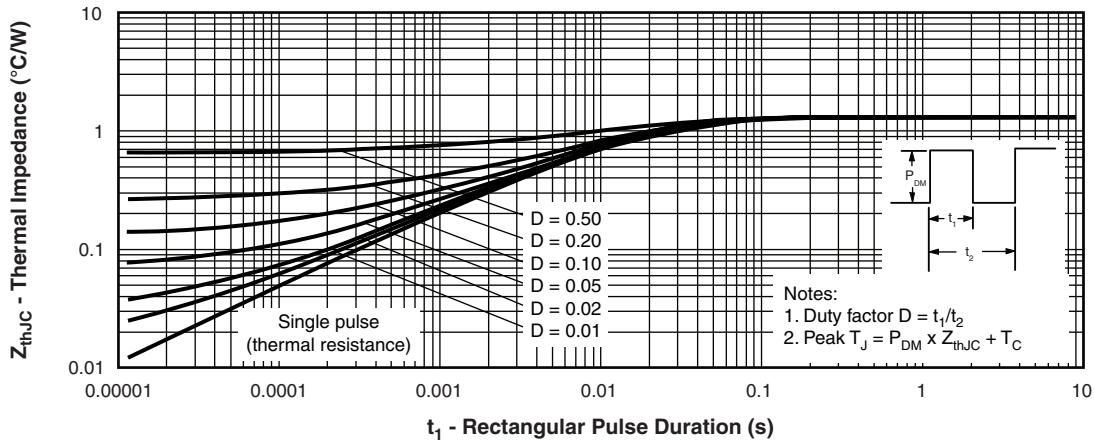


Fig. 4 - Maximum Thermal Impedance  $Z_{thJC}$  Characteristics

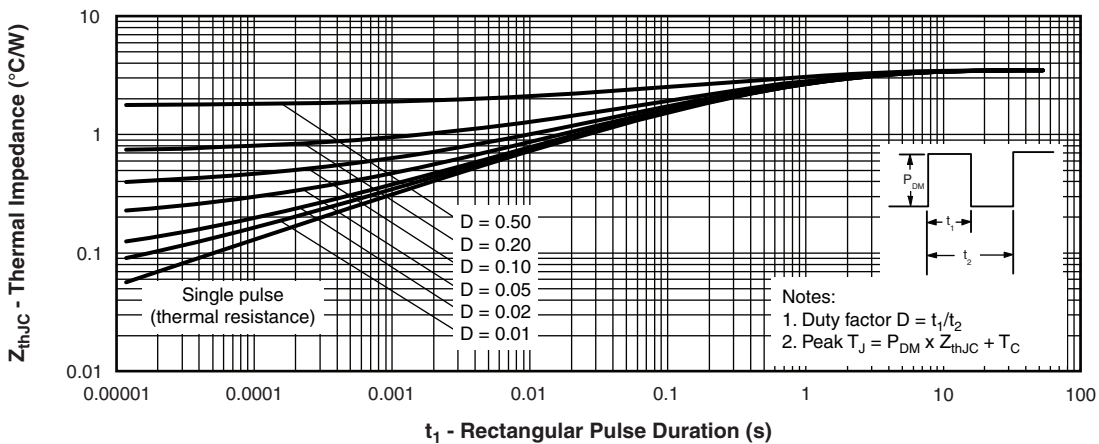


Fig. 5 - Maximum Thermal Impedance  $Z_{thJC}$  Characteristics (FULL-PAK)

