



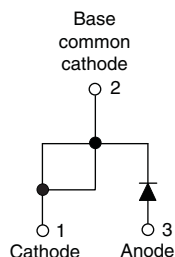
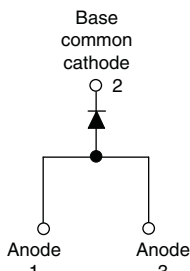
## Ultrafast Soft Recovery Diode, 60 A FRED Pt®



TO-247AC modified



TO-247AC

VS-60EPU02PbF  
VS-60EPU02-N3VS-60APU02PbF  
VS-60APU02-N3

## FEATURES

- Ultrafast recovery time
- Low forward voltage drop
- 175 °C operating junction temperature
- Output rectification
- 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)



**RoHS**  
COMPLIANT  
HALOGEN  
**FREE**  
Available

## BENEFITS

- Reduced RFI and EMI
- Higher frequency operation
- Reduced snubbing
- Reduced parts count

## DESCRIPTION/APPLICATIONS

These diodes are optimized to reduce losses and EMI/RFI in high frequency power conditioning systems.

The softness of the recovery eliminates the need for a snubber in most applications. These devices are ideally suited for HF welding, power converters and other applications where switching losses are not significant portion of the total losses.

## PRODUCT SUMMARY

|                 |                                         |
|-----------------|-----------------------------------------|
| Package         | TO-247AC,<br>TO-247AC modified (2 pins) |
| $I_{F(AV)}$     | 60 A                                    |
| $V_R$           | 200 V                                   |
| $V_F$ at $I_F$  | 1.08 V                                  |
| $t_{rr}$ typ.   | See Recovery table                      |
| $T_J$ max.      | 175 °C                                  |
| Diode variation | Single die                              |

## ABSOLUTE MAXIMUM RATINGS

| PARAMETER                                   | SYMBOL         | TEST CONDITIONS       | VALUES      | UNITS |
|---------------------------------------------|----------------|-----------------------|-------------|-------|
| Cathode to anode voltage                    | $V_R$          |                       | 200         | V     |
| Continuous forward current                  | $I_{F(AV)}$    | $T_C = 127\text{ °C}$ | 60          | A     |
| Single pulse forward current                | $I_{FSM}$      | $T_C = 25\text{ °C}$  | 800         |       |
| Maximum repetitive forward current          | $I_{FRM}$      | Square wave, 20 kHz   | 120         |       |
| Operating junction and storage temperatures | $T_J, T_{Stg}$ |                       | - 55 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 | $V_{BR}, V_R$ | $I_R = 100\text{ }\mu\text{A}$               | 200  | -    | -    | V             |
| Forward voltage                     | $V_F$         | $I_F = 60\text{ A}$                          | -    | 0.98 | 1.08 |               |
|                                     |               | $I_F = 60\text{ A}, T_J = 175\text{ °C}$     | -    | 0.81 | 0.88 |               |
| Reverse leakage current             | $I_R$         | $V_R = V_R$ rated                            | -    | -    | 50   | $\mu\text{A}$ |
|                                     |               | $T_J = 150\text{ °C}, V_R = V_R$ rated       | -    | -    | 2    | mA            |
| Junction capacitance                | $C_T$         | $V_R = 200\text{ V}$                         | -    | 87   | -    | 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> = 1.0 A, dI <sub>F</sub> /dt = 200 A/μs, V <sub>R</sub> = 30 V |                                                                                   | -    | -    | 35   | ns    |
|                                                                                      |                  | T <sub>J</sub> = 25 °C                                                        | I <sub>F</sub> = 60 A<br>dI <sub>F</sub> /dt = 200 A/μs<br>V <sub>R</sub> = 160 V | -    | 28   | -    |       |
|                                                                                      |                  | T <sub>J</sub> = 125 °C                                                       |                                                                                   | -    | 50   | -    |       |
| Peak recovery current                                                                | I <sub>RRM</sub> | T <sub>J</sub> = 25 °C                                                        |                                                                                   | -    | 4    | -    | A     |
|                                                                                      |                  | T <sub>J</sub> = 125 °C                                                       |                                                                                   | -    | 8    | -    |       |
| Reverse recovery charge                                                              | Q <sub>rr</sub>  | T <sub>J</sub> = 25 °C                                                        |                                                                                   | -    | 59   | -    | nC    |
|                                                                                      |                  | T <sub>J</sub> = 125 °C                                                       |                                                                                   | -    | 220  | -    |       |

