# IntelliMAX™ Advanced Load Management Product

# FPF2123-FPF2125

## Description

The FPF2123, FPF2124, and FPF2125 are a series of load switches which provide full protection to systems and loads which may encounter large current conditions. These devices contain a 0.125 Ω current−limited P−channel MOSFET which can operate over an input voltage range of 1.8−5.5 V. The current limit is settable using an external resistor. Internally, current is prevented from flowing when the MOSFET is off and the output voltage is higher than the input voltage. Switch control is by a logic input (ON) capable of interfacing directly with low voltage control signals. Each part contains thermal shutdown protection which shuts off the switch to prevent damage to the part when a continuous over−current condition causes excessive heating.

When the switch current reaches the current limit, the parts operate in a constant−current mode to prohibit excessive currents from causing damage. For the FPF2123 and FPF2124 if the constant current condition still persists after 10 ms, these parts will shut off the switch. The FPF2123 has an auto−restart feature which will turn the switch on again after 160 ms if the ON pin is still active. The FPF2124 does not have this auto−restart feature so the switch will remain off after a current limit fault until the ON pin is cycled. The FPF2125 will not turn off after a current limit fault, but will rather remain in the constant current mode indefinitely. The minimum current limit is 150 mA.

These parts are available in a space−saving 5 pin SOT23 package.

## Features

- 1.8 to 5.5 V Input Voltage Range
- Controlled Turn−On
- 0.15−1.5 A Adjustable Current Limit
- Under−Voltage Lockout
- Thermal Shutdown
- < 2 μA Shutdown Current
- Auto Restart
- Fast Current Limit Response Time
  - ◆ 3 μs to Moderate Over Currents
- Fault Blanking
- Reverse Current Blocking
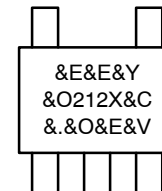- These Devices are Pb−Free and are RoHS Compliant

## Applications

- PDAs
- Cell Phones
- GPS Devices
- MP3 Players
- Digital Cameras
- Peripheral Ports
- Hot Swap Supplies
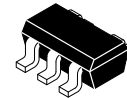
**SOT23−5**
**CASE 527AH**

## MARKING DIAGRAM

&E&E&Y
&O212X&C
&.&O&E&V

| | |
|---|---|
| &E | = Designates Space |
| &Y | = Binary Calendar Year Coding Scheme |
| &O | = Plant Code identifier |
| 212X | = Device Specific Code |
| | X = 3. 4 or 5 |
| &C | = Single digit Die Run Code |
| &. | = Pin One Dot |
| &V | = Eight−Week Binary Datecoding Scheme |

## ORDERING INFORMATION

See detailed ordering and shipping information on page 11 of this data sheet.
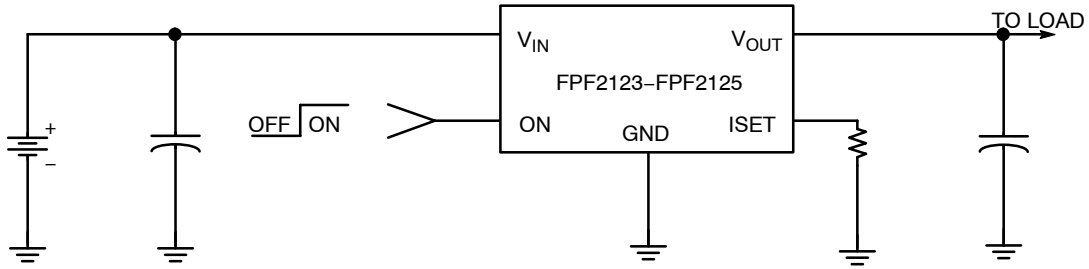
# FPF2123−FPF2125

**Typical Application Circuit**



**Figure 1. Typical Application**
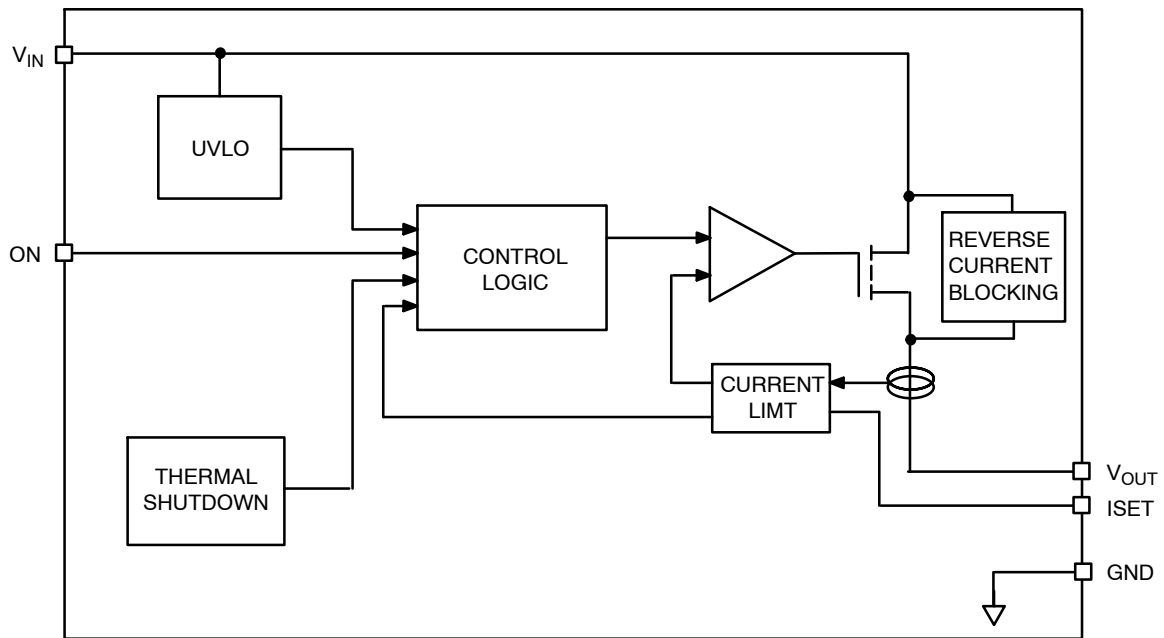
**Functional Block Diagram**



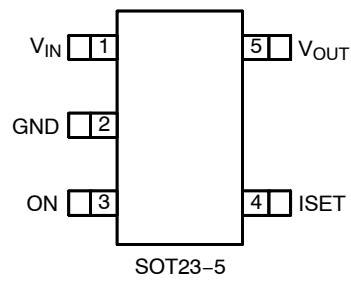**Figure 2. Block Diagram**

**Pin Configuration**



SOT23−5

**Figure 3. Pin Assignment**

## PIN DESCRIPTIONS

| Pin | Name | Function |
|---|---|---|
| 1 | $V_{IN}$ | Supply Input: Input to the power switch and the supply voltage for the IC |
| 2 | GND | Ground |
| 3 | ON | ON Control Input |
| 4 | ISET | Current Limit Set Input: A resistor from ISET to ground sets the current limit for the switch. |
| 5 | $V_{OUT}$ | Switch Output: Output of the power switch |

