

## Product Summary

- Continuous Drain Source Voltage: 60V
- On-State Resistance: 500mΩ
- Nominal Load Current ( $V_{IN} = 5V$ ): 1.3A
- Clamping Energy: 90mJ

## Description

The ZXMS6004FFQ is a self-protected low side IntelliFET™ MOSFET with logic level input. It integrates overtemperature, overcurrent, overvoltage (active clamp) and ESD protected logic level functionality. The ZXMS6004FFQ is ideal as a general purpose switch driven from 3.3V or 5V microcontrollers in harsh environments where standard MOSFETs are not rugged enough.

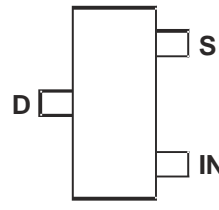
## Applications

- Especially Suited for Loads with a High In-Rush Current such as Lamps and Motors
- All Types of Resistive, Inductive and Capacitive Loads in Switching Applications
- $\mu$ C Compatible Power Switch for 12V and 24V DC Applications
- Automotive Rated
- Replaces Electromechanical Relays and Discrete Circuits
- Linear Mode Capability – the current-limiting protection circuitry is designed to de-activate at low  $V_{DS}$  to minimize on state power dissipation. The maximum DC operating current is therefore determined by the thermal capability of the package/board combination, rather than by the protection circuitry. This does not compromise the product's ability to self-protect at low  $V_{DS}$ .

SOT23F



Top View



Top view  
Pin Out

## Features and Benefits

- Compact High Power Dissipation Package
- Low Input Current
- Logic Level Input (3.3V and 5V)
- Short Circuit Protection with Auto Restart
- Overvoltage Protection (Active Clamp)
- Thermal Shutdown with Auto Restart
- Overcurrent Protection
- Input Protection (ESD)
- High Continuous Current Rating
- **Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)**
- **Halogen and Antimony Free. "Green" Device (Note 3)**
- **Qualified to AEC-Q101 Standards for High Reliability**
- **PPAP Capable (Note 4)**

## Mechanical Data

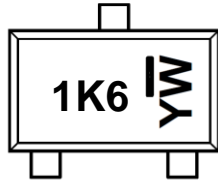
- Case: SOT23F
- Case Material: Molded Plastic, "Green" Molding Compound. UL Flammability Classification Rating 94V-0
- Moisture Sensitivity: Level 1 per J-STD-020
- Terminals: Matte Tin Finish  $\text{Ⓜ}$
- Weight: 0.012 grams (Approximate)

## Ordering Information (Note 5)

| Product       | Marking | Reel Size (inches) | Tape Width (mm) | Quantity per Reel |
|---------------|---------|--------------------|-----------------|-------------------|
| ZXMS6004FFQTA | 1K6     | 7                  | 12              | 3,000             |

