



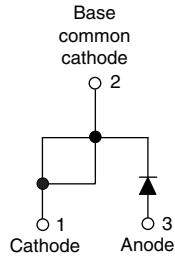
## Ultrafast Soft Recovery Diode, 60 A FRED Pt®



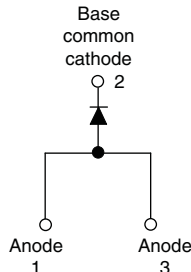
TO-247AC modified



TO-247AC



VS-60EPU02PbF  
VS-60EPU02-N3



VS-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)



### 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  | $V_F$         | $I_F = 60\text{ A}$<br>$I_F = 60\text{ A}, T_J = 175\text{ °C}$ | -    | 0.98<br>0.81 | 1.08<br>0.88 |                     |
| Reverse leakage current  | $I_R$         | $V_R = V_R$ rated<br>$T_J = 150\text{ °C}, V_R = V_R$ rated     | -    | -            | 50<br>2      | $\mu\text{A}$<br>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                  |



| <b>DYNAMIC RECOVERY CHARACTERISTICS</b> ( $T_C = 25\text{ }^\circ\text{C}$ unless otherwise specified) |           |   |      |      |      |       |
|--|-----------|---|------|------|------|-------|
| PARAMETER  | SYMBOL    | TEST CONDITIONS   | MIN. | TYP. | MAX. | UNITS |
| Reverse recovery time  | $t_{rr}$  | $I_F = 1.0\text{ A}$ , $dI_F/dt = 200\text{ A}/\mu\text{s}$ , $V_R = 30\text{ V}$ | -    | -    | 35   | ns    |
|  |           | $T_J = 25\text{ }^\circ\text{C}$  | -    | 28   | -    |       |
|  |           | $T_J = 125\text{ }^\circ\text{C}$   | -    | 50   | -    |       |
| Peak recovery current  | $I_{RRM}$ | $T_J = 25\text{ }^\circ\text{C}$  | -    | 4    | -    | A     |
|  |           | $T_J = 125\text{ }^\circ\text{C}$   | -    | 8    | -    |       |
| Reverse recovery charge  | $Q_{rr}$  | $T_J = 25\text{ }^\circ\text{C}$  | -    | 59   | -    | nC    |
|  |           | $T_J = 125\text{ }^\circ\text{C}$   | -    | 220  | -    |       |

| <b>THERMAL - MECHANICAL SPECIFICATIONS</b> |            |  |         |      |      |       |
|--|------------|--|---------|------|------|-------|
| 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 |      |      |       |