## ABSOLUTE MAXIMUM RATINGS

| Parameter | | Min | Max | Unit |
|---|---|---|---|---|
| $V_{IN}$, $V_{OUT}$, ON, ISET to GND | | −0.3 | 6.0 | V |
| Power Dissipation @ $T_A$ = 25°C (Note 1) | | | 667 | mW |
| Operating Temperature Range | | −40 | 125 | °C |
| Storage Temperature | | −65 | 150 | °C |
| Thermal Resistance, Junction to Ambient | | | 150 | °C/W |
| Electrostatic Discharge Protection | HBM | 4000 | | V |
| | MM | 400 | | |

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.
1. Package power dissipation on 1 square inch pad, 2 oz copper board.

## RECOMMENDED OPERATING CONDITIONS

| Symbol | Parameter | Min | Max | Unit |
|---|---|---|---|---|
| $V_{IN}$ | Input Voltage | 1.8 | 5.5 | V |
| $T_A$ | Ambient Operating Temperature | −40 | 85 | °C |

Functional operation above the stresses listed in the Recommended Operating Ranges is not implied. Extended exposure to stresses beyond the Recommended Operating Ranges limits may affect device reliability.

## ELECTRICAL CHARACTERISTICS

$V_{IN}$ = 1.8 to 5.5 V, $T_A$ = −40 to +85°C unless otherwise noted. Typical values are at $V_{IN}$ = 3.3 V and $T_A$ = 25°C.

| Symbol | Parameter | Test Condition | | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|---|
| **BASIC OPERATION** | | | | | | | |
| $V_{IN}$ | Operating Voltage | | | 1.8 | | 5.5 | V |
| $I_Q$ | Quiescent Current | $I_{OUT}$ = 0 mA | $V_{IN}$ = 1.8 to 3.3 V | | 75 | | μA |
| | | | $V_{IN}$ = 3.3 to 5.5 V | | 80 | 120 | |
| $I_{SHDN}$ | Shutdown Current | | | | | 2 | μA |
| $I_{BLOCK}$ | Reverse Block Leakage Current | | | | | 1 | μA |
| $I_{LATCHOFF}$ | Latch−Off Current | FPF2124 | | | 50 | | μA |
| $R_{ON}$ | ON−Resistance | $V_{IN}$ = 3.3 V, $I_{OUT}$ = 50 mA, $T_A$ = 25°C | | | 125 | 160 | mΩ |
| | | $V_{IN}$ = 3.3 V, $I_{OUT}$ = 50 mA, $T_A$ = 85°C | | | 150 | 200 | |
| | | $V_{IN}$ = 3.3 V, $I_{OUT}$ = 50 mA, $T_A$ = −40°C to + 85°C | | 65 | | 200 | |
| $V_{IH}$ | ON Input Logic High Voltage (ON) | $V_{IN}$ = 1.8 V | | 0.75 | | | V |
| | | $V_{IN}$ = 5.5 V | | 1.30 | | | |
| $V_{IL}$ | ON Input Logic Low Voltage (ON) | $V_{IN}$ = 1.8 V | | | | 0.5 | V |
| | | $V_{IN}$ = 5.5 V | | | | 1.0 | |

# FPF2123−FPF2125

**ELECTRICAL CHARACTERISTICS** (continued)

$V_{IN}$ = 1.8 to 5.5 V, $T_A$ = −40 to +85°C unless otherwise noted. Typical values are at $V_{IN}$ = 3.3 V and $T_A$ = 25°C.

| Symbol | Parameter | Test Condition | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| **BASIC OPERATION** | | | | | | |
| | ON Input Leakage | $V_{ON}$ = $V_{IN}$ or GND | | | 1 | μA |
| $I_{SWOFF}$ | Off Switch Leakage | $V_{ON}$ = 0 V, $V_{OUT}$ = 0 V | | | 1 | μA |
| **PROTECTIONS** | | | | | | |
| $I_{LIM}$ | Current Limit | $V_{IN}$ = 3.3 V, $V_{OUT}$ = 3.0 V, RSET = 576 Ω | 600 | 800 | 1000 | mA |
| $I_{LIM(min.)}$ | Min. Current Limit | $V_{IN}$ = 3.3 V, $V_{OUT}$ = 3.0 V | | 150 | | mA |
| | Thermal Shutdown | Shutdown Threshold | | 140 | | °C |
| | | Return from Shutdown | | 130 | | |
| | | Hysteresis | | 10 | | |
| UVLO | Under Voltage Shutdown | $V_{IN}$ Increasing | 1.5 | 1.6 | 1.7 | V |
| | Under Voltage Shutdown Hysteresis | | | 50 | | mV |
| **DYNAMIC** | | | | | | |
| $t_{ON}$ | Turn On Time | $R_L$ = 500 Ω, $C_L$ = 0.1 μF | | 25 | | μs |
| $t_{OFF}$ | Turn Off Time | $R_L$ = 500 Ω, $C_L$ = 0.1 μF | | 70 | | μs |
| $t_R$ | $V_{OUT}$ Rise Time | $R_L$ = 500 Ω, $C_L$ = 0.1 μF | | 12 | | μs |
| $t_F$ | $V_{OUT}$ Fall Time | $R_L$ = 500 Ω, $C_L$ = 0.1 μF | | 200 | | μs |
| $t_{BLANK}$ | Over Current Blanking Time | FPF2123, FPF2124 | 5 | 10 | 20 | ms |
| $t_{RESTART}$ | Auto−Restart Time | FPF2123 | 80 | 160 | 320 | ms |
| | | FPF2124, FPF2125 | | NA | | |
| | Short Circuit Response Time | $V_{IN}$ = $V_{ON}$ = 3.3 V Moderate Over−Current Conditions | | 3 | | μs |
| | | $V_{IN}$ = $V_{ON}$ = 3.3 V Hard Short | | 20 | | μs |