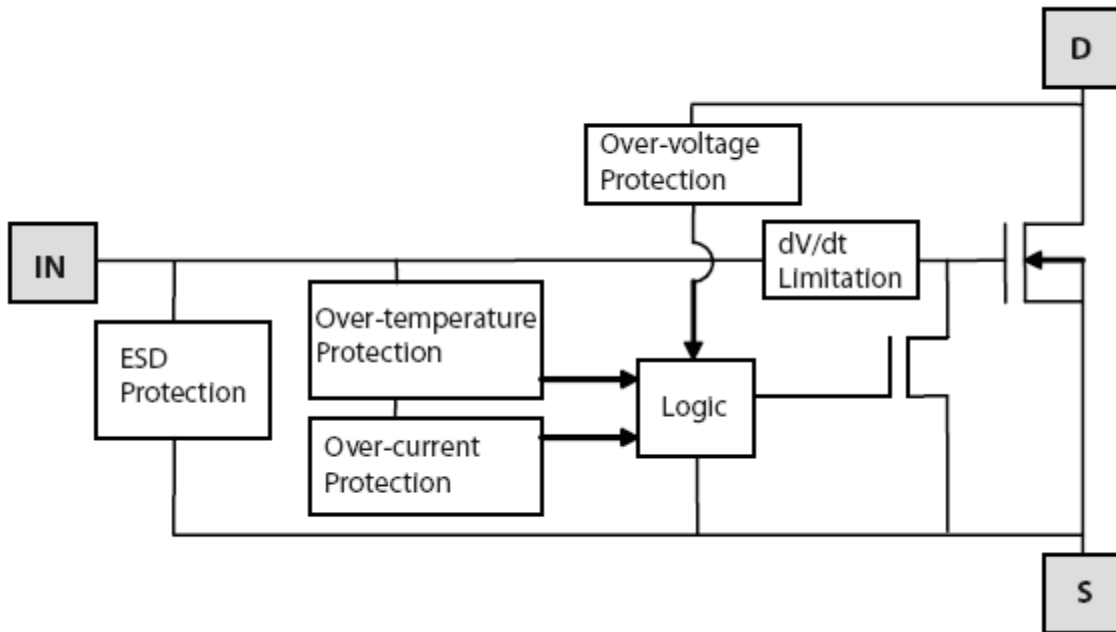
- Notes:
1. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS) & 2011/65/EU (RoHS 2) compliant.
  2. See [http://www.diodes.com/quality/lead\\_free.html](http://www.diodes.com/quality/lead_free.html) for more information about Diodes Incorporated's definitions of Halogen- and Antimony-free, "Green" and Lead-free.
  3. Halogen- and Antimony-free "Green" products are defined as those which contain <900ppm bromine, <900ppm chlorine (<1500ppm total Br + Cl) and <1000ppm antimony compounds.
  4. Automotive products are AEC-Q10x qualified and are PPAP capable. Refer to [http://www.diodes.com/quality/product\\_compliance\\_definitions/](http://www.diodes.com/quality/product_compliance_definitions/).
  5. For packaging details, go to our website at <http://www.diodes.com/products/packages.html>.

**Marking Information**



Y: Year: 0~9  
 W: Week: A-Z : 1~26  
 a-z: 27~52  
 z: Represents 52 & 53 Week  
 1K6 = Product Type Marking Code

**Functional Block Diagram**



**Maximum Ratings** (@T<sub>A</sub> = +25°C, unless otherwise specified.)

| Characteristic   | Symbol              | Value                 | Units |
|--|---------------------|-----------------------|-------|
| Continuous Drain-Source Voltage  | V <sub>DS</sub>     | 60                    | V     |
| Drain-Source Voltage for Short Circuit Protection  | V <sub>DS(SC)</sub> | 36                    | V     |
| Continuous Input Voltage   | V <sub>IN</sub>     | -0.5 ... +6           | V     |
| Continuous Input Current @ -0.2V ≤ V <sub>IN</sub> ≤ 6V  | I <sub>IN</sub>     | No limit              | mA    |
| Continuous Input Current @ V <sub>IN</sub> < -0.2V or V <sub>IN</sub> > 6V                                       |                     | I <sub>IN</sub>   ≤ 2 |       |
| Pulsed Drain Current @ V <sub>IN</sub> = 3.3V  | I <sub>DM</sub>     | 2                     | A     |
| Pulsed Drain Current @ V <sub>IN</sub> = 5V  | I <sub>DM</sub>     | 2.5                   | A     |
| Continuous Source Current (Body Diode)   | I <sub>S</sub>      | 1                     | A     |
| Pulsed Source Current (Body Diode)   | I <sub>SM</sub>     | 5                     | A     |
| Unclamped Single Pulse Inductive Energy,<br>T <sub>J</sub> = +25°C, I <sub>D</sub> = 0.5A, V <sub>DD</sub> = 24V | E <sub>AS</sub>     | 90                    | mJ    |
| Electrostatic Discharge (Human Body Model)   | V <sub>ESD</sub>    | 4,000                 | V     |
| Charged Device Model   | V <sub>CDM</sub>    | 1,000                 | V     |