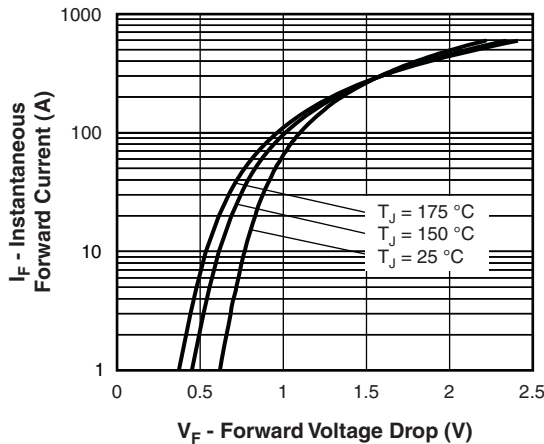


Fig. 1 - Typical Forward Voltage Drop Characteristics

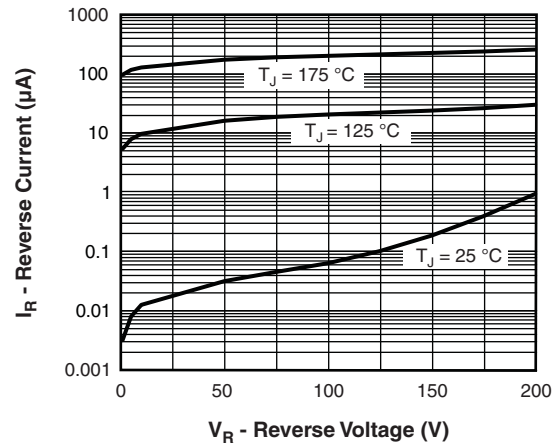


Fig. 2 - Typical Values of Reverse Current vs. Reverse Voltage

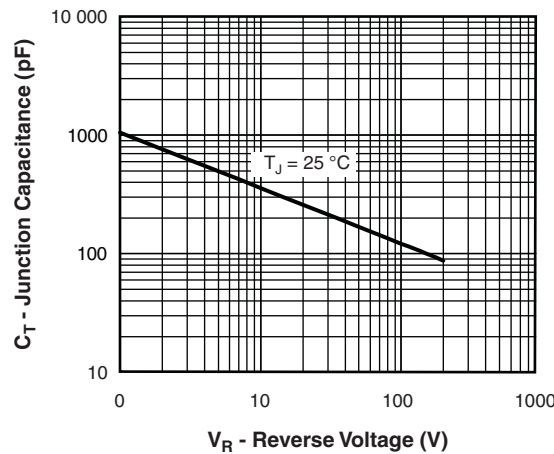


Fig. 3 - Typical Junction Capacitance vs. Reverse Voltage

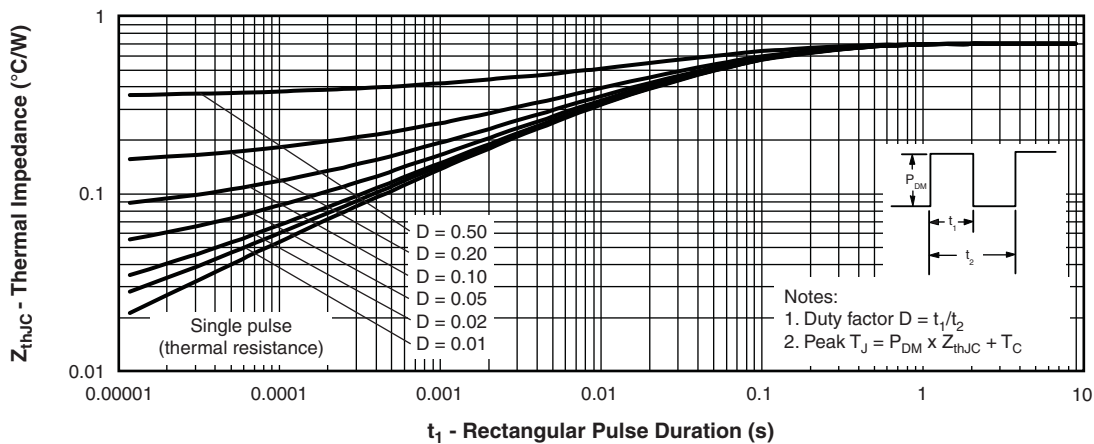


Fig. 4 - Maximum Thermal Impedance  $Z_{thJC}$  Characteristics

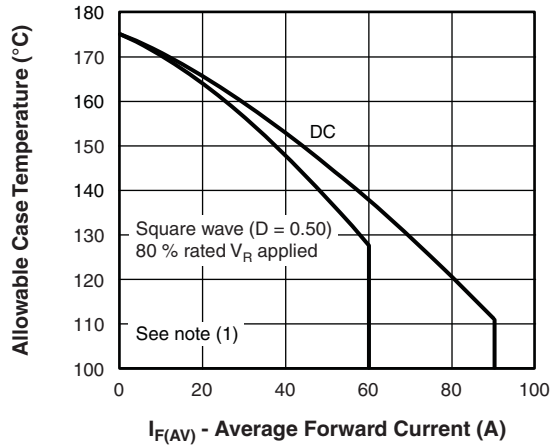