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

**TYPICAL CHARACTERISTICS**
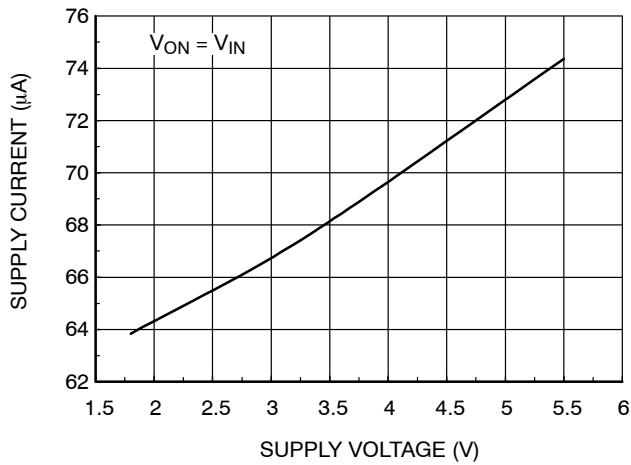


Figure 4. Quiescent Current vs. Input Voltage
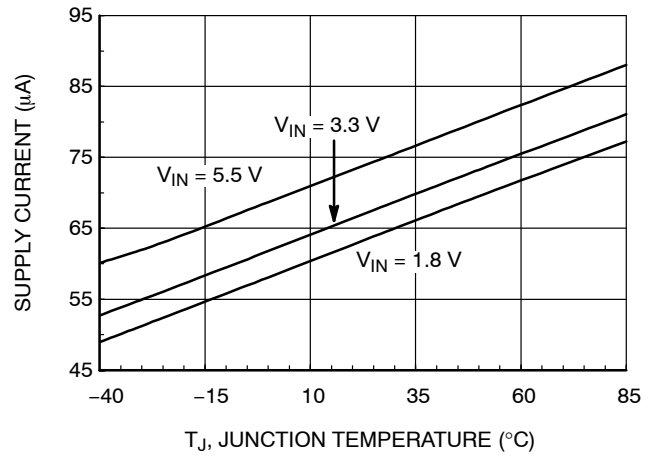


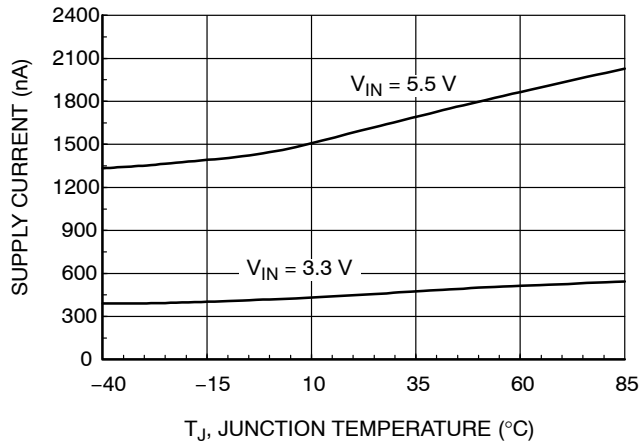Figure 5. Quiescent Current vs. Temperature
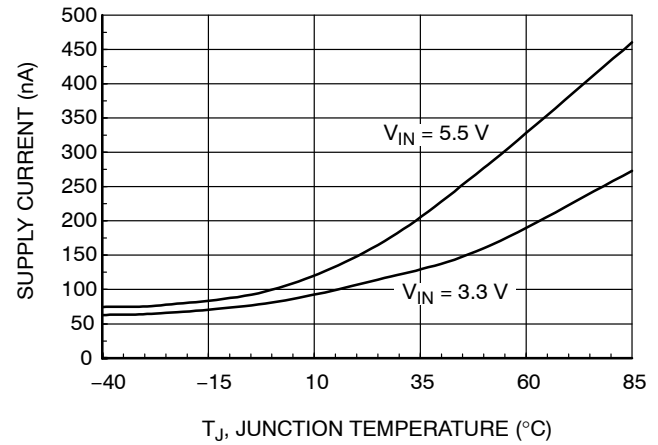


Figure 6. I$_{SHUTDOWN}$ Current vs. Temperature
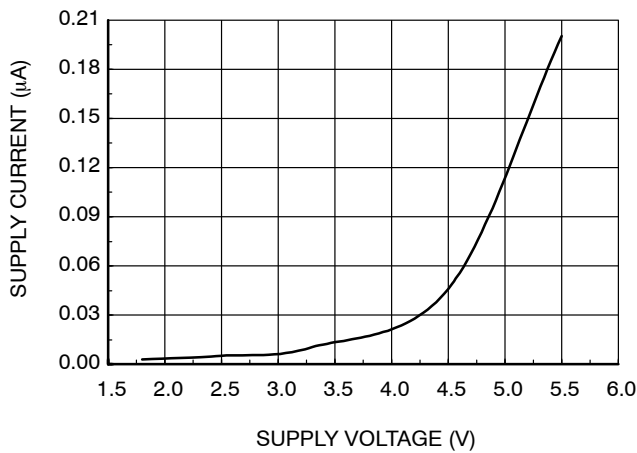


Figure 7. I$_{SWITCH-OFF}$ Current vs. Temperature
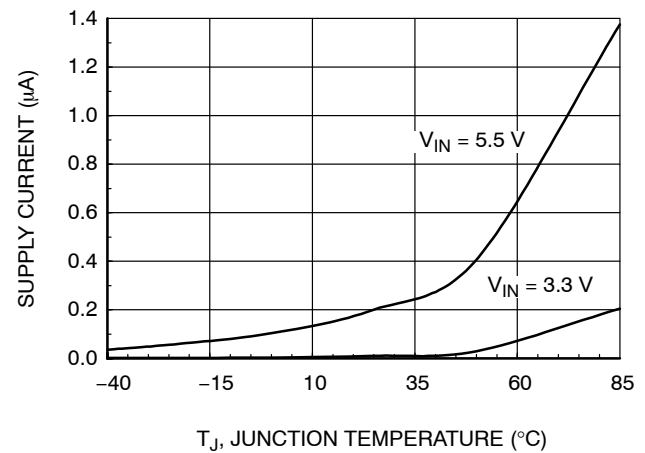