| THERMAL - MECHANICAL SPECIFICATIONS  |            |                                            |         |      |      |       |
|--------------------------------------|------------|--------------------------------------------|---------|------|------|-------|
| PARAMETER                            | SYMBOL     | TEST CONDITIONS                            | MIN.    | TYP. | MAX. | UNITS |
| Thermal resistance, junction to case | $R_{thJC}$ |                                            | -       | -    | 0.70 | K/W   |
| Thermal resistance, case to heatsink | $R_{thCS}$ | Mounting surface, flat, smooth and greased | -       | 0.2  | -    |       |
| Weight                               |            |                                            | -       | 5.5  | -    | g     |
|                                      |            |                                            | -       | 0.2  | -    | oz.   |
| Mounting torque                      |            |                                            | -       | -    | 1.2  | N · m |
| Marking device                       |            | Case style TO-247AC modified               | 60EPU02 |      |      |       |
|                                      |            | Case style TO-247AC                        | 60APU02 |      |      |       |

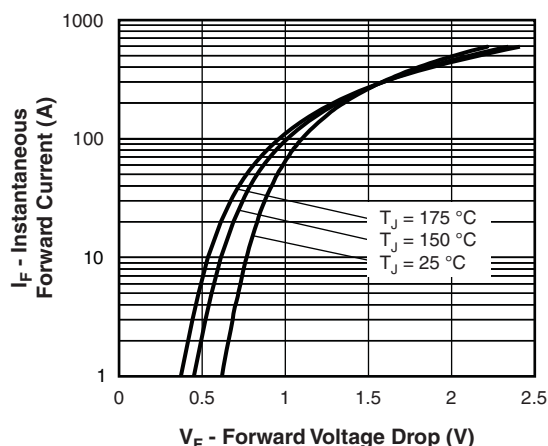


Fig. 1 - Typical Forward Voltage Drop Characteristics

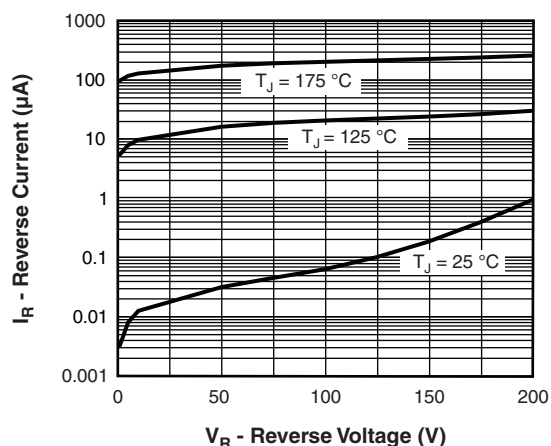


Fig. 2 - Typical Values of Reverse Current vs. Reverse Voltage

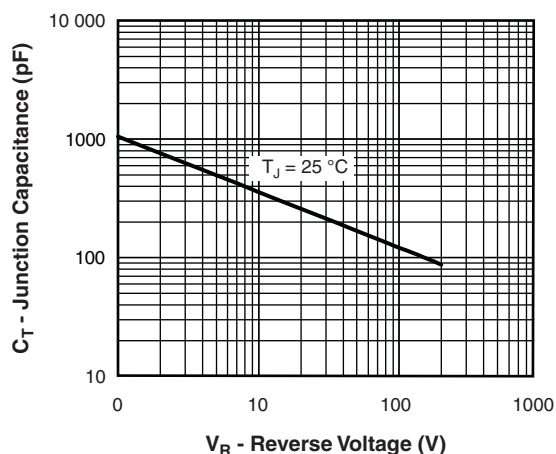


Fig. 3 - Typical Junction Capacitance vs. Reverse Voltage

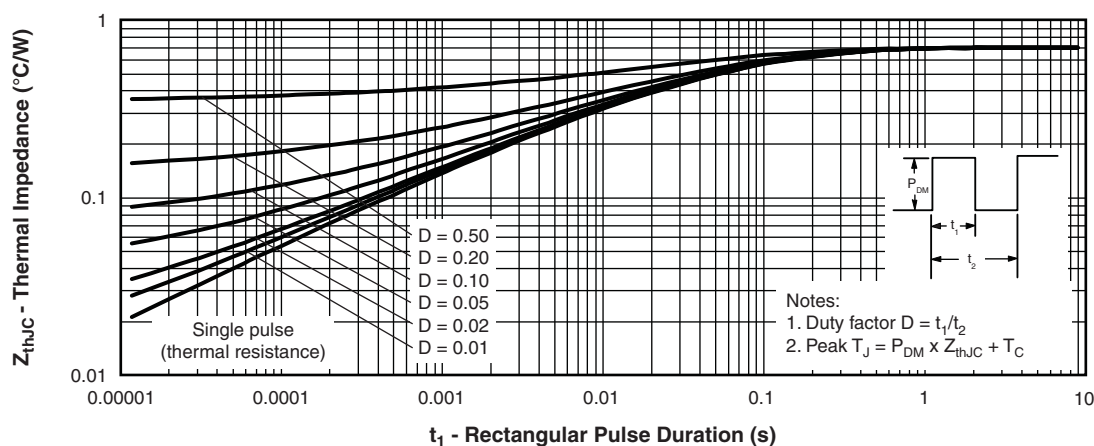


Fig. 4 - Maximum Thermal Impedance  $Z_{thJC}$  Characteristics

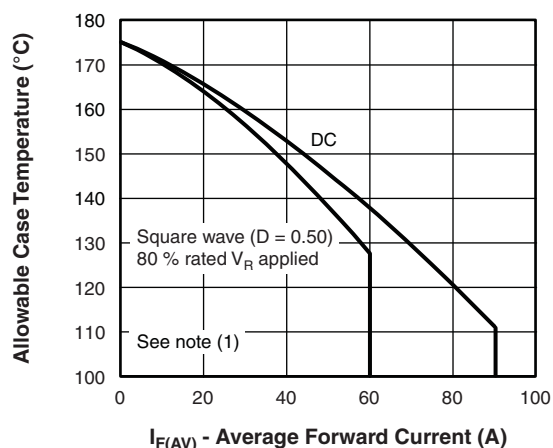


Fig. 5 - Maximum Allowable Case Temperature vs. Average Forward Current

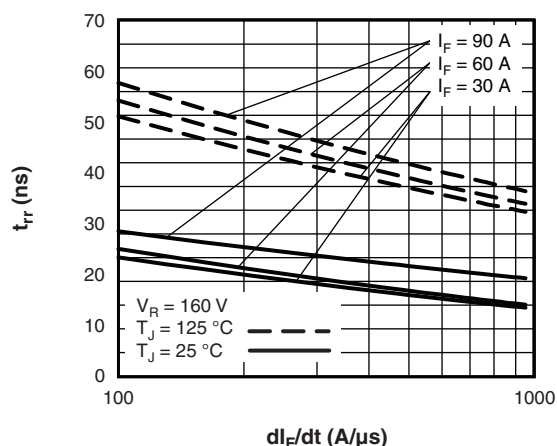


Fig. 7 - Typical Reverse Recovery Time vs.  $dI_F/dt$

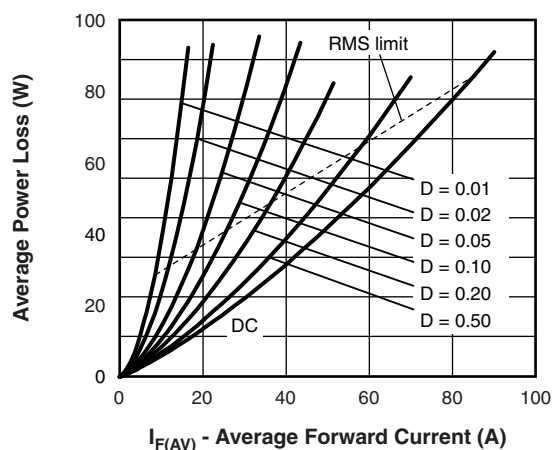


Fig. 6 - Forward Power Loss Characteristics

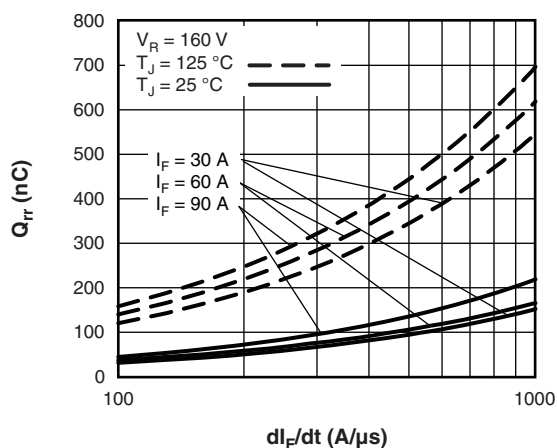


Fig. 8 - Typical Stored Charge vs.  $dI_F/dt$

#### Note

- (1) Formula used:  $T_C = T_J - (P_d + P_{dREV}) \times R_{thJC}$ ;  
