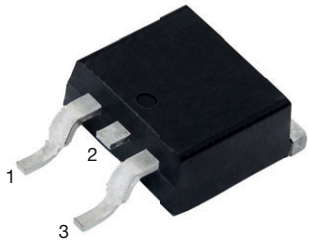
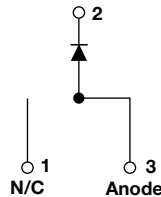


# HEXFRED<sup>®</sup>, Ultrafast Soft Recovery Diode, 4 A


**D<sup>2</sup>PAK (TO-263AB)**

**FEATURES**

- Ultrafast recovery
- Ultrasoft recovery
- Very low  $I_{RRM}$
- Very low  $Q_{rr}$
- Specified at operating temperature
- Meets MSL level 1, per J-STD-020, LF maximum peak of 245 °C
- Material categorization: for definitions of compliance please see [www.vishay.com/doc?99912](http://www.vishay.com/doc?99912)


**RoHS**  
COMPLIANT  
HALOGEN  
FREE

**BENEFITS**

- Reduced RFI and EMI
- Reduced power loss in diode and switching transistor
- Higher frequency operation
- Reduced snubbing
- Reduced parts count

**DESCRIPTION**

VS-HFA04TB60S is a state of the art ultrafast recovery diode. Employing the latest in epitaxial construction and advanced processing techniques it features a superb combination of characteristics which result in performance which is unsurpassed by any rectifier previously available. With basic ratings of 600 V and 4 A continuous current, the VS-HFA04TB60S is especially well suited for use as the companion diode for IGBTs and MOSFETs. In addition to ultrafast recovery time, the HEXFRED<sup>®</sup> product line features extremely low values of peak recovery current ( $I_{RRM}$ ) and does not exhibit any tendency to “snap-off” during the  $t_b$  portion of recovery. The HEXFRED features combine to offer designers a rectifier with lower noise and significantly lower switching losses in both the diode and the switching transistor. These HEXFRED advantages can help to significantly reduce snubbing, component count and heatsink sizes. The HEXFRED VS-HFA04TB60S is ideally suited for applications in power supplies and power conversion systems (such as inverters), motor drives, and many other similar applications where high speed, high efficiency is needed.

**PRIMARY CHARACTERISTICS**

|                       |                               |
|-----------------------|-------------------------------|
| $I_{F(AV)}$           | 4 A                           |
| $V_R$                 | 600 V                         |
| $V_F$ at $I_F$        | 1.4 V                         |
| $t_{rr}$ (typ.)       | 17 ns                         |
| $T_J$ max.            | 150 °C                        |
| Package               | D <sup>2</sup> PAK (TO-263AB) |
| Circuit configuration | Single                        |

**ABSOLUTE MAXIMUM RATINGS**

| PARAMETER  | SYMBOL         | TEST CONDITIONS       | VALUES      | UNITS |
|--|----------------|-----------------------|-------------|-------|
| Cathode to anode voltage                         | $V_R$          |                       | 600         | V     |
| Maximum continuous forward current               | $I_F$          | $T_C = 100\text{ °C}$ | 4           | A     |
| Single pulse forward current                     | $I_{FSM}$      |                       | 25          |       |
| Maximum repetitive forward current               | $I_{FRM}$      |                       | 16          |       |
| Maximum power dissipation                        | $P_D$          | $T_C = 25\text{ °C}$  | 25          | W     |
|  |                | $T_C = 100\text{ °C}$ | 10          |       |
| Operating junction and storage temperature range | $T_J, T_{Stg}$ |                       | -55 to +150 | °C    |



| <b>ELECTRICAL SPECIFICATIONS</b> ( $T_J = 25\text{ }^\circ\text{C}$ unless otherwise specified) |          |   |      |      |      |               |
|---|----------|---|------|------|------|---------------|
| PARAMETER   | SYMBOL   | TEST CONDITIONS   | MIN. | TYP. | MAX. | UNITS         |
| Cathode to anode breakdown voltage  | $V_{BR}$ | $I_R = 100\text{ }\mu\text{A}$                                | 600  | -    | -    | V             |
| Maximum forward voltage   | $V_{FM}$ | $I_F = 4.0\text{ A}$  | -    | 1.5  | 1.8  |               |
|   |          | $I_F = 8.0\text{ A}$  | -    | 1.8  | 2.2  |               |
|   |          | $I_F = 4.0\text{ A}, T_J = 125\text{ }^\circ\text{C}$         | -    | 1.4  | 1.7  |               |
| Maximum reverse leakage current   | $I_{RM}$ | $V_R = V_R$ rated   | -    | 0.17 | 3.0  | $\mu\text{A}$ |
|   |          | $T_J = 125\text{ }^\circ\text{C}, V_R = 0.8 \times V_R$ rated | -    | 44   | 300  |               |
| Junction capacitance  | $C_T$    | $V_R = 200\text{ V}$  | -    | 4.0  | 8.0  | pF            |
| Series inductance   | $L_S$    | Measured lead to lead 5 mm from package body                  | -    | 8.0  | -    | nH            |