Figure 8. Reverse Current vs. V$_{OUT}$



Figure 9. Reverse Current vs. Temperature
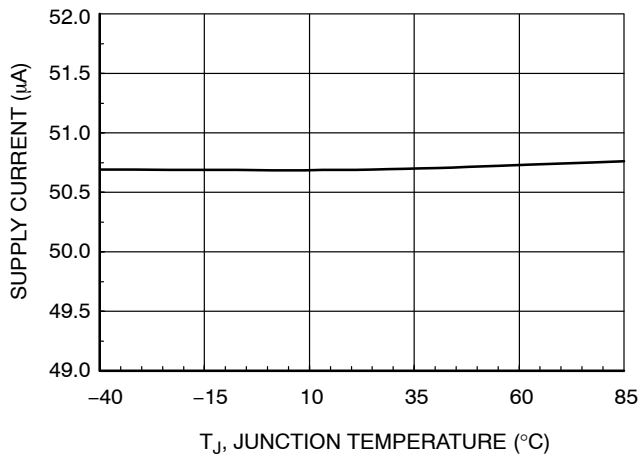
**TYPICAL CHARACTERISTICS** (Continued)
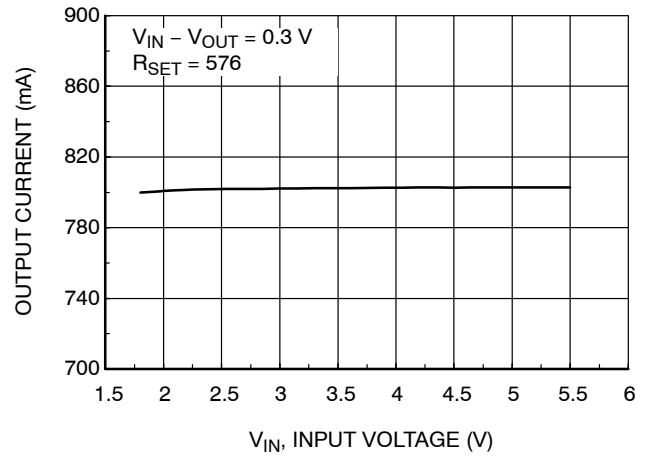
Figure 10. I$_{LATCH-OFF}$ Current vs. Temperature
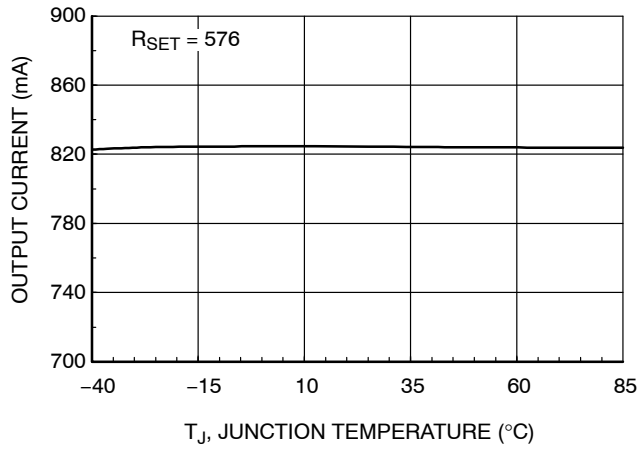
Figure 11. Current Limit vs. Input Voltage

Figure 12. Current Limit vs. Temperature
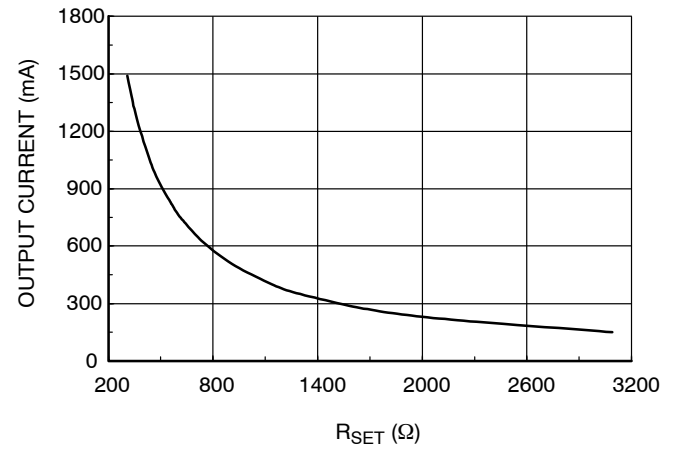
Figure 13. Current Limit vs. Rest
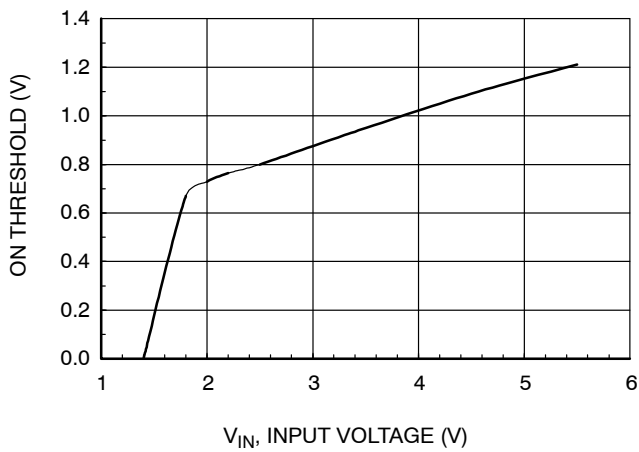
Figure 14. V$_{IH}$ vs. V$_{IN}$
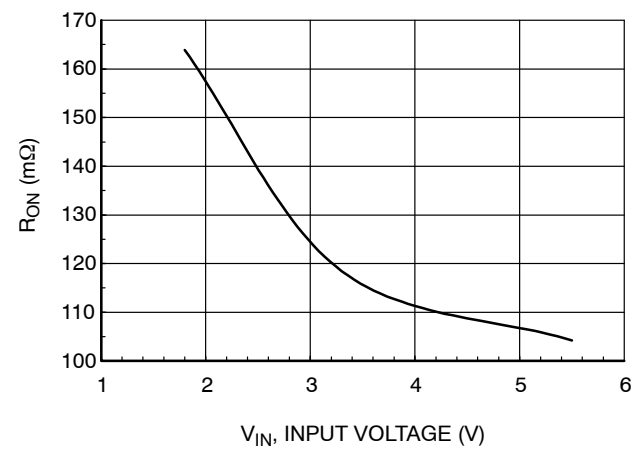
Figure 15. R$_{ON}$ vs. V$_{IN}$