**Thermal Characteristics** (@T<sub>A</sub> = +25°C, unless otherwise specified.)

| Characteristic                                      | Symbol           | Value       | Units |
|---|------------------|-------------|-------|
| Power Dissipation @ T <sub>A</sub> = +25°C (Note 6) | P <sub>D</sub>   | 0.83        | W     |
| Linear Derating Factor                              |                  | 6.66        | mW/°C |
| Power Dissipation @ T <sub>A</sub> = +25°C (Note 7) | P <sub>D</sub>   | 1.5         | W     |
| Linear Derating Factor                              |                  | 12.0        | mW/°C |
| Thermal Resistance, Junction to Ambient (Note 6)    | R <sub>θJA</sub> | 150         | °C/W  |
| Thermal Resistance, Junction to Ambient (Note 7)    | R <sub>θJA</sub> | 83          | °C/W  |
| Thermal Resistance, Junction to Case (Note 8)       | R <sub>θJC</sub> | 44          | °C/W  |
| Operating Temperature Range                         | T <sub>J</sub>   | -40 to +150 | °C    |
| Storage Temperature Range                           | T <sub>STG</sub> | -55 to +150 | °C    |

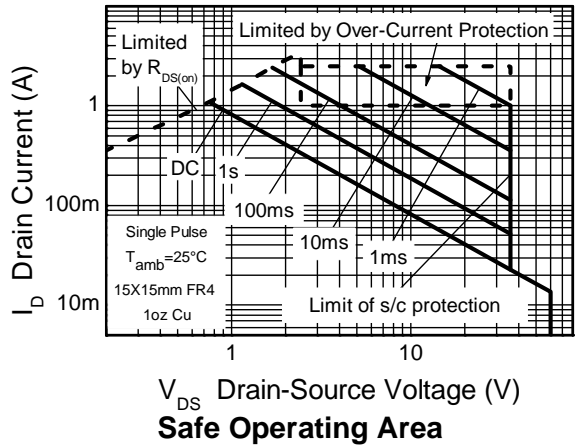
- Notes:
6. For a device surface mounted on 15mm x 15mm single sided, 1oz weight copper on 1.6mm FR4 board, in still air conditions.
  7. For a device surface mounted on 50mm x 50mm single sided, 2oz weight copper on 1.6mm FR4 board, in still air conditions.
  8. Thermal resistance from junction and the mounting surfaces of the drain pins.

**Recommended Operating Conditions**

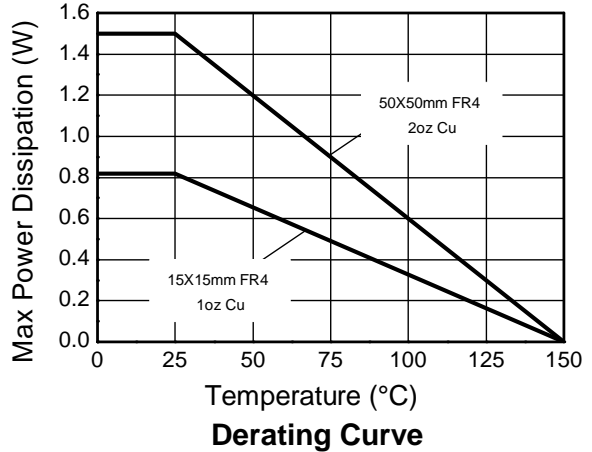
The ZXMS6004FF is optimized for use with μC operating from 3.3V and 5V supplies.

| Characteristic  | Symbol          | Min | Max  | Unit |
|---|-----------------|-----|------|------|
| Input Voltage Range   | V <sub>IN</sub> | 0   | 5.5  | V    |
| Ambient Temperature Range                                     | T <sub>A</sub>  | -40 | +125 | °C   |
| High Level Input Voltage for MOSFET to be On                  | V <sub>IH</sub> | 3   | 5.5  | V    |
| Low Level Input Voltage for MOSFET to be Off                  | V <sub>IL</sub> | 0   | 0.7  | V    |
| Peripheral Supply Voltage (Voltage to which Load is Referred) | V <sub>P</sub>  | 0   | 36   | V    |