 $P_d$  = Forward power loss =  $I_{F(AV)} \times V_{FM}$  at  $(I_{F(AV)}/D)$  (see fig. 6);  
 $P_{dREV}$  = Inverse power loss =  $V_{R1} \times I_R (1 - D)$ ;  $I_R$  at  $V_{R1} = 80\%$  rated  $V_R$

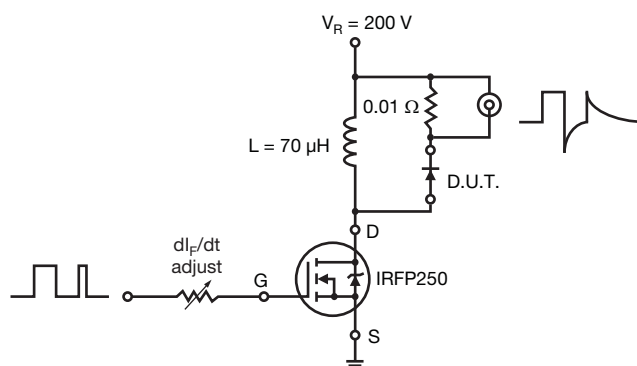
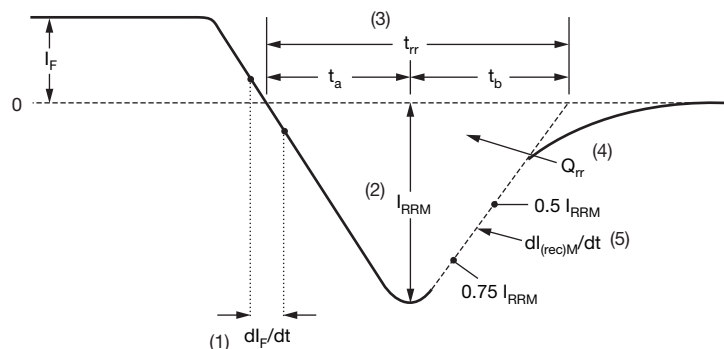


Fig. 9 - Reverse Recovery Parameter Test Circuit



(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  $I_{RRM}$

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

(5)  $di_{(rec)M}/dt$  - peak rate of change of current during  $t_b$  portion of  $t_{rr}$

Fig. 10 - Reverse Recovery Waveform and Definitions

**ORDERING INFORMATION TABLE**

|             |            |           |          |          |          |           |            |
|-------------|------------|-----------|----------|----------|----------|-----------|------------|
| Device code | <b>VS-</b> | <b>60</b> | <b>E</b> | <b>P</b> | <b>U</b> | <b>02</b> | <b>PbF</b> |
|             | 1          | 2         | 3        | 4        | 5        | 6         | 7          |