## TYPICAL CHARACTERISTICS (Continued)
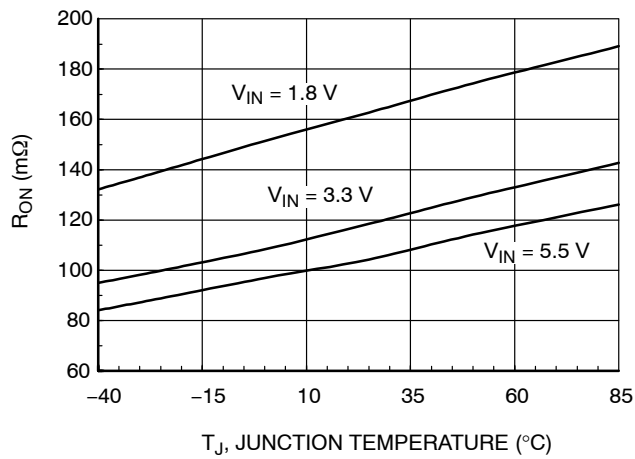
Figure 16. R(ON) vs. Temperature
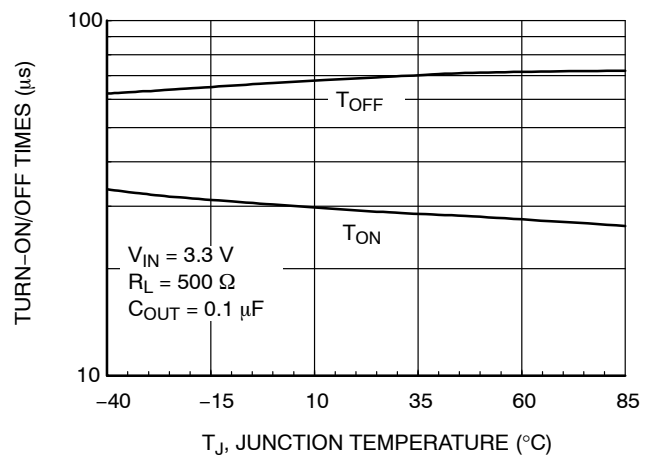
Figure 17. T_ON/T_OFF vs Temperature
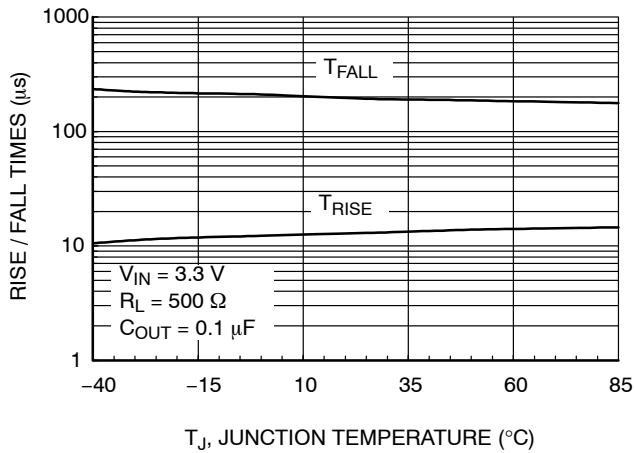
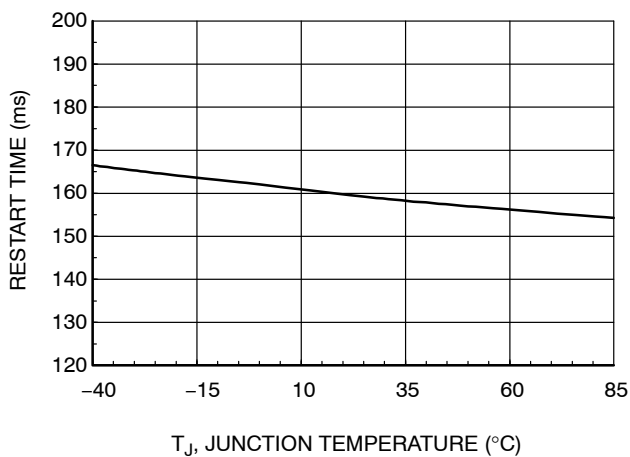Figure 18. T_RISE/T_FALL vs. Temperature
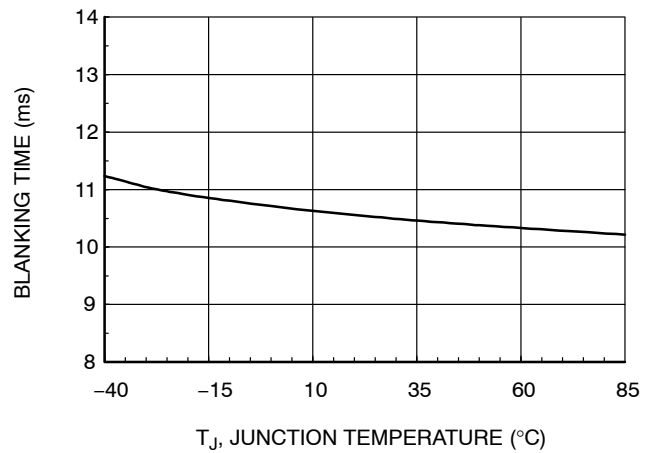
Figure 19. T_BLANK vs. Temperature

Figure 20. T_RESTART vs. Temperature
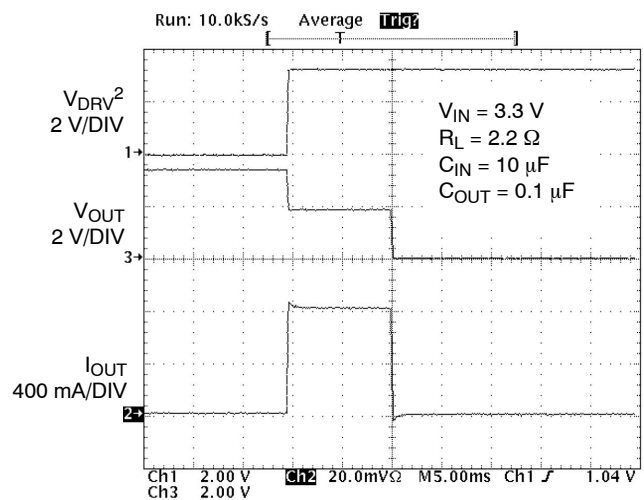
Figure 21. T_BLANK Response