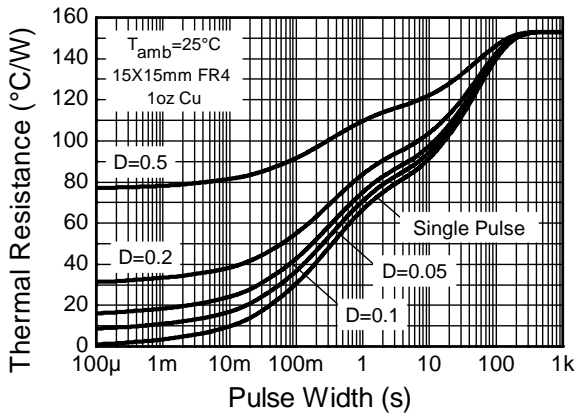
**Typical Thermal Characteristics**



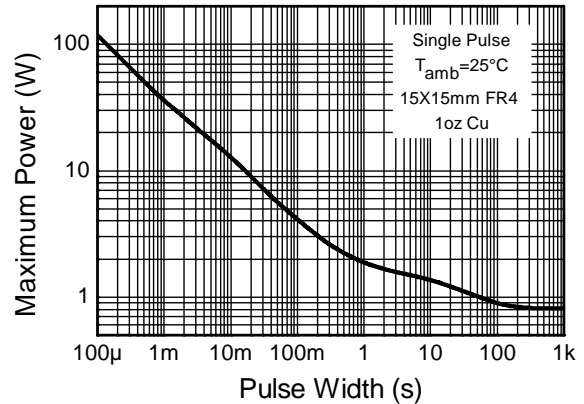
**Safe Operating Area**



**Derating Curve**



**Transient Thermal Impedance**



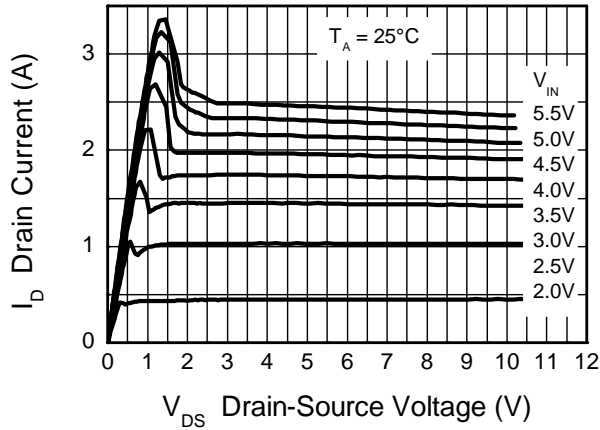
**Pulse Power Dissipation**

**Electrical Characteristics** (@T<sub>A</sub> = +25°C, unless otherwise specified.)

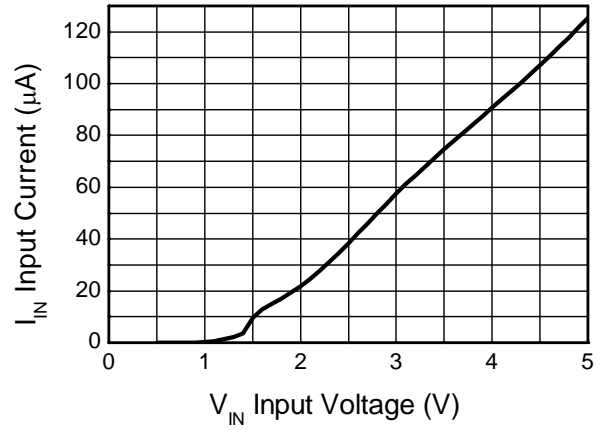
| Characteristic                              | Symbol              | Min  | Typ  | Max | Unit | Test Condition   |
|---|---------------------|------|------|-----|------|--|
| <b>Static Characteristics</b>               |                     |      |      |     |      |  |
| Drain-Source Clamp Voltage                  | V <sub>DS(AZ)</sub> | 60   | 65   | 70  | V    | I <sub>D</sub> = 10mA  |
| Off-State Drain Current                     | I <sub>DSS</sub>    | —    | —    | 500 | nA   | V <sub>DS</sub> = 12V, V <sub>IN</sub> = 0V                        |
|   |                     | —    | —    | 1   | μA   | V <sub>DS</sub> = 36V, V <sub>IN</sub> = 0V                        |
| Input Threshold Voltage                     | V <sub>IN(TH)</sub> | 0.7  | 1    | 1.5 | V    | V <sub>DS</sub> = V <sub>GS</sub> , I <sub>D</sub> = 1mA           |
| Input Current                               | I <sub>IN</sub>     | —    | 60   | 100 | μA   | V <sub>IN</sub> = +3V  |
|   |                     | —    | 120  | 200 |      | V <sub>IN</sub> = +5V  |
| Input Current while Overtemperature Active  | —                   | —    | —    | 220 | μA   | V <sub>IN</sub> = +5V  |
| Static Drain-Source On-State Resistance     | R <sub>DS(ON)</sub> | —    | 400  | 600 | mΩ   | V <sub>IN</sub> = +3V, I <sub>D</sub> = 0.5A                       |
|   |                     | —    | 350  | 500 |      | V <sub>IN</sub> = +5V, I <sub>D</sub> = 0.5A                       |
| Continuous Drain Current (Note 6)           | I <sub>D</sub>      | 0.9  | —    | —   | A    | V <sub>IN</sub> = 3V; T <sub>A</sub> = +25°C                       |