- |          |   |                                                                                                                                  |
|----------|---|----------------------------------------------------------------------------------------------------------------------------------|
| <b>1</b> | - | Vishay Semiconductors product                                                                                                    |
| <b>2</b> | - | Current rating (60 = 60 A)                                                                                                       |
| <b>3</b> | - | Circuit configuration: <ul style="list-style-type: none"><li>• E = Single diode</li><li>• A = Single diode, 3 pins</li></ul>     |
| <b>4</b> | - | Package:<br>P = TO-247AC (modified)                                                                                              |
| <b>5</b> | - | Type of silicon:<br>U = Ultrafast recovery                                                                                       |
| <b>6</b> | - | Voltage rating (02 = 200 V)                                                                                                      |
| <b>7</b> | - | Environmental digit:<br>PbF = Lead (Pb)-free and RoHS compliant<br>-N3 = Halogen-free, RoHS compliant and totally lead (Pb)-free |

**ORDERING INFORMATION (Example)**

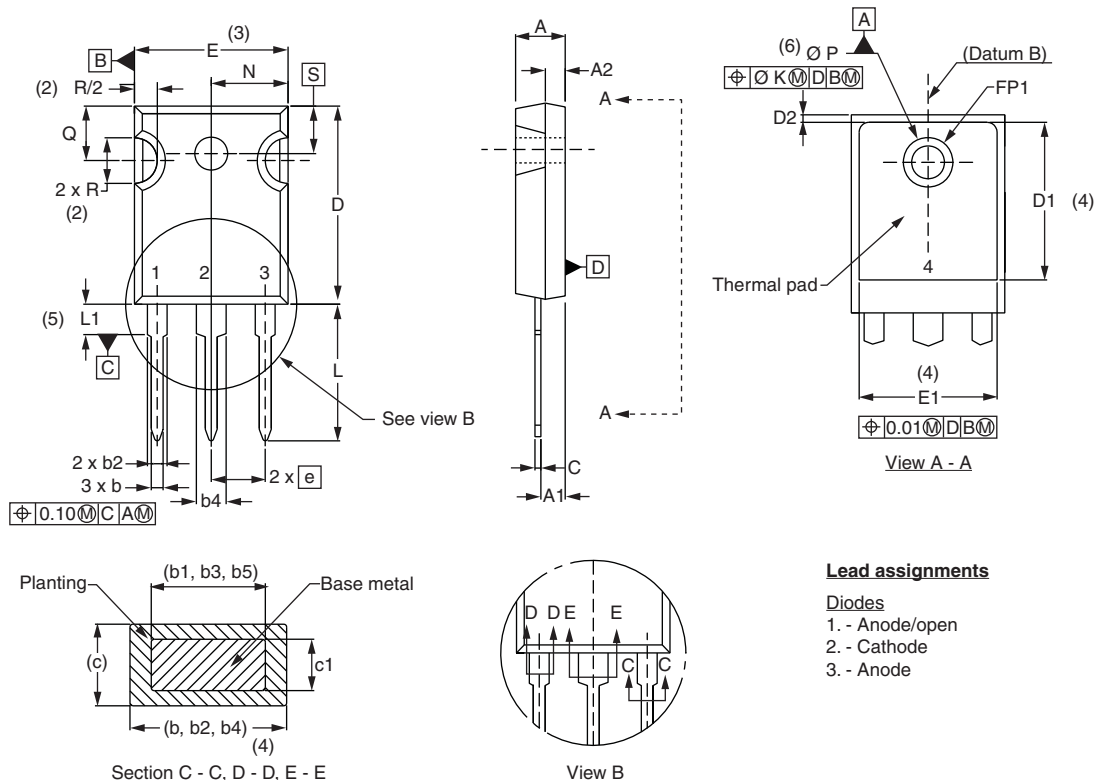
| PREFERRED P/N | QUANTITY PER T/R | MINIMUM ORDER QUANTITY | PACKAGING DESCRIPTION   |
|---------------|------------------|------------------------|-------------------------|
| VS-60EPU02PbF | 25               | 500                    | Antistatic plastic tube |
| VS-60EPU02-N3 | 25               | 500                    | Antistatic plastic tube |
| VS-60APU02PbF | 25               | 500                    | Antistatic plastic tube |
| VS-60APU02-N3 | 25               | 500                    | Antistatic plastic tube |