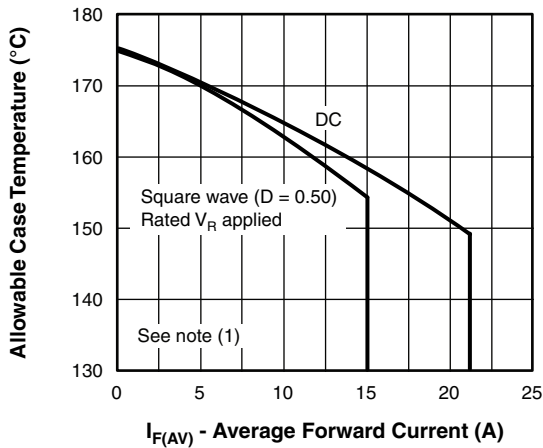


Fig. 6 - Maximum Allowable Case Temperature vs. Average Forward Current

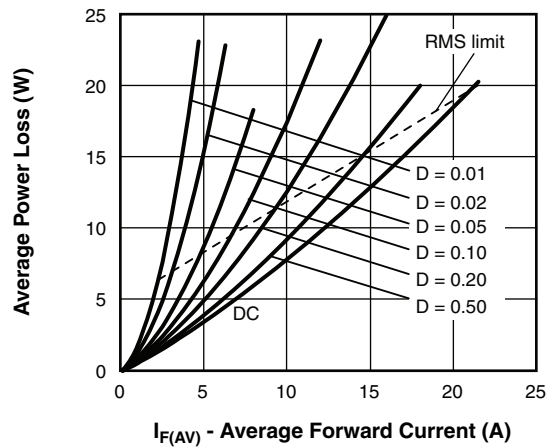


Fig. 8 - Forward Power Loss Characteristics

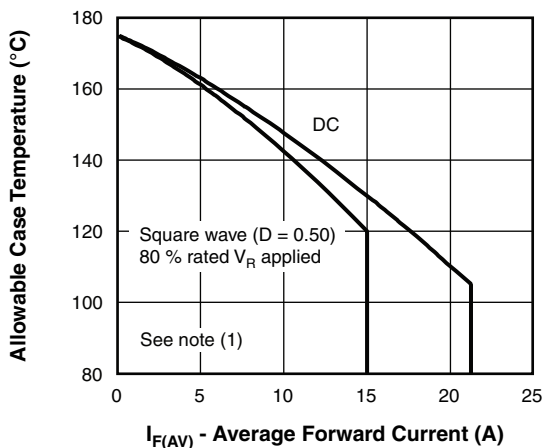


Fig. 7 - Maximum Allowable Case Temperature vs. Average Forward Current (FULL-PAK)

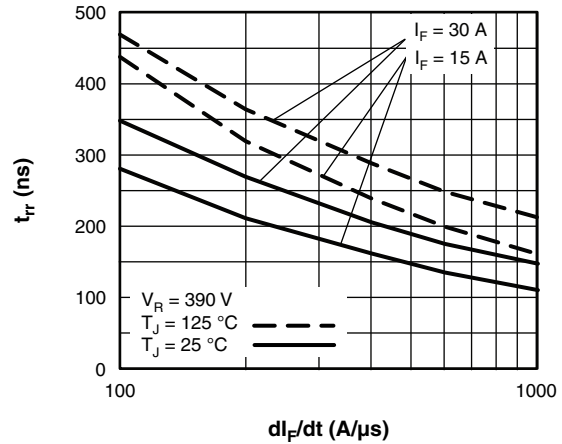


Fig. 9 - Typical Reverse Recovery Time vs.  $dI_F/dt$

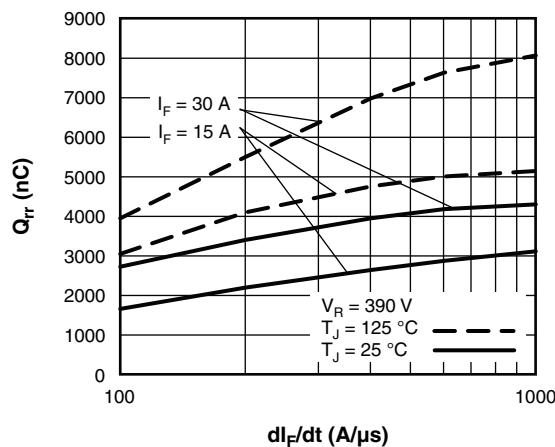


Fig. 10 - Typical Stored Charge vs.  $dI_F/dt$

**Note**

- (1) Formula used:  $T_C = T_J - (Pd + Pd_{REV}) \times R_{thJC}$ ;  
 $Pd$  = Forward power loss =  $I_{F(AV)} \times V_{FM}$  at  $(I_{F(AV)}/D)$  (see fig. 8);  
 $Pd_{REV}$  = Inverse power loss =  $V_{R1} \times I_R (1 - D)$ ;  $I_R$  at  $V_{R1}$  = Rated  $V_R$