Fig. 5 - Maximum Allowable Case Temperature vs. Average Forward Current

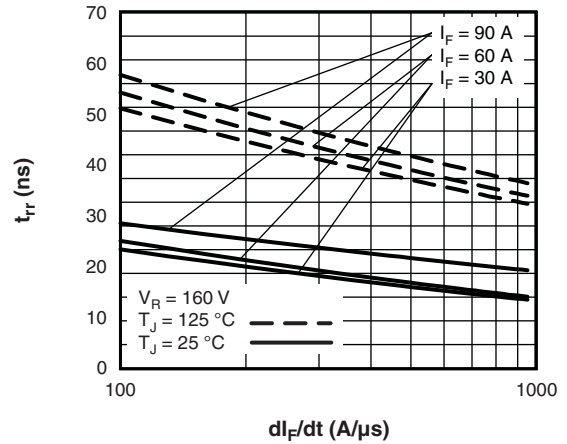


Fig. 7 - Typical Reverse Recovery Time vs.  $dI_F/dt$

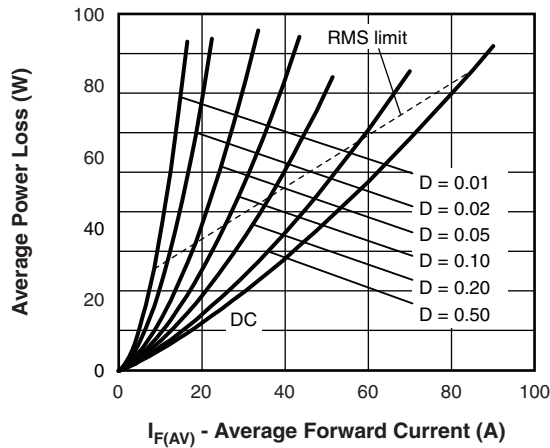


Fig. 6 - Forward Power Loss Characteristics

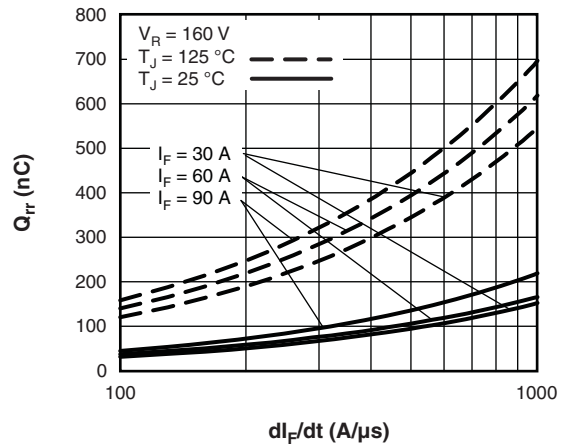


Fig. 8 - Typical Stored Charge vs.  $dI_F/dt$

**Note**

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

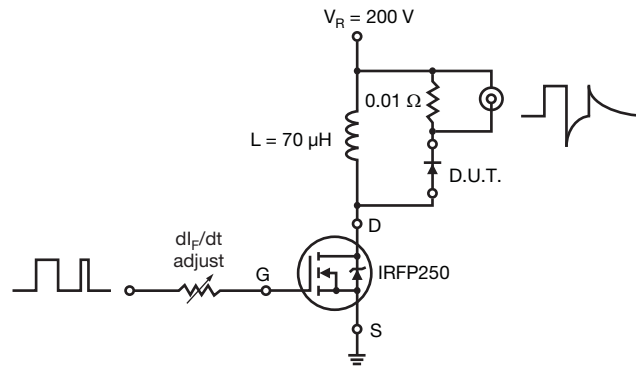
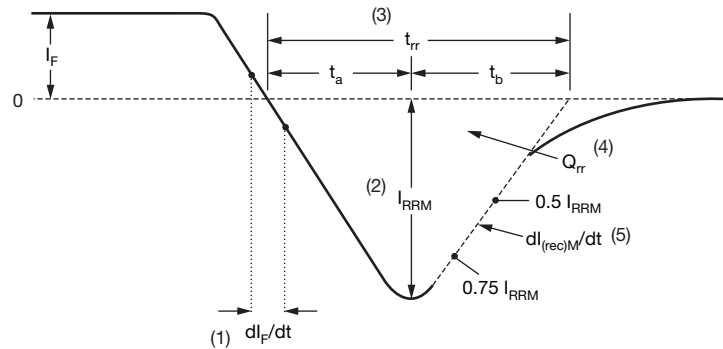