| <b>DYNAMIC RECOVERY CHARACTERISTICS</b> ( $T_J = 25\text{ }^\circ\text{C}$ unless otherwise specified) |                   |   |      |      |      |                        |
|--|-------------------|---|------|------|------|------------------------|
| PARAMETER  | SYMBOL            | TEST CONDITIONS   | MIN. | TYP. | MAX. | UNITS                  |
| Reverse recovery time<br>See fig. 5, 6   | $t_{rr}$          | $I_F = 1.0\text{ A}, di_F/dt = 200\text{ A}/\mu\text{s}, V_R = 30\text{ V}$ | -    | 17   | -    | ns                     |
|  | $t_{rr1}$         | $T_J = 25\text{ }^\circ\text{C}$  | -    | 28   | 42   |                        |
|  | $t_{rr2}$         | $T_J = 125\text{ }^\circ\text{C}$   | -    | 38   | 57   |                        |
| Peak recovery current  | $I_{RRM1}$        | $T_J = 25\text{ }^\circ\text{C}$  | -    | 2.9  | 5.2  | A                      |
|  | $I_{RRM2}$        | $T_J = 125\text{ }^\circ\text{C}$   | -    | 3.7  | 6.7  |                        |
| Reverse recovery charge<br>See fig. 7  | $Q_{rr1}$         | $T_J = 25\text{ }^\circ\text{C}$  | -    | 40   | 60   | nC                     |
|  | $Q_{rr2}$         | $T_J = 125\text{ }^\circ\text{C}$   | -    | 70   | 105  |                        |
| Peak rate of fall of recovery current<br>during $t_b$ , see fig. 8                                     | $di_{(rec)M}/dt1$ | $T_J = 25\text{ }^\circ\text{C}$  | -    | 280  | -    | $\text{A}/\mu\text{s}$ |
|  | $di_{(rec)M}/dt2$ | $T_J = 125\text{ }^\circ\text{C}$   | -    | 235  | -    |                        |

| <b>THERMAL - MECHANICAL SPECIFICATIONS</b> |            |  |            |      |      |                  |
|--|------------|--|------------|------|------|------------------|
| PARAMETER                                  | SYMBOL     | TEST CONDITIONS                          | MIN.       | TYP. | MAX. | UNITS            |
| Lead temperature                           | $T_{lead}$ | 0.063" from case (1.6 mm) for 10 s       | -          | -    | 300  | $^\circ\text{C}$ |
| Thermal resistance, junction-to-case       | $R_{thJC}$ |  | -          | -    | 5.0  | K/W              |
| Thermal resistance, junction-to-ambient    | $R_{thJA}$ | Typical socket mount                     | -          | -    | 80   |                  |
| Weight                                     |            |  | -          | 2.0  | -    | g                |
|  |            |  | -          | 0.07 | -    | oz.              |
| Marking device                             |            | Case style D <sup>2</sup> PAK (TO-263AB) | HFA04TB60S |      |      |                  |

