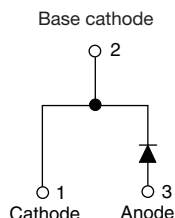
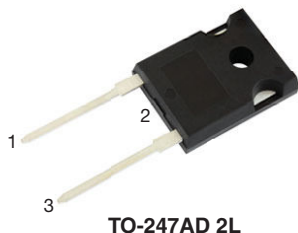


## Hyperfast Soft Recovery Diode, 60 A FRED Pt® Gen 4



### FEATURES

- Gen 4 FRED Pt® technology
- Low  $I_{RRM}$  and reverse recovery charge
- Very low forward voltage drop
- Polyimide passivated chip for high reliability standard
- 175 °C operating junction temperature
- AEC-Q101 qualified, meets JESD 201 class 1 whisker test
- Material categorization: for definitions of compliance please see [www.vishay.com/doc?99912](http://www.vishay.com/doc?99912)



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

### PRODUCT SUMMARY

|                 |                    |
|-----------------|--------------------|
| Package         | TO-247AD 2L        |
| $I_{F(AV)}$     | 60 A               |
| $V_R$           | 600 V              |
| $V_F$ at $I_F$  | 1.48 V             |
| $t_{rr}$ typ.   | see Recovery table |
| $T_J$ max.      | 175 °C             |
| Diode variation | Single die         |

### DESCRIPTION

Gen 4 Fred technology, state of the art, ultralow  $V_F$ , soft switching optimized for Discontinuous (Critical) Mode (DCM) and IGBT F/W diode.

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

### ABSOLUTE MAXIMUM RATINGS

| PARAMETER                                   | SYMBOL         | TEST CONDITIONS   | MAX.        | UNITS |
|---|----------------|---|-------------|-------|
| Cathode to anode voltage                    | $V_R$          |   | 600         | V     |
| Average rectified forward current           | $I_{F(AV)}$    | $T_C = 106\text{ °C}$   | 60          | A     |
| Single pulse forward current                | $I_{FSM}$      | $T_C = 25\text{ °C}$ , $t_p = 8.3\text{ ms}$ , half sine wave | 425         |       |
| 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 | $V_{BR}, V_R$ | $I_R = 100\text{ }\mu\text{A}$              | 600  | -    | -    | V             |
| Forward voltage                     | $V_F$         | $I_F = 50\text{ A}$                         | -    | 1.68 | -    |               |
|                                     |               | $I_F = 60\text{ A}$                         | -    | 1.75 | 2.0  |               |
|                                     |               | $I_F = 50\text{ A}$ , $T_J = 125\text{ °C}$ | -    | 1.44 | -    |               |
|                                     |               | $I_F = 60\text{ A}$ , $T_J = 125\text{ °C}$ | -    | 1.55 | -    |               |
|                                     |               | $I_F = 50\text{ A}$ , $T_J = 150\text{ °C}$ | -    | 1.39 | -    |               |
|                                     |               | $I_F = 60\text{ A}$ , $T_J = 150\text{ °C}$ | -    | 1.48 | 1.65 |               |
| Reverse leakage current             | $I_R$         | $V_R = V_R$ rated                           | -    | -    | 50   | $\mu\text{A}$ |
|                                     |               | $T_J = 125\text{ °C}$ , $V_R = V_R$ rated   | -    | -    | 500  |               |
| Junction capacitance                | $C_T$         | $V_R = 600\text{ V}$                        | -    | 30   | -    | pF            |



| DYNAMIC RECOVERY CHARACTERISTICS (T <sub>J</sub> = 25 °C unless otherwise specified) |                  |                         |  |      |      |      |       |
|--|------------------|-------------------------|--|------|------|------|-------|
| PARAMETER  | SYMBOL           | TEST CONDITIONS         |  | MIN. | TYP. | MAX. | UNITS |
| Reverse recovery time  | t <sub>rr</sub>  | T <sub>J</sub> = 25 °C  | I <sub>F</sub> = 60 A<br>di <sub>F</sub> /dt = 1000 A/μs<br>V <sub>R</sub> = 400 V | -    | 68   | -    | ns    |
|  |                  | T <sub>J</sub> = 125 °C |  | -    | 92   | -    |       |
| Peak recovery current  | I <sub>RRM</sub> | T <sub>J</sub> = 25 °C  |  | -    | 20   | -    | A     |
|  |                  | T <sub>J</sub> = 125 °C |  | -    | 40   | -    |       |
| Reverse recovery charge  | Q <sub>rr</sub>  | T <sub>J</sub> = 25 °C  |  | -    | 945  | -    | nC    |
|  |                  | T <sub>J</sub> = 125 °C |  | -    | 2500 | -    |       |