|   |                     | 1.0  | —    | —   |      | V <sub>IN</sub> = 5V; T <sub>A</sub> = +25°C                       |
| Continuous Drain Current (Note 7)           |                     | 1.2  | —    | —   |      | V <sub>IN</sub> = 3V; T <sub>A</sub> = +25°C                       |
|   |                     | 1.3  | —    | —   |      | V <sub>IN</sub> = 5V; T <sub>A</sub> = +25°C                       |
| Current Limit (Note 9)                      | I <sub>D(LIM)</sub> | 0.7  | 1.7  | —   | A    | V <sub>IN</sub> = +3V  |
|   |                     | 1    | 2.2  | —   |      | V <sub>IN</sub> = +5V  |
| <b>Dynamic Characteristics</b>              |                     |      |      |     |      |  |
| Turn-On Delay Time                          | t <sub>D(ON)</sub>  | —    | 5    | —   | μs   | V <sub>DD</sub> = 12V, I <sub>D</sub> = 0.5A, V <sub>GS</sub> = 5V |
| Rise Time                                   | t <sub>R</sub>      | —    | 10   | —   |      |  |
| Turn-Off Delay Time                         | t <sub>D(OFF)</sub> | —    | 45   | —   |      |  |
| Fall Time                                   | t <sub>F</sub>      | —    | 15   | —   |      |  |
| <b>Overtemperature Protection</b>           |                     |      |      |     |      |  |
| Thermal Overload Trip Temperature (Note 10) | T <sub>JT</sub>     | +150 | +175 | —   | °C   | —  |
| Thermal Hysteresis (Note 10)                | f <sub>F</sub>      | —    | +10  | —   | °C   | —  |

- Notes:
- The drain current is restricted only when the device is in saturation (see graph 'Typical Output Characteristic'). This allows the device to be used in the fully on-state without interference from the current limit. The device is fully protected at all drain currents, as the low power dissipation generated outside saturation makes current limit unnecessary.
  - Overtemperature protection is designed to prevent device destruction under fault conditions. Fault conditions are considered as "outside" normal operating range, so this part is not designed to withstand over-temperature for extended periods.