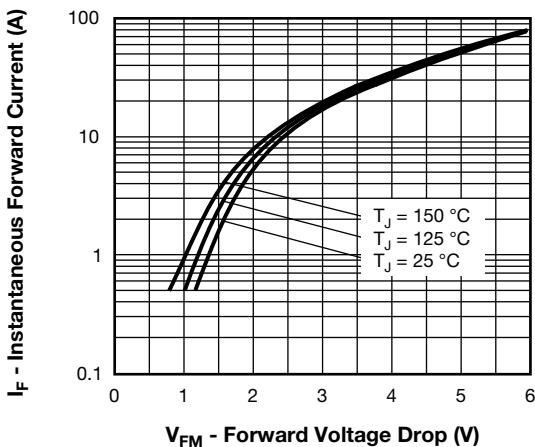


Fig. 1 - Maximum Forward Voltage Drop vs. Instantaneous Forward Current

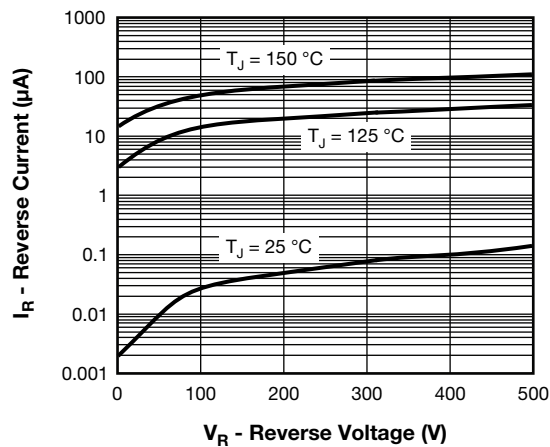


Fig. 2 - Typical Reverse Current vs. Reverse Voltage

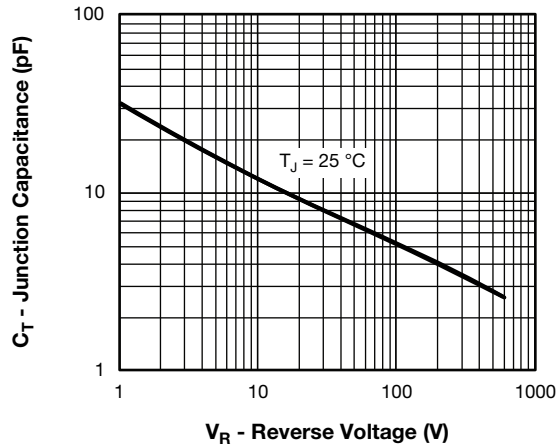


Fig. 3 - Typical Junction Capacitance vs. Reverse Voltage

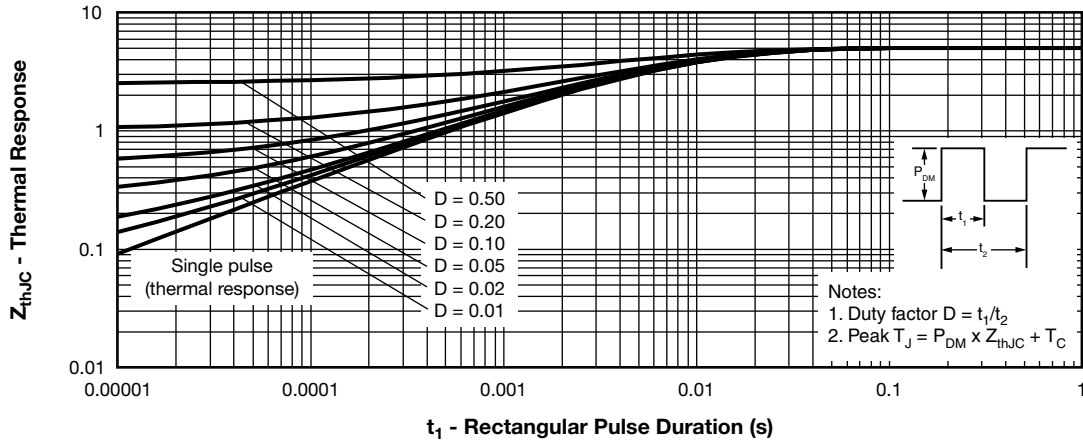


Fig. 4 - Maximum Thermal Impedance  $Z_{thJC}$  Characteristics

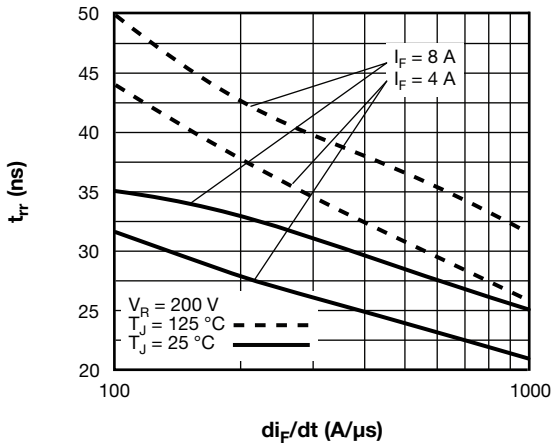


Fig. 5 - Typical Reverse Recovery Time vs.  $di_F/dt$

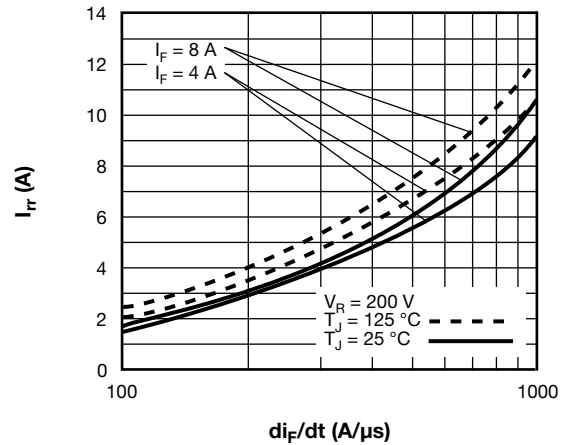


Fig. 6 - Typical Recovery Current vs.  $di_F/dt$

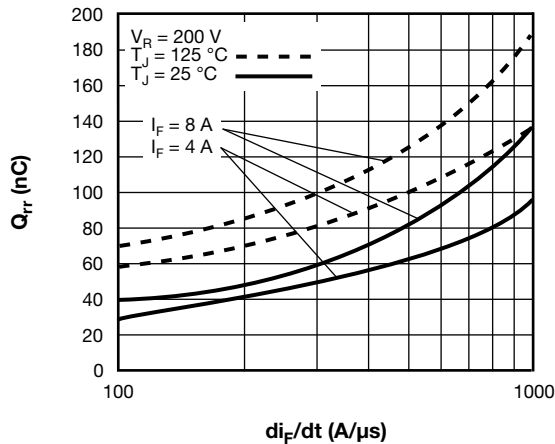