## TYPICAL CHARACTERISTICS (Continued)

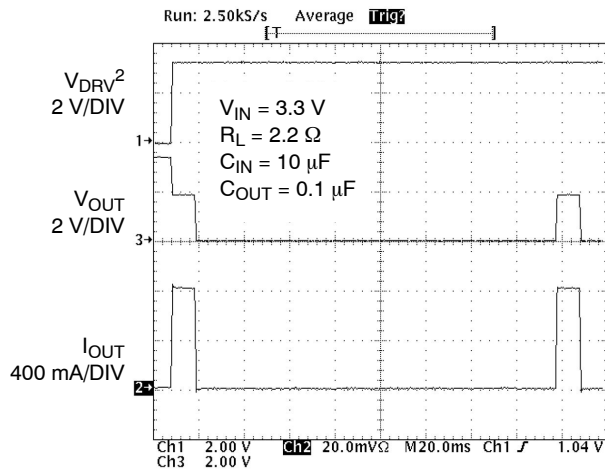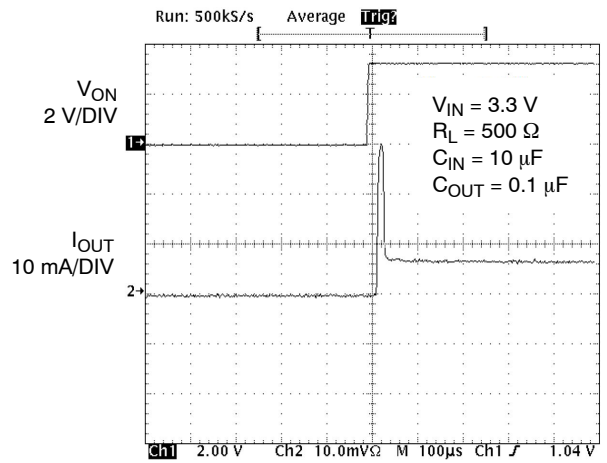**Figure 22. T$_{RESTART}$ Response**
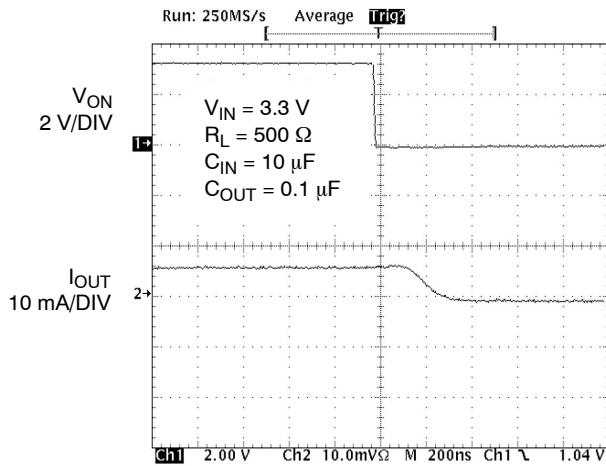
**Figure 23. T$_{ON}$ Response**
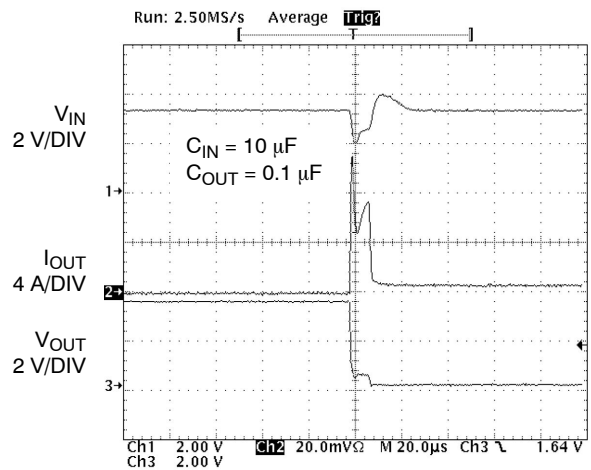
**Figure 24. T$_{OFF}$ Response**

**Figure 25. Short Circuit Response
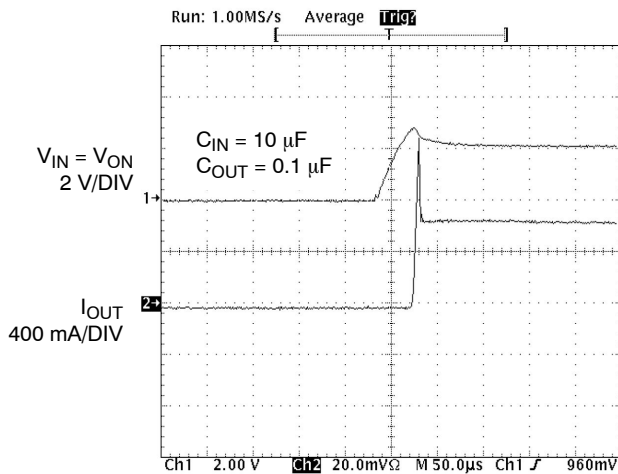(Output Shorted to GND)**

**Figure 26. Current Limit Response
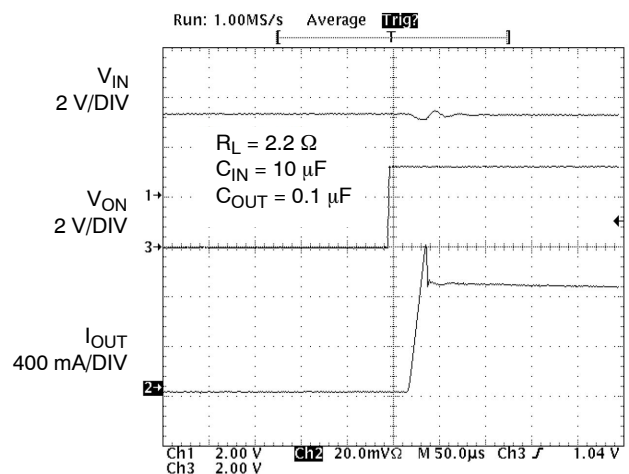(Switch Power Up to Hard Short)**

**Figure 27. Current Limit Response
(Output Shorted to GND by 2.2 Ω, Moderate Short)**

NOTE:  V$_{DRV}$ signal forces the device to go into overcurrent condition by loading a 2.2 Ω resistor.

# FPF2123−FPF2125

**Description of Operation**

The FPF2123, FPF2124, and FPF2125 are current limited switches that protect systems and loads which can be damaged or disrupted by the application of high currents. The core of each device is a 0.125 Ω P−channel MOSFET and a controller capable of functioning over a wide input operating range of 1.8−5.5 V. The controller protects against system malfunctions through current limiting under−voltage lockout and thermal shutdown. The current limit is adjustable from 150 mA to 1.5 A through the selection of an external resistor.