Fig. 9 - Reverse Recovery Parameter Test Circuit



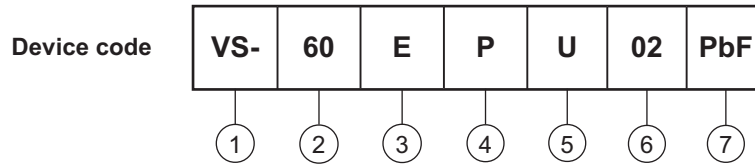
- (1)  $di_F/dt$  - rate of change of current through zero crossing
- (2)  $I_{RRM}$  - peak reverse recovery current
- (3)  $t_{rr}$  - reverse recovery time measured from zero crossing point of negative going  $I_F$  to point where a line passing through  $0.75 I_{RRM}$  and  $0.50 I_{RRM}$  extrapolated to zero current.
- (4)  $Q_{rr}$  - area under curve defined by  $t_{rr}$  and  $I_{RRM}$
- (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. 10 - Reverse Recovery Waveform and Definitions



ORDERING INFORMATION TABLE



- 1** - Vishay Semiconductors product
- 2** - Current rating (60 = 60 A)
- 3** - Circuit configuration:
  - E = Single diode
  - A = Single diode, 3 pins
- 4** - Package:
  - P = TO-247AC (modified)
- 5** - Type of silicon:
  - U = Ultrafast recovery
- 6** - Voltage rating (02 = 200 V)
- 7** - 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-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 | SYMBOL | MILLIMETERS |       | INCHES    |       | NOTES |
|--------|-------------|-------|--------|-------|-------|--------|-------------|-------|-----------|-------|-------|
|        | MIN.        | MAX.  | MIN.   | MAX.  |       |        | MIN.        | MAX.  | MIN.      | MAX.  |       |
| A      | 4.65        | 5.31  | 0.183  | 0.209 |       | D2     | 0.51        | 1.30  | 0.020     | 0.051 |       |
| A1     | 2.21        | 2.59  | 0.087  | 0.102 |       | E      | 15.29       | 15.87 | 0.602     | 0.625 | 3     |
| A2     | 1.50        | 2.49  | 0.059  | 0.098 |       | E1     | 13.72       | -     | 0.540     | -     |       |
| b      | 0.99        | 1.40  | 0.039  | 0.055 |       | e      | 5.46 BSC    |       | 0.215 BSC |       |       |
| b1     | 0.99        | 1.35  | 0.039  | 0.053 |       | FK     | 2.54        |       | 0.010     |       |       |
| b2     | 1.65        | 2.39  | 0.065  | 0.094 |       | L      | 14.20       | 16.10 | 0.559     | 0.634 |       |
| b3     | 1.65        | 2.37  | 0.065  | 0.094 |       | L1     | 3.71        | 4.29  | 0.146     | 0.169 |       |
| b4     | 2.59        | 3.43  | 0.102  | 0.135 |       | N      | 7.62 BSC    |       | 0.3       |       |       |
| b5     | 2.59        | 3.38  | 0.102  | 0.133 |       | ΦP     | 3.56        | 3.66  | 0.14      | 0.144 |       |
| c      | 0.38        | 0.86  | 0.015  | 0.034 |       | ΦP1    | -           | 6.98  | -         | 0.275 |       |
| c1     | 0.38        | 0.76  | 0.015  | 0.030 |       | Q      | 5.31        | 5.69  | 0.209     | 0.224 |       |
| D      | 19.71       | 20.70 | 0.776  | 0.815 | 3     | R      | 4.52        | 5.49  | 1.78      | 0.216 |       |
| D1     | 13.08       | -     | 0.515  | -     | 4     | 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) Ø 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



| 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     |
| 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 |       |       |
| ΦK     | 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       |       |       |
| ΦP     | 3.56        | 3.66  | 0.14      | 0.144 |       |
| ΦP1    | -           | 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**

- Dimensioning and tolerance per ASME Y14.5M-1994
- Contour of slot optional
- 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
- Thermal pad contour optional with dimensions D1 and E1
- Lead finish uncontrolled in L1
- ΦP 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")
- Outline conforms to JEDEC outline TO-247 with exception of dimension c





## Disclaimer

ALL PRODUCT, PRODUCT SPECIFICATIONS AND DATA ARE SUBJECT TO CHANGE WITHOUT NOTICE TO IMPROVE RELIABILITY, FUNCTION OR DESIGN OR OTHERWISE.