Fig. 7 - Typical Stored Charge vs.  $di_F/dt$

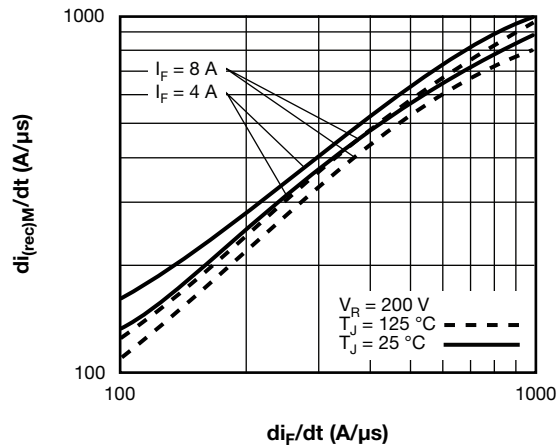
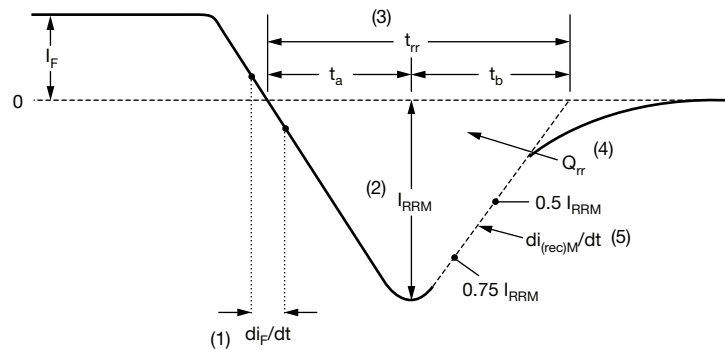


Fig. 8 - Typical  $di_{(rec)M}/dt$  vs.  $di_F/dt$



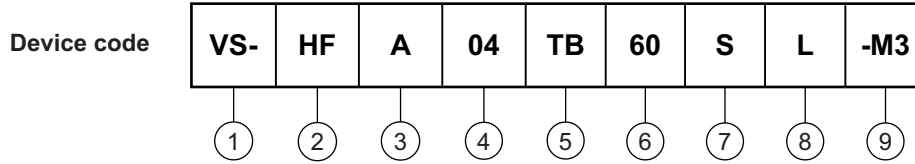
- (1)  $di_F/dt$  - rate of change of current through zero crossing
- (2)  $I_{RRM}$  - peak reverse recovery current
- (3)  $t_{rr}$  - reverse recovery time measured from zero crossing point of negative going  $I_F$  to point where a line passing through  $0.75 I_{RRM}$  and  $0.50 I_{RRM}$  extrapolated 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. 9 - Reverse Recovery Waveform and Definitions