| THERMAL - MECHANICAL SPECIFICATIONS   |                   |  |            |      |            |                        |
|---------------------------------------|-------------------|--|------------|------|------------|------------------------|
| PARAMETER                             | SYMBOL            | TEST CONDITIONS                            | MIN.       | TYP. | MAX.       | UNITS                  |
| Thermal resistance, junction to case  | R <sub>thJC</sub> |  | -          | -    | 0.6        | °C/W                   |
| Thermal resistance, case to heat sink | R <sub>thCS</sub> | Mounting surface, flat, smooth and greased | -          | 0.25 | -          |                        |
| Weight                                |                   |  | -          | 6.0  | -          | g                      |
|                                       |                   |  | -          | 0.21 | -          | oz.                    |
| Mounting torque                       |                   |  | 6.0<br>(5) | -    | 12<br>(20) | kgf · cm<br>(lbf · in) |
| Marking device                        |                   | Case style TO-247AD 2L                     | E4PH6006LH |      |            |                        |

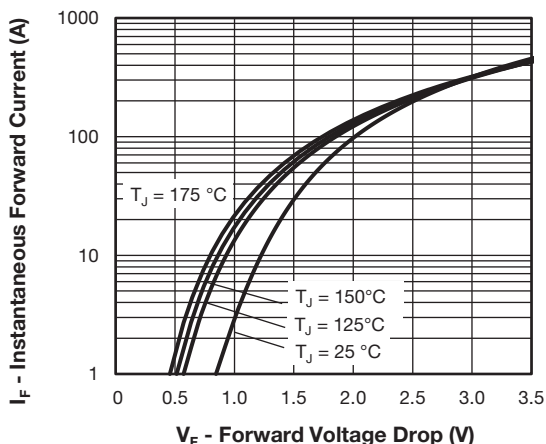


Fig. 1 - Typical Forward Voltage Drop Characteristics

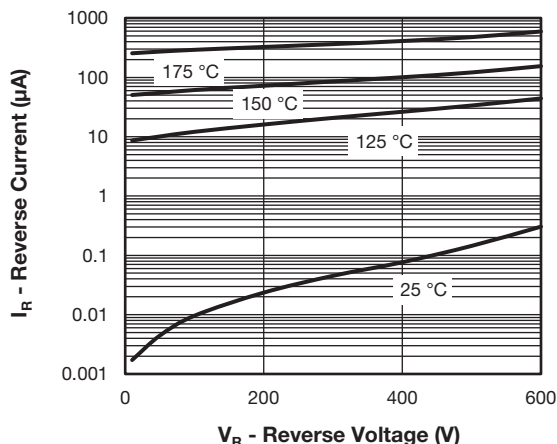


Fig. 2 - Typical Values of Reverse Current vs. Reverse Voltage

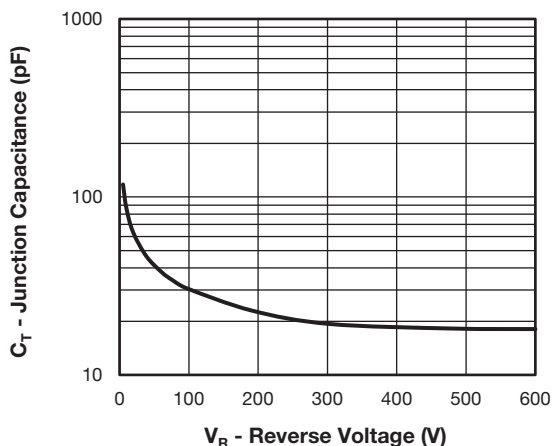


Fig. 3 - Typical Junction Capacitance vs. Reverse Voltage

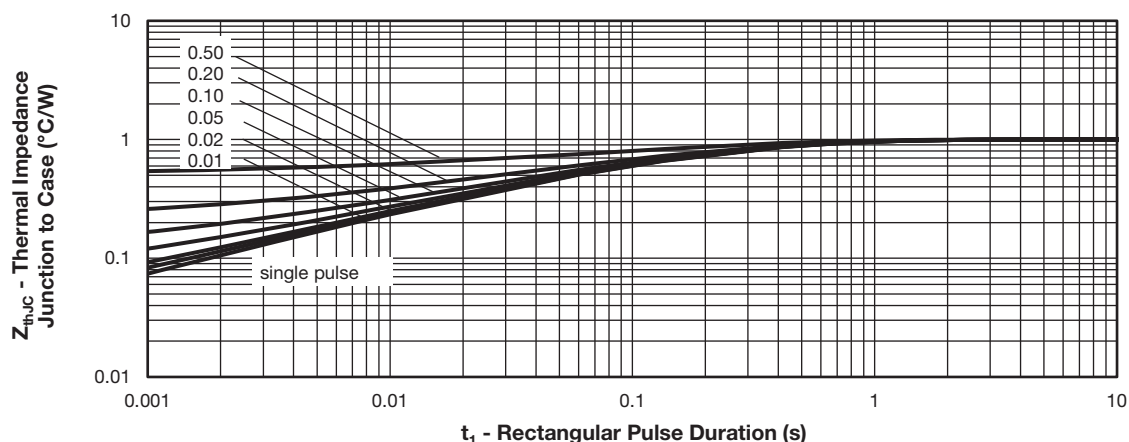
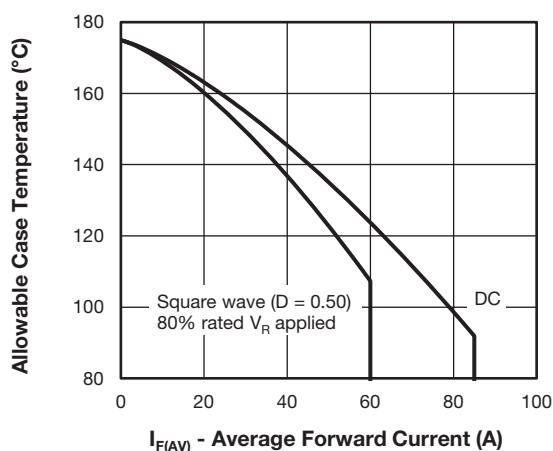

Fig. 4 - Maximum Thermal Impedance  $Z_{thJC}$  Characteristics


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

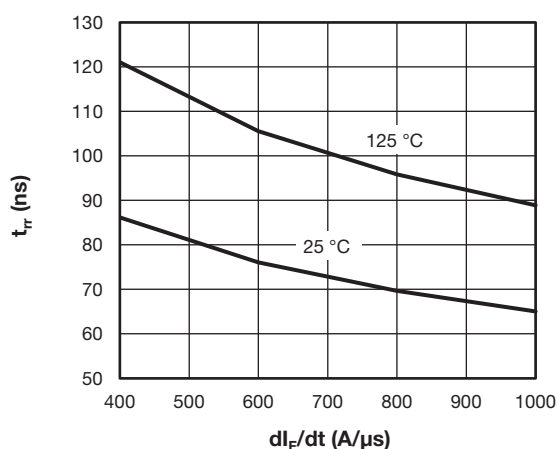
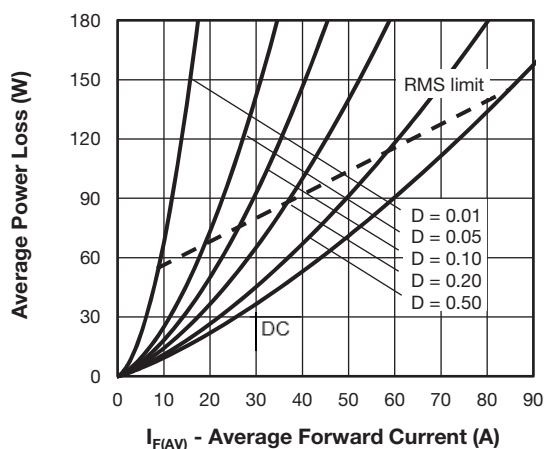
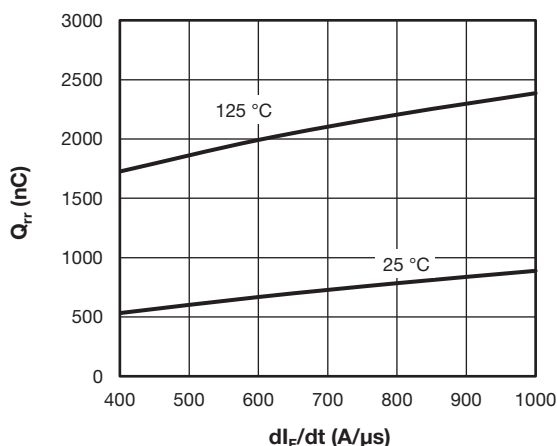