**On/Off Control**

The ON pin controls the state of the switch. When ON is high, the switch is in the on state. Activating ON continuously holds the switch in the on state so long as there is no fault. For all versions, an under−voltage on $V_{IN}$ or a junction temperature in excess of 140°C overrides the ON control to turn off the switch. In addition, excessive currents will cause the switch to turn off in the FPF2123 and FPF2124. The FPF2123 has an Auto−Restart feature which will automatically turn the switch on again after 160 ms. For the FPF2124, the ON pin must be toggled to turn−on the switch again. The FPF2125 does not turn off in response to an over current condition but instead remains operating in a constant current mode so long as ON is active and the thermal shutdown or under−voltage lockout have not activated.

The ON pin control voltage and $V_{IN}$ pin have independent recommended operating ranges. The ON pin voltage can be driven by a voltage level higher than the input voltage.

**Current Limiting**

The current limit ensures that the current through the switch doesn't exceed a maximum value while not limiting at less than a minimum value. The current at which the parts will limit is adjustable through the selection of an external resistor connected to ISET. Information for selecting the resistor is found in the Application Info section. The FPF2123 and FPF2124 have a blanking time of 10 ms, nominally, during which the switch will act as a constant current source. At the end of the blanking time, the switch will be turned−off. The FPF2125 has no current limit blanking period so it will remain in a constant current state until the ON pin is deactivated or the thermal shutdown turns−off the switch.

**Under−Voltage Lockout**

The under−voltage lockout turns−off the switch if the input voltage drops below the under−voltage lockout threshold. With the ON pin active, the input voltage rising above the under−voltage lockout threshold will cause a controlled turn−on of the switch which limits current over−shoots.

**Thermal Shutdown**

The thermal shutdown protects the die from internally or externally generated excessive temperatures. During an over−temperature condition the switch is turned−off. The switch automatically turns−on again if the temperature of the die drops below the threshold temperature.
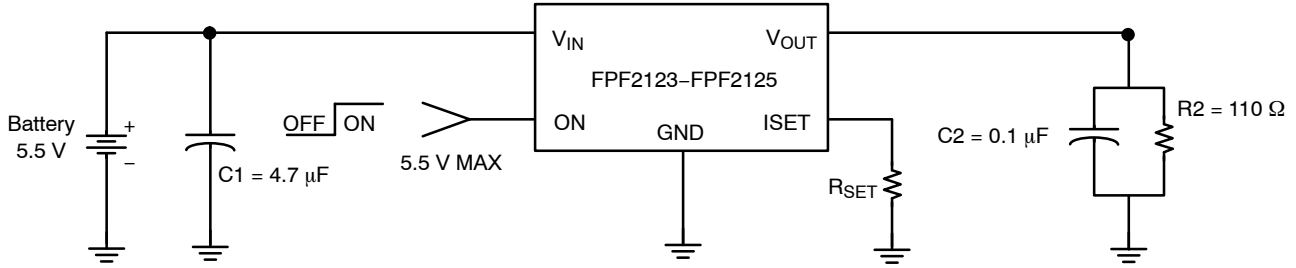
## APPLICATIONS INFORMATION



**Figure 28. Typical Application**

**Setting Current Limit**

The FPF2123, FPF2124, and FPF2125 have a current limit which is set with an external resistor connected between ISET and GND. This resistor is selected by using the following equation (1),

$$R_{SET} = \frac{460}{I_{LIM}} \qquad \text{(eq. 1)}$$

$R_{SET}$ is in Ohms and that of $I_{LIM}$ is Amps.

The table below can also be used to select $R_{SET}$. A typical application would be the 500 mA current that is required by a single USB port. Using the table below an appropriate selection for the $R_{SET}$ resistor would be 604 Ω. This will ensure that the port load could draw 570 mA, but not more than 950 mA. Likewise for a dual port system, an $R_{SET}$ of 340 Ω would always deliver at least 1120 mA and never more than 1860 mA.

**Input Capacitor**

To limit the voltage drop on the input supply caused by transient in−rush currents when the switch turns−on into a discharged load capacitance or a short−circuit, a capacitor needs to be placed between $V_{IN}$ and GND. A 4.7 μF ceramic capacitor, $C_{IN}$, must be placed close to the $V_{IN}$ pin. A higher value of $C_{IN}$ can be used to further reduce the voltage drop experienced as the switch is turned on into a large capacitive load.

**Output Capacitor**

A 0.1 μF capacitor, $C_{OUT}$, should be placed between $V_{OUT}$ and GND. This capacitor will prevent parasitic board inductances from forcing $V_{OUT}$ below GND when the switch turns−off. For the FPF2123 and FPF2124, the total output capacitance needs to be kept below a maximum

value, $C_{OUT(max)}$, to prevent the part from registering an over−current condition and turning−off the switch. The maximum output capacitance can be determined from the following formula,

$$C_{OUT}(max) = \frac{I_{LIM}(min) \times t_{BLANK}(min)}{V_{IN}} \qquad \text{(eq. 2)}$$

**Table 1. Current Limit Various $R_{SET}$ Values**

| $R_{SET}$ [Ω] | Min. Current Limit [mA] | Typ. Current Limit [mA] | Max. Current Limit [mA] |
|---|---|---|---|
| 309 | 1120 | 1490 | 1860 |
| 340 | 1010 | 1350 | 1690 |
| 374 | 920 | 1230 | 1540 |
| 412 | 840 | 1120 | 1400 |
| 453 | 760 | 1010 | 1270 |
| 499 | 690 | 920 | 1150 |
| 549 | 630 | 840 | 1050 |
| 576 | 600 | 800 | 1000 |
| 604 | 570 | 760 | 950 |
| 732 | 470 | 630 | 790 |
| 887 | 390 | 520 | 650 |
| 1070 | 320 | 430 | 540 |
| 1300 | 260 | 350 | 440 |
| 1910 | 180 | 240 | 300 |
| 3090 | 110 | 150 | 190 |

# FPF2123−FPF2125

**Power Dissipation**

During normal operation as a switch, the power dissipated in the part will depend upon the level at which the current limit is set. The maximum allowed setting for the current limit is 1.5 A and this will result in a typical power dissipation of,

$$P = (I_{LIM})^2 \times R_{ON} = (1.5)^2 \times 0.125 = 281 \text{ mW} \quad \text{(eq. 3)}$$

If the part goes into current limit the maximum power dissipation will occur when the output is shorted to ground. For the FPF2123 the power dissipation will scale by the Auto−Restart Time, $t_{RESTART}$, and the Over Current Blanking Time, $t_{BLANK}$, so that the maximum power dissipated is,

$$P(max) = \frac{t_{BLANK}(max)}{t_{RESTART}(min) + t_{BLANK}(max)} \times$$

$$\times V_{IN}(max) \times I_{LIM}(max) = \frac{20}{80 + 20} \times 5.5 \times 1.5 = 1.65 \text{ W}$$