**LINKS TO RELATED DOCUMENTS**

|                          |                       |                                                                        |
|--------------------------|-----------------------|------------------------------------------------------------------------|
| Dimensions               | TO-247AC modified     | <a href="http://www.vishay.com/doc?95253">www.vishay.com/doc?95253</a> |
|                          | TO-247AC              | <a href="http://www.vishay.com/doc?95223">www.vishay.com/doc?95223</a> |
| Part marking information | TO-247AC modified PbF | <a href="http://www.vishay.com/doc?95255">www.vishay.com/doc?95255</a> |
|                          | TO-247AC modified -N3 | <a href="http://www.vishay.com/doc?95442">www.vishay.com/doc?95442</a> |
|                          | TO-247ACPbF           | <a href="http://www.vishay.com/doc?95226">www.vishay.com/doc?95226</a> |
|                          | TO-247AC-N3           | <a href="http://www.vishay.com/doc?95007">www.vishay.com/doc?95007</a> |
| SPIICE model             |                       | <a href="http://www.vishay.com/doc?95416">www.vishay.com/doc?95416</a> |



**DIMENSIONS** in millimeters and inches



### Lead assignments

#### Diodes

1. - Anode/open
2. - Cathode
3. - Anode

| SYMBOL | MILLIMETERS |       | INCHES |       | NOTES |
|--------|-------------|-------|--------|-------|-------|
|        | MIN.        | MAX.  | MIN.   | MAX.  |       |
| A      | 4.65        | 5.31  | 0.183  | 0.209 |       |
| A1     | 2.21        | 2.59  | 0.087  | 0.102 |       |
| A2     | 1.50        | 2.49  | 0.059  | 0.098 |       |
| b      | 0.99        | 1.40  | 0.039  | 0.055 |       |
| b1     | 0.99        | 1.35  | 0.039  | 0.053 |       |
| b2     | 1.65        | 2.39  | 0.065  | 0.094 |       |
| b3     | 1.65        | 2.37  | 0.065  | 0.094 |       |
| b4     | 2.59        | 3.43  | 0.102  | 0.135 |       |
| b5     | 2.59        | 3.38  | 0.102  | 0.133 |       |
| c      | 0.38        | 0.86  | 0.015  | 0.034 |       |
| c1     | 0.38        | 0.76  | 0.015  | 0.030 |       |
| D      | 19.71       | 20.70 | 0.776  | 0.815 | 3     |
| D1     | 13.08       | -     | 0.515  | -     | 4     |