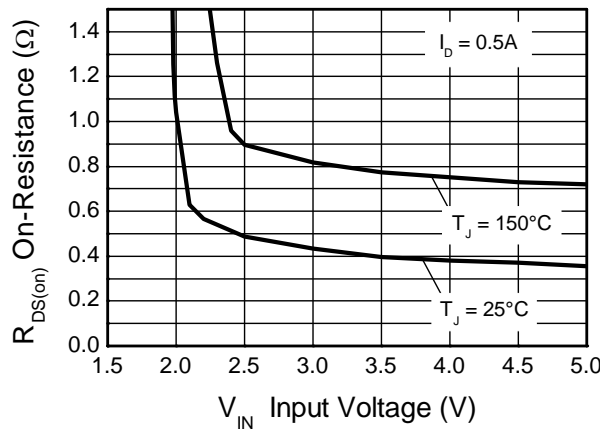
**Typical Performance Characteristics**



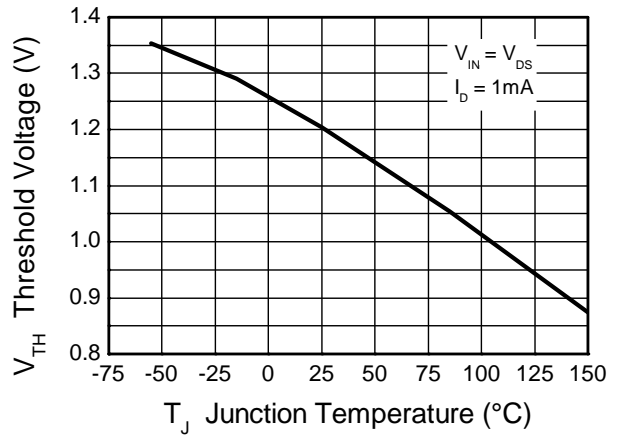
**Typical Output Characteristic**



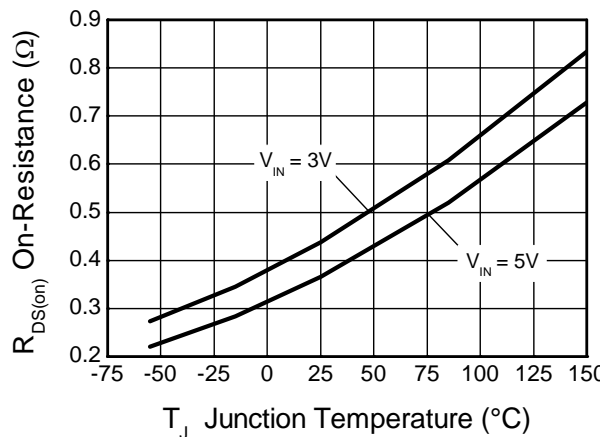
**Input Current vs Input Voltage**



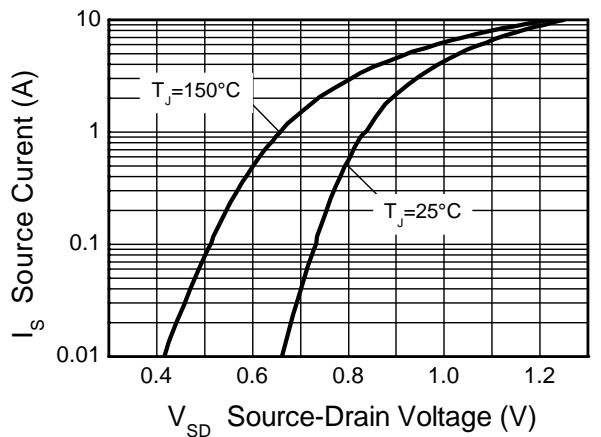
**On-Resistance vs Input Voltage**



**Threshold Voltage vs Temperature**

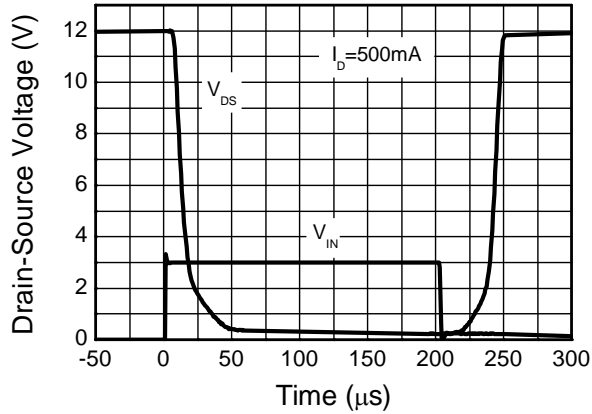


**On-Resistance vs Temperature**

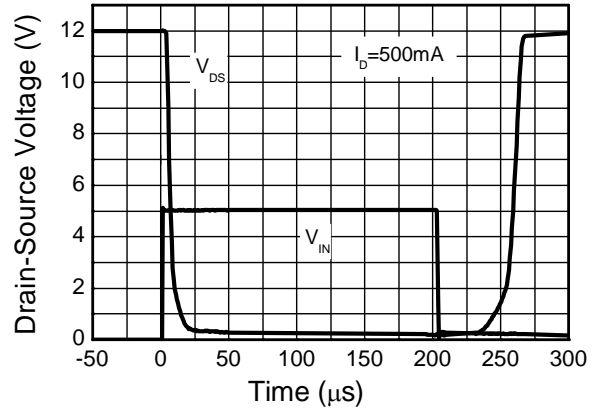


**Reverse Diode Characteristic**

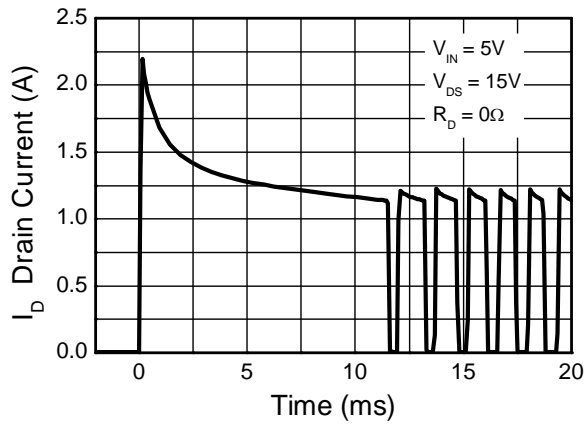
**Typical Performance Characteristics** (continued)



**Switching Speed**



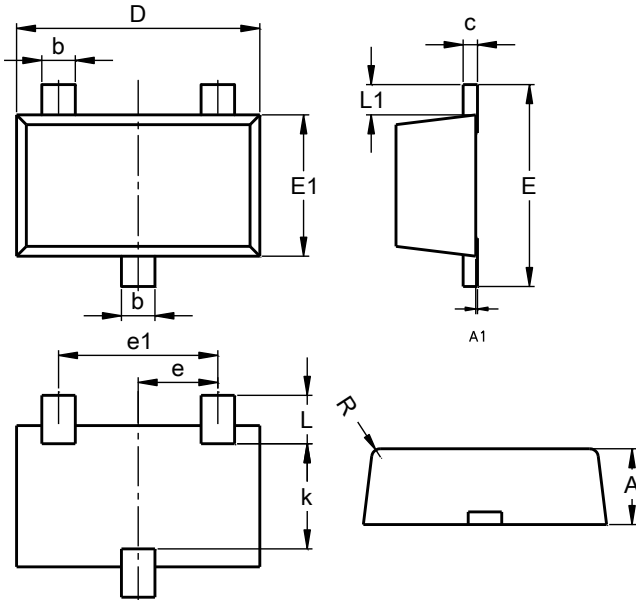
**Switching Speed**



**Typical Short Circuit Protection**

**Package Outline Dimensions**

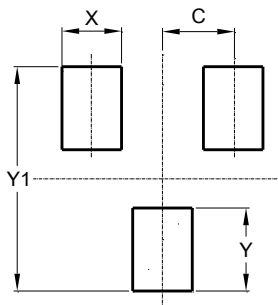
Please see AP02001 at [http://www.diodes.com/\\_files/datasheets/ap02001.pdf](http://www.diodes.com/_files/datasheets/ap02001.pdf) for the latest version.



| SOT23F               |           |      |      |
|----------------------|-----------|------|------|
| Dim                  | Min       | Max  | Typ  |
| A                    | 0.80      | 1.00 | 0.90 |
| b                    | 0.35      | 0.50 | 0.44 |
| c                    | 0.10      | 0.20 | 0.16 |
| D                    | 2.80      | 3.00 | 2.90 |
| e                    | 0.95 REF  |      |      |
| e1                   | 0.190 REF |      |      |
| E                    | 2.30      | 2.50 | 2.40 |
| E1                   | 1.50      | 1.70 | 1.65 |
| k                    | 1.20      | -    | -    |
| L                    | 0.30      | 0.65 | 0.50 |
| L1                   | 0.30      | 0.50 | 0.40 |
| R                    | 0.05      | 0.15 | -    |
| All Dimensions in mm |           |      |      |

**Suggested Pad Layout**

Please see AP02001 at [http://www.diodes.com/\\_files/datasheets/ap02001.pdf](http://www.diodes.com/_files/datasheets/ap02001.pdf) for the latest version.



| Dimensions | Value (in mm) |
|------------|---------------|
| C          | 0.95          |
| X          | 0.80          |
| Y          | 1.110         |
| Y1         | 3.000         |



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