ORDERING INFORMATION TABLE



- 1** - Vishay Semiconductors product
- 2** - HEXFRED® family
- 3** - Process designator: A = electron irradiated
- 4** - Current rating (04 = 4 A)
- 5** - Package outline (TB = TO-220, 2 leads)
- 6** - Voltage rating (60 = 600 V)
- 7** - S = D<sup>2</sup>PAK (TO-263AB)
- 8** -
  - None = tube (50 pieces)
  - L = tape and reel (left oriented)
  - R = tape and reel (right oriented)
- 9** - Environmental digit:
  - M3 = halogen-free, RoHS-compliant, and terminations lead (Pb)-free

| ORDERING INFORMATION (Example) |                                    |                        |                         |
|--------------------------------|------------------------------------|------------------------|-------------------------|
| PREFERRED P/N                  | QUANTITY PER TUBE OR TAPE AND REEL | MINIMUM ORDER QUANTITY | PACKAGING DESCRIPTION   |
| VS-HFA04TB60S-M3               | 50                                 | 1000                   | Antistatic plastic tube |
| VS-HFA04TB60SL-M3              | 800                                | 800                    | 13" diameter reel       |
| VS-HFA04TB60SR-M3              | 800                                | 800                    | 13" diameter reel       |

| LINKS TO RELATED DOCUMENTS |  |
|----------------------------|--|
| Dimensions                 | <a href="http://www.vishay.com/doc?96164">www.vishay.com/doc?96164</a> |
| Part marking information   | <a href="http://www.vishay.com/doc?95444">www.vishay.com/doc?95444</a> |
| Packaging information      | <a href="http://www.vishay.com/doc?96424">www.vishay.com/doc?96424</a> |



# D<sup>2</sup>PAK

**DIMENSIONS** in millimeters and inches

Conforms to JEDEC<sup>®</sup> outline D<sup>2</sup>PAK (SMD-220)



| SYMBOL | MILLIMETERS |       | INCHES |       | NOTES | SYMBOL | MILLIMETERS |       | INCHES    |       | NOTES |
|--------|-------------|-------|--------|-------|-------|--------|-------------|-------|-----------|-------|-------|
|        | MIN.        | MAX.  | MIN.   | MAX.  |       |        | MIN.        | MAX.  | MIN.      | MAX.  |       |
| A      | 4.06        | 4.83  | 0.160  | 0.190 |       | D1     | 6.86        | 8.00  | 0.270     | 0.315 | 3     |
| A1     | 0.00        | 0.254 | 0.000  | 0.010 |       | E      | 9.65        | 10.67 | 0.380     | 0.420 | 2, 3  |
| b      | 0.51        | 0.99  | 0.020  | 0.039 |       | E1     | 7.90        | 8.80  | 0.311     | 0.346 | 3     |
| b1     | 0.51        | 0.89  | 0.020  | 0.035 | 4     | e      | 2.54 BSC    |       | 0.100 BSC |       |       |
| b2     | 1.14        | 1.78  | 0.045  | 0.070 |       | H      | 14.61       | 15.88 | 0.575     | 0.625 |       |
| b3     | 1.14        | 1.73  | 0.045  | 0.068 | 4     | L      | 1.78        | 2.79  | 0.070     | 0.110 |       |
| c      | 0.38        | 0.74  | 0.015  | 0.029 |       | L1     | -           | 1.65  | -         | 0.066 | 3     |
| c1     | 0.38        | 0.58  | 0.015  | 0.023 | 4     | L2     | 1.27        | 1.78  | 0.050     | 0.070 |       |
| c2     | 1.14        | 1.65  | 0.045  | 0.065 |       | L3     | 0.25 BSC    |       | 0.010 BSC |       |       |
| D      | 8.51        | 9.65  | 0.335  | 0.380 | 2     | L4     | 4.78        | 5.28  | 0.188     | 0.208 |       |

**Notes**

- (1) Dimensioning and tolerancing per ASME Y14.5 M-1994
- (2) 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 outmost extremes of the plastic body
- (3) Thermal pad contour optional within dimension E, L1, D1 and E1
- (4) Dimension b1 and c1 apply to base metal only
- (5) Datum A and B to be determined at datum plane H
- (6) Controlling dimension: inches
- (7) Outline conforms to JEDEC<sup>®</sup> outline TO-263AB



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