Fig. 7 - Typical Reverse Recovery Time vs.  $dI_F/dt$ 


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.5)  
 $P_{dREV}$  = Inverse power loss =  $V_{R1} \times I_R (1 - D)$ ;  $I_R$  at  $V_R$  = rated  $V_R$

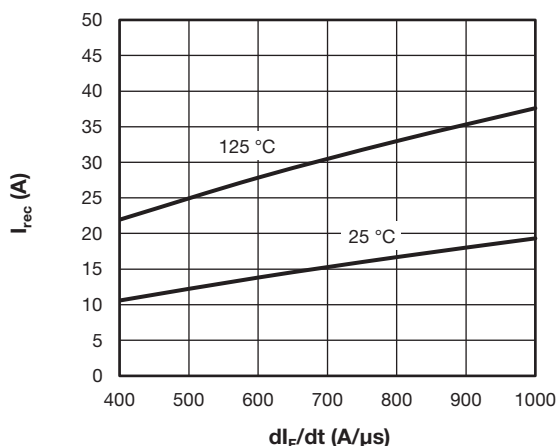


Fig. 9 - Typical Reverse Recovery vs.  $di_F/dt$

## ORDERING INFORMATION TABLE

| Device code | VS- | E   | 4 | P | H | 60 | 06 | L | H | N3 |
|-------------|-----|---|---|---|---|----|----|---|---|----|
|             | 1   | 2   | 3 | 4 | 5 | 6  | 7  | 8 | 9 | 10 |
|             | 1   | - Vishay Semiconductors product                               |   |   |   |    |    |   |   |    |
|             | 2   | - Circuit configuration:                                      |   |   |   |    |    |   |   |    |
|             |     | E = single diode 2 pins                                       |   |   |   |    |    |   |   |    |
|             | 3   | - FRED Gen 4  |   |   |   |    |    |   |   |    |
|             | 4   | - P = TO-247 package  |   |   |   |    |    |   |   |    |
|             | 5   | - Process type:   |   |   |   |    |    |   |   |    |
|             |     | H = Hyperfast recovery  |   |   |   |    |    |   |   |    |
|             | 6   | - Current rating (60 = 60 A)                                  |   |   |   |    |    |   |   |    |
|             | 7   | - Voltage rating (06 = 600 V)                                 |   |   |   |    |    |   |   |    |
|             | 8   | - L = long lead   |   |   |   |    |    |   |   |    |
|             | 9   | - H = AEC-Q101 qualified                                      |   |   |   |    |    |   |   |    |
|             | 10  | - Environmental digit:  |   |   |   |    |    |   |   |    |
|             |     | N3 = halogen-free, RoHS-compliant, and totally lead (Pb)-free |   |   |   |    |    |   |   |    |