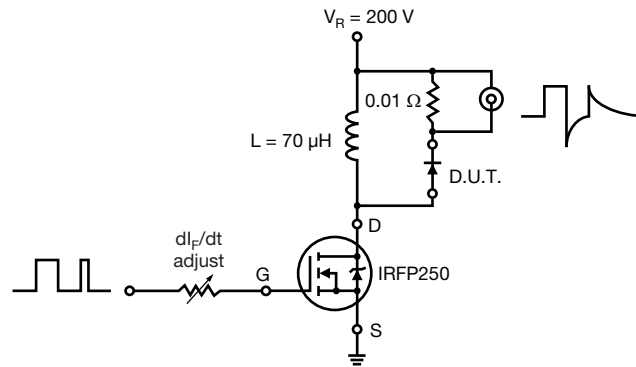
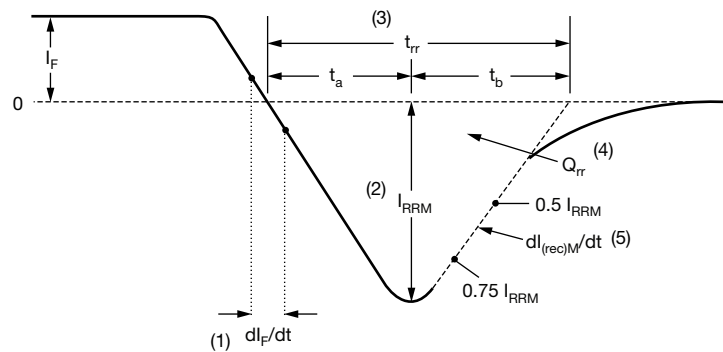


Fig. 11 - Reverse Recovery Parameter Test Circuit



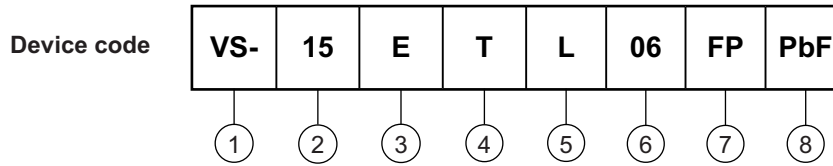
- (1)  $dI_F/dt$  - rate of change of current through zero crossing
- (2)  $I_{RRM}$  - peak reverse recovery current
- (3)  $t_{rr}$  - reverse recovery time measured from zero crossing point of negative going  $I_F$  to point where a line passing through  $0.75 I_{RRM}$  and  $0.50 I_{RRM}$  extrapolated to zero current.
- (4)  $Q_{rr}$  - area under curve defined by  $t_{rr}$  and  $I_{RRM}$
- (5)  $dI_{(rec)M}/dt$  - peak rate of change of current during  $t_b$  portion of  $t_{rr}$

$$Q_{rr} = \frac{t_{rr} \times I_{RRM}}{2}$$

Fig. 12 - Reverse Recovery Waveform and Definitions



ORDERING INFORMATION TABLE



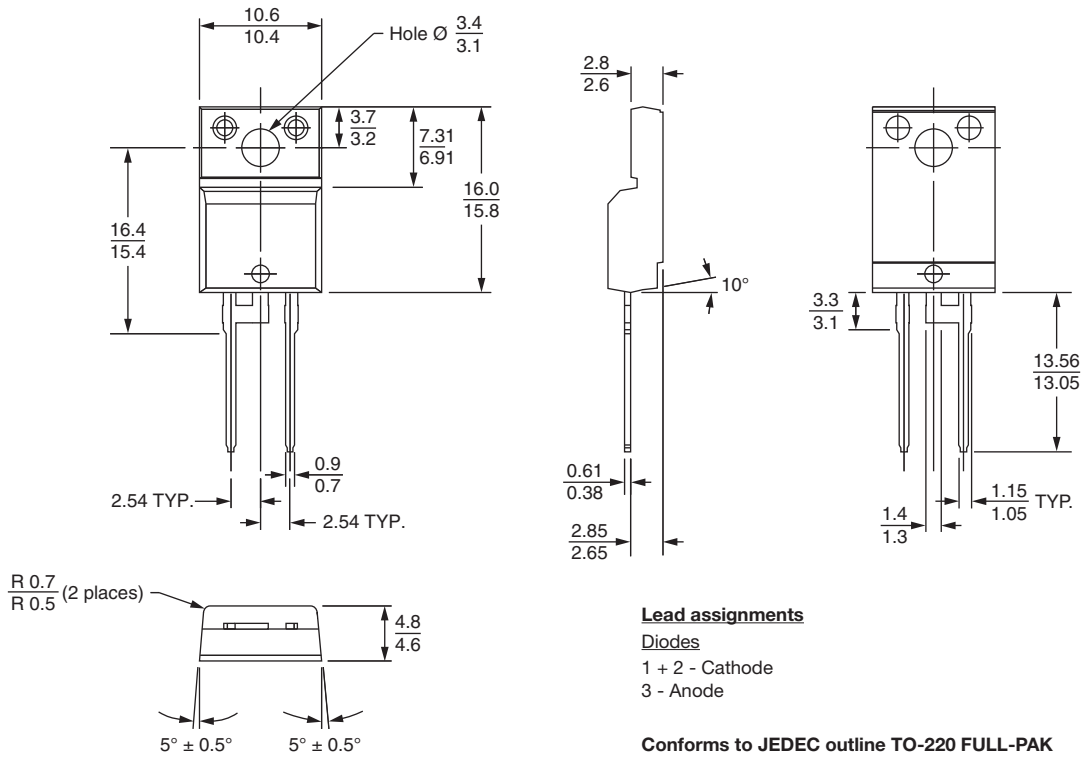
- 1** - Vishay Semiconductors product
- 2** - Current rating (15 = 15 A)
- 3** - E = Single diode
- 4** - T = TO-220, D<sup>2</sup>PAK
- 5** - L = Ultralow V<sub>F</sub> hyperfast recovery
- 6** - Voltage rating (06 = 600 V)
- 7** -
  - None = TO-220AC
  - FP = TO-220 FULL-PAK
- 8** - Environmental digit:
  - PbF = Lead (Pb)-free and RoHS compliant
  - N3 = Halogen-free, RoHS compliant and totally lead (Pb)-free