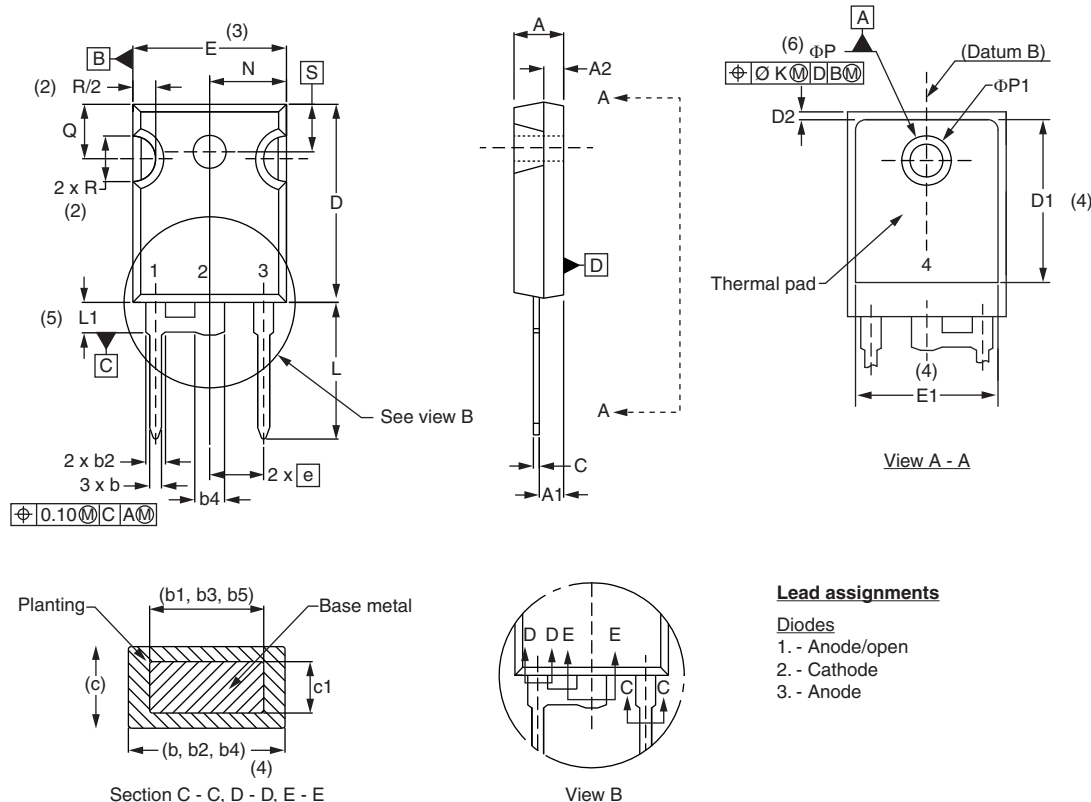
| SYMBOL    | MILLIMETERS |       | INCHES    |       | NOTES |
|-----------|-------------|-------|-----------|-------|-------|
|           | MIN.        | MAX.  | MIN.      | MAX.  |       |
| D2        | 0.51        | 1.30  | 0.020     | 0.051 |       |
| E         | 15.29       | 15.87 | 0.602     | 0.625 | 3     |
| E1        | 13.72       | -     | 0.540     | -     |       |
| e         | 5.46 BSC    |       | 0.215 BSC |       |       |
| FK        | 2.54        |       | 0.010     |       |       |
| L         | 14.20       | 16.10 | 0.559     | 0.634 |       |
| L1        | 3.71        | 4.29  | 0.146     | 0.169 |       |
| N         | 7.62 BSC    |       | 0.3       |       |       |
| $\Phi P$  | 3.56        | 3.66  | 0.14      | 0.144 |       |
| $\Phi P1$ | -           | 6.98  | -         | 0.275 |       |
| Q         | 5.31        | 5.69  | 0.209     | 0.224 |       |
| R         | 4.52        | 5.49  | 1.78      | 0.216 |       |
| S         | 5.51 BSC    |       | 0.217 BSC |       |       |

### Notes

- (1) Dimensioning and tolerancing per ASME Y14.5M-1994
- (2) Contour of slot optional
- (3) Dimension D 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) Thermal pad contour optional with dimensions D1 and E1
- (5) Lead finish uncontrolled in L1
- (6)  $\Phi P$  to have a maximum draft angle of 1.5 to the top of the part with a maximum hole diameter of 3.91 mm (0.154")
- (7) Outline conforms to JEDEC outline TO-247 with exception of dimension c



### DIMENSIONS in millimeters and inches



#### Lead assignments

##### Diodes

1. - Anode/open
2. - Cathode
3. - Anode

| SYMBOL | MILLIMETERS |       | INCHES |       | NOTES |
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| E         | 15.29       | 15.87 | 0.602     | 0.625 | 3     |
| E1        | 13.72       | -     | 0.540     | -     |       |
| e         | 5.46 BSC    |       | 0.215 BSC |       |       |
| $\Phi K$  | 2.54        |       | 0.010     |       |       |
| L         | 14.20       | 16.10 | 0.559     | 0.634 |       |
| L1        | 3.71        | 4.29  | 0.146     | 0.169 |       |
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#### Notes

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- (2) Contour of slot optional
- (3) Dimension D 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
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**Please note that some Vishay documentation may still make reference to RoHS Directive 2002/95/EC. We confirm that all the products identified as being compliant to Directive 2002/95/EC conform to Directive 2011/65/EU.**