Vishay Intertechnology, Inc., its affiliates, agents, and employees, and all persons acting on its or their behalf (collectively, "Vishay"), disclaim any and all liability for any errors, inaccuracies or incompleteness contained in any datasheet or in any other disclosure relating to any product.

Vishay makes no warranty, representation or guarantee regarding the suitability of the products for any particular purpose or the continuing production of any product. To the maximum extent permitted by applicable law, Vishay disclaims (i) any and all liability arising out of the application or use of any product, (ii) any and all liability, including without limitation special, consequential or incidental damages, and (iii) any and all implied warranties, including warranties of fitness for particular purpose, non-infringement and merchantability.

Statements regarding the suitability of products for certain types of applications are based on Vishay's knowledge of typical requirements that are often placed on Vishay products in generic applications. Such statements are not binding statements about the suitability of products for a particular application. It is the customer's responsibility to validate that a particular product with the properties described in the product specification is suitable for use in a particular application. Parameters provided in datasheets and/or specifications may vary in different applications and performance may vary over time. All operating parameters, including typical parameters, must be validated for each customer application by the customer's technical experts. Product specifications do not expand or otherwise modify Vishay's terms and conditions of purchase, including but not limited to the warranty expressed therein.

Except as expressly indicated in writing, Vishay products are not designed for use in medical, life-saving, or life-sustaining applications or for any other application in which the failure of the Vishay product could result in personal injury or death. Customers using or selling Vishay products not expressly indicated for use in such applications do so at their own risk and agree to fully indemnify and hold Vishay and its distributors harmless from and against any and all claims, liabilities, expenses and damages arising or resulting in connection with such use or sale, including attorneys fees, even if such claim alleges that Vishay or its distributor was negligent regarding the design or manufacture of the part. Please contact authorized Vishay personnel to obtain written terms and conditions regarding products designed for such applications.

No license, express or implied, by estoppel or otherwise, to any intellectual property rights is granted by this document or by any conduct of Vishay. Product names and markings noted herein may be trademarks of their respective owners.

## Material Category Policy

**Vishay Intertechnology, Inc. hereby certifies that all its products that are identified as RoHS-Compliant fulfill the definitions and restrictions defined under Directive 2011/65/EU of The European Parliament and of the Council of June 8, 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment (EEE) - recast, unless otherwise specified as non-compliant.**

**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.**



Компания «ЭлектроПласт» предлагает заключение долгосрочных отношений при поставках импортных электронных компонентов на взаимовыгодных условиях!

Наши преимущества:

- Оперативные поставки широкого спектра электронных компонентов отечественного и импортного производства напрямую от производителей и с крупнейших мировых складов;
- Поставка более 17-ти миллионов наименований электронных компонентов;
- Поставка сложных, дефицитных, либо снятых с производства позиций;
- Оперативные сроки поставки под заказ (от 5 рабочих дней);
- Экспресс доставка в любую точку России;
- Техническая поддержка проекта, помощь в подборе аналогов, поставка прототипов;
- Система менеджмента качества сертифицирована по Международному стандарту ISO 9001;
- Лицензия ФСБ на осуществление работ с использованием сведений, составляющих государственную тайну;
- Поставка специализированных компонентов (Xilinx, Altera, Analog Devices, Intersil, Interpoint, Microsemi, Aeroflex, Peregrine, Syfer, Eurofarad, Texas Instrument, Miteq, Cobham, E2V, MA-COM, Hittite, Mini-Circuits, General Dynamics и др.);

Помимо этого, одним из направлений компании «ЭлектроПласт» является направление «Источники питания». Мы предлагаем Вам помощь Конструкторского отдела:

- Подбор оптимального решения, техническое обоснование при выборе компонента;
- Подбор аналогов;
- Консультации по применению компонента;
- Поставка образцов и прототипов;
- Техническая поддержка проекта;
- Защита от снятия компонента с производства.



#### Как с нами связаться

**Телефон:** 8 (812) 309 58 32 (многоканальный)

**Факс:** 8 (812) 320-02-42

**Электронная почта:** [org@eplast1.ru](mailto:org@eplast1.ru)

**Адрес:** 198099, г. Санкт-Петербург, ул. Калинина, дом 2, корпус 4, литера А.