| ORDERING INFORMATION (Example) |                  |                        |                         |
|--------------------------------|------------------|------------------------|-------------------------|
| PREFERRED P/N                  | QUANTITY PER T/R | MINIMUM ORDER QUANTITY | PACKAGING DESCRIPTION   |
| VS-15ETL06PbF                  | 50               | 1000                   | Antistatic plastic tube |
| VS-15ETL06-N3                  | 50               | 1000                   | Antistatic plastic tube |
| VS-15ETL06FPPbF                | 50               | 1000                   | Antistatic plastic tube |
| VS-15ETL06FP-N3                | 50               | 1000                   | Antistatic plastic tube |

| LINKS TO RELATED DOCUMENTS |             |  |
|----------------------------|-------------|--|
| Dimensions                 | TO-220AC    | <a href="http://www.vishay.com/doc?95221">www.vishay.com/doc?95221</a> |
|                            | TO-220FP    | <a href="http://www.vishay.com/doc?95005">www.vishay.com/doc?95005</a> |
| Part marking information   | TO-220ACPbF | <a href="http://www.vishay.com/doc?95224">www.vishay.com/doc?95224</a> |
|                            | TO-220AC-N3 | <a href="http://www.vishay.com/doc?95068">www.vishay.com/doc?95068</a> |
|                            | TO-220FPPbF | <a href="http://www.vishay.com/doc?95009">www.vishay.com/doc?95009</a> |
|                            | TO-220FP-N3 | <a href="http://www.vishay.com/doc?95440">www.vishay.com/doc?95440</a> |