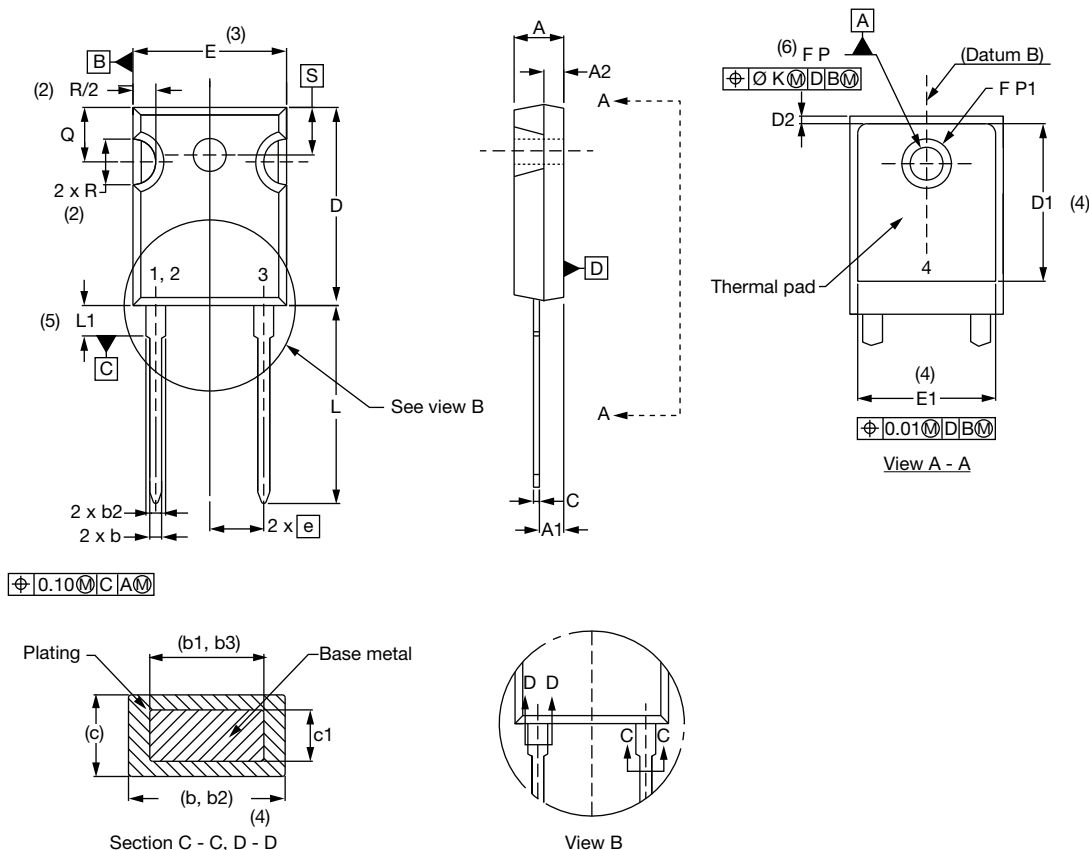
| ORDERING INFORMATION (Example) |                   |                        |                         |
|--------------------------------|-------------------|------------------------|-------------------------|
| PREFERRED P/N                  | QUANTITY PER TUBE | MINIMUM ORDER QUANTITY | PACKAGING DESCRIPTION   |
| VS-E4PH6006LHN3                | 25                | 500                    | Antistatic plastic tube |

| LINKS TO RELATED DOCUMENTS |             |  |
|----------------------------|-------------|--|
| Dimensions                 | TO-247AD 2L | <a href="http://www.vishay.com/doc?95536">www.vishay.com/doc?95536</a> |
| Part marking information   | TO-247AD 2L | <a href="http://www.vishay.com/doc?95648">www.vishay.com/doc?95648</a> |



### TO-247AD 2L

**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        | 2.34  | 0.065  | 0.092 |       |
| c      | 0.38        | 0.89  | 0.015  | 0.035 |       |
| c1     | 0.38        | 0.84  | 0.015  | 0.033 |       |
| D      | 19.71       | 20.70 | 0.776  | 0.815 | 3     |
| D1     | 13.08       | -     | 0.515  | -     | 4     |
| D2     | 0.51        | 1.35  | 0.020  | 0.053 |       |

| SYMBOL    | MILLIMETERS |       | INCHES    |       | NOTES |
|-----------|-------------|-------|-----------|-------|-------|
|           | MIN.        | MAX.  | MIN.      | MAX.  |       |
| E         | 15.29       | 15.87 | 0.602     | 0.625 | 3     |
| E1        | 13.46       | -     | 0.53      | -     |       |
| e         | 5.46 BSC    |       | 0.215 BSC |       |       |
| $\phi K$  | 0.254       |       | 0.010     |       |       |
| L         | 19.81       | 20.32 | 0.780     | 0.800 |       |
| L1        | 3.71        | 4.29  | 0.146     | 0.169 |       |
| $\phi P$  | 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  | 0.178     | 0.216 |       |
| S         | 5.51 BSC    |       | 0.217 BSC |       |       |

#### Notes

- Dimensioning and tolerancing per ASME Y14.5M-1994
- Contour of slot optional
- Dimension D and E do not include mold flash. 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
- $\phi P$  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")
- Outline conforms to JEDEC® outline TO-247 with exception of dimension A min., D, E min., Q min., S, and note 4



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