(eq. 4)

This is more power than the package can dissipate, but the thermal shutdown of the part will activate to protect the part from damage due to excessive heating. When using the FPF2124, attention must be given to the manual resetting of the part. Continuously resetting the part when a short on the output is present will cause the temperature of the part to increase. The junction temperature will only be able to increase to the thermal shutdown threshold. Once this temperature has been reached, toggling ON will not turn−on the switch until the junction temperature drops. For the FPF2125, a short on the output will cause the part to operate in a constant current state dissipating a worst case power of,

$$P(max) = V_{IN}(max) \times I_{LIM}(max) = 5.5 \times 1.5 = 8.25 \text{ W}$$

(eq. 5)

This large amount of power will activate the thermal shutdown and the part will cycle in and out of thermal shutdown so long as the ON pin is active and the short is present.

**Board Layout**

For best performance, all traces should be as short as possible. To be most effective, the input and output capacitors should be placed close to the device to minimize the effects that parasitic trace inductances may have on normal and short−circuit operation. Using wide traces for $V_{IN}$, $V_{OUT}$ and GND will help minimize parasitic electrical effects along with minimizing the case to ambient thermal impedance.

## ORDERING INFORMATION

| Part Number | Current Limit [A] | Current Limit Blanking Time [ms] | Auto Restart Time [ms] | On Pin Activity | Top Mark | Shipping[†] |
|---|---|---|---|---|---|---|
| FPF2123 | 0.15 – 1.5 | 5/10/20 | 80/160/320 | Active HI | 2123 | 3000 / Tape & Reel |
| FPF2124 | 0.15 – 1.5 | 5/10/20 | NA | Active HI | 2124 | 3000 / Tape & Reel |
| FPF2125 | 0.15 – 1.5 | Infinite | NA | Active HI | 2425 | 3000 / Tape & Reel |

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D
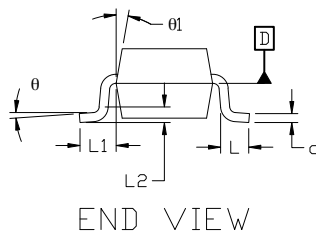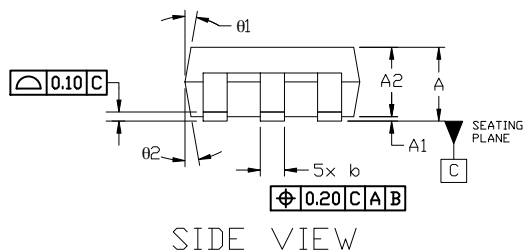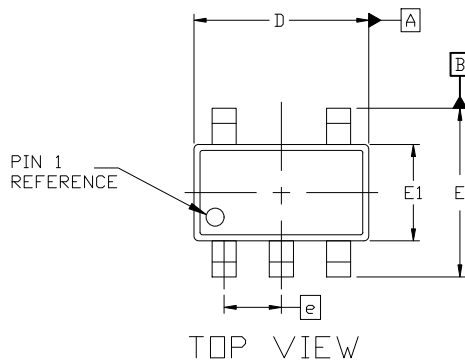
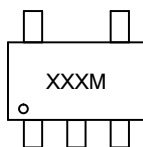# MECHANICAL CASE OUTLINE
## PACKAGE DIMENSIONS
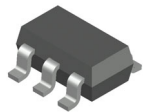
**SOT−23, 5 Lead**
CASE 527AH
ISSUE A

DATE 09 JUN 2021

NOTES:
1.  DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 19894
2.  CONTROLLING DIMENSION: MILLIMETERS
3.  MAXIMUM LEAD THICKNESS INCLUDES LEAD FINISH THICKNESS. MINIMUM LEAD THICKNESS IS THE MINIMUM THICKNESS OF THE BASE MATERIAL.
4.  DIMENSIONS D AND E1 DO NOT INCLUDE MOLD FLASH, PROTRUSIONS, OR GATE BURRS. MOLD FLASH, PROTRUSIONS, OR GATE BURRS SHALL NOT EXCEED 0.25 PER SIDE. D AND E1 DIMENSIONS ARE DETERMINED AT DATUM D.
5.  DIMENSION 'b' DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.08mm TOTAL IN EXCESS OF THE 'b' DIMENSION AT MAXIMUM MATERIAL CONDITION. MINIMUM SPACE BETWEEN PROTRUSION AND AN ADJACENT LEAD SHALL NOT BE LESS THAN 0.07mm.

TOP VIEW

SIDE VIEW

END VIEW

| DIM | MILLIMETERS | | |
| --- | --- | --- | --- |
| | MIN. | NOM. | MAX. |
| A | 0.90 | — | 1.45 |
| A1 | 0.00 | — | 0.15 |
| A2 | 0.90 | 1.15 | 1.30 |
| b | 0.30 | — | 0.50 |
| c | 0.08 | — | 0.22 |
| D | 2.90 BSC | | |
| E | 2.80 BSC | | |
| E1 | 1.60 BSC | | |
| e | 0.95 BSC | | |
| L | 0.30 | 0.45 | 0.60 |
| L1 | 0.60 REF | | |
| L2 | 0.25 REF | | |
| θ | 0° | 4° | 8° |
| θ1 | 0° | 10° | 15° |
| θ2 | 0° | 10° | 15° |

## GENERIC MARKING DIAGRAM*

XXXM

XXX = Specific Device Code
M   = Date Code

*This information is generic. Please refer to device data sheet for actual part marking. Pb−Free indicator, "G" or microdot "▪", may or may not be present. Some products may not follow the Generic Marking.
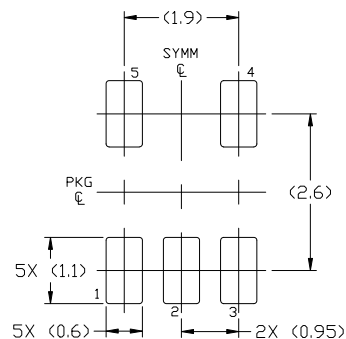
## RECOMMENDED MOUNTING FOOTPRINT

For additional information on our Pb−Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

| DOCUMENT NUMBER: | 98AON34320E | |
| --- | --- | --- |
| DESCRIPTION: | SOT−23, 5 LEAD | PAGE 1 OF 1 |

## PUBLICATION ORDERING INFORMATION

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