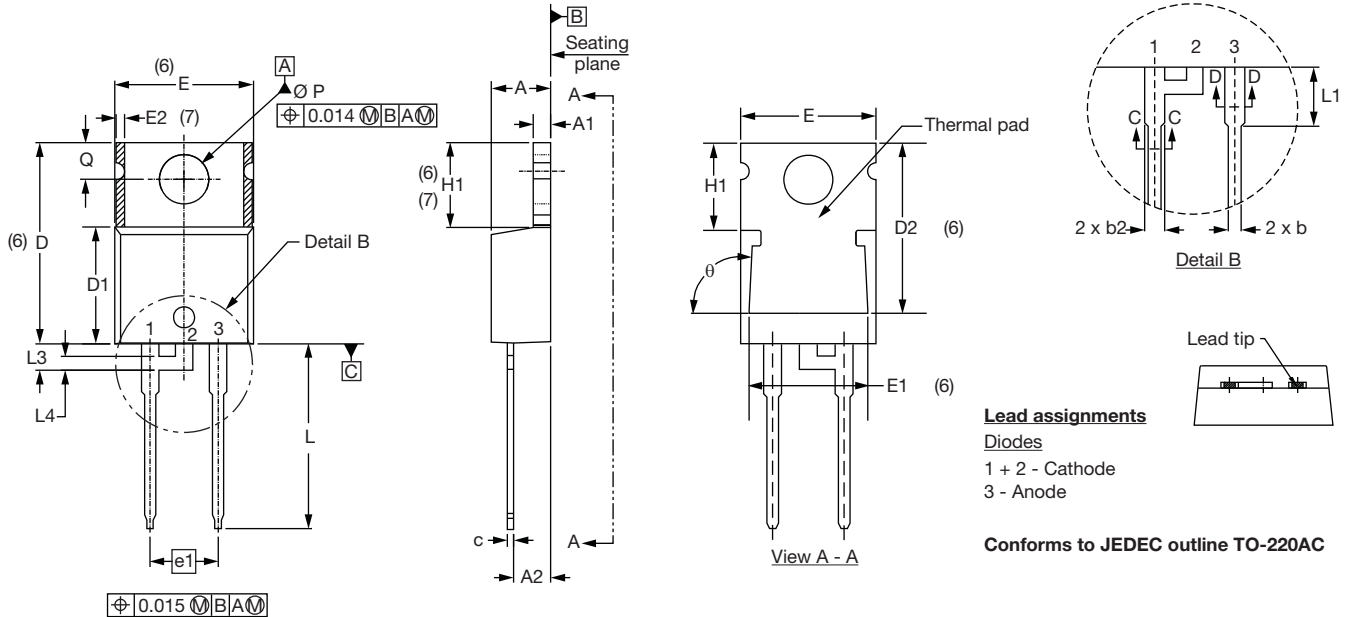


**DIMENSIONS** in millimeters



## TO-220AC

**DIMENSIONS** in millimeters and inches



| SYMBOL          | MILLIMETERS |       | INCHES     |       | NOTES |
|-----------------|-------------|-------|------------|-------|-------|
|                 | MIN.        | MAX.  | MIN.       | MAX.  |       |
| A               | 4.25        | 4.65  | 0.167      | 0.183 |       |
| A1              | 1.14        | 1.40  | 0.045      | 0.055 |       |
| A2              | 2.56        | 2.92  | 0.101      | 0.115 |       |
| b               | 0.69        | 1.01  | 0.027      | 0.040 |       |
| b1              | 0.38        | 0.97  | 0.015      | 0.038 | 4     |
| b2              | 1.20        | 1.73  | 0.047      | 0.068 |       |
| b3              | 1.14        | 1.73  | 0.045      | 0.068 | 4     |
| c               | 0.36        | 0.61  | 0.014      | 0.024 |       |
| c1              | 0.36        | 0.56  | 0.014      | 0.022 | 4     |
| D               | 14.85       | 15.25 | 0.585      | 0.600 | 3     |
| D1              | 8.38        | 9.02  | 0.330      | 0.355 |       |
| D2              | 11.68       | 12.88 | 0.460      | 0.507 | 6     |
| E               | 10.11       | 10.51 | 0.398      | 0.414 | 3, 6  |
| E1              | 6.86        | 8.89  | 0.270      | 0.350 | 6     |
| E2              | -           | 0.76  | -          | 0.030 | 7     |
| e               | 2.41        | 2.67  | 0.095      | 0.105 |       |
| e1              | 4.88        | 5.28  | 0.192      | 0.208 |       |
| H1              | 6.09        | 6.48  | 0.240      | 0.255 | 6, 7  |
| L               | 13.52       | 14.02 | 0.532      | 0.552 |       |
| L1              | 3.32        | 3.82  | 0.131      | 0.150 | 2     |
| L3              | 1.78        | 2.13  | 0.070      | 0.084 |       |
| L4              | 0.76        | 1.27  | 0.030      | 0.050 | 2     |
| $\varnothing P$ | 3.54        | 3.73  | 0.139      | 0.147 |       |
| Q               | 2.60        | 3.00  | 0.102      | 0.118 |       |
| $\theta$        | 90° to 93°  |       | 90° to 93° |       |       |

**Notes**

- (1) Dimensioning and tolerancing as per ASME Y14.5M-1994
- (2) Lead dimension and finish uncontrolled in L1
- (3) Dimension D, D1 and E do not include mold flash. Mold flash shall not exceed 0.127 mm (0.005") per side. These dimensions are measured at the outermost extremes of the plastic body
- (4) Dimension b1, b3 and c1 apply to base metal only
- (5) Controlling dimension: inches
- (6) Thermal pad contour optional within dimensions E, H1, D2 and E1
- (7) Dimension E2 x H1 define a zone where stamping and singulation irregularities are allowed
- (8) Outline conforms to JEDEC TO-220, D2 (minimum) where dimensions are derived from the actual package outline





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