# AAT4611

*Current Limited Load Switch in an SOT23 Package*

## General Description

The AAT4611 SmartSwitch is a current limited P-channel MOSFET power switch designed for high-side load switching applications. This switch operates with inputs ranging from 2.7V to 5.5V, making it ideal for both 3V and 5V systems. An integrated current-limiting circuit protects the input supply against large currents which may cause the supply to fall out of regulation. The AAT4611 is also protected from thermal overload which limits power dissipation and junction temperatures. It can be used to control loads that require up to 1A. Current limit threshold is programmed with a resistor from SET to ground. The quiescent supply current is typically a low 15µA max. In shutdown mode, the supply current decreases to less than 1µA.

The AAT4611 is available in a Pb-free 5-pin SOT23 package and is specified over the -40°C to +85°C temperature range.
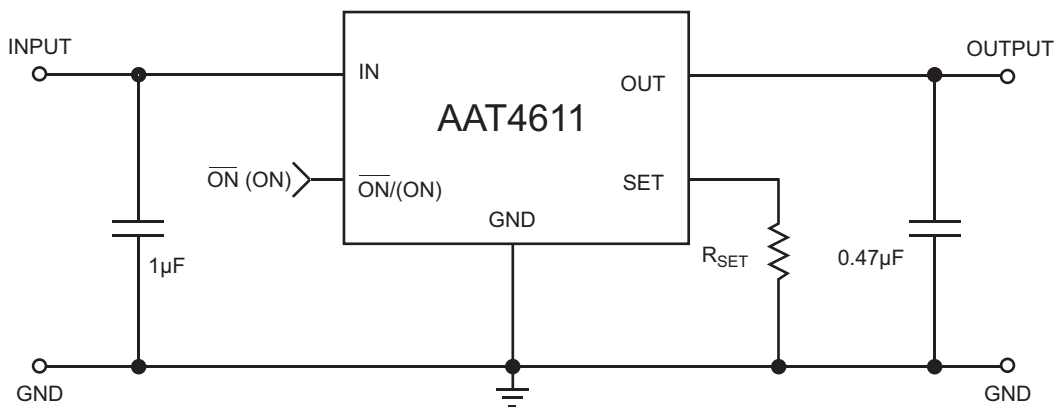
## Features

- Input Voltage Range: 2.7V to 5.5V
- Programmable Over-Current Threshold
- Fast Transient Response:
  - <1µs Response to Short Circuit
- Low Quiescent Current
  - 15µA Typical
  - 1µA Max with Switch Off
- 160mΩ Typical $R_{DS(ON)}$
- Only 2.5V Needed for ON/OFF Control
- Under-Voltage Lockout
- Thermal Shutdown
- 4kV ESD Rating
- 5-Pin SOT23 Package
- Temperature Range: -40°C to +85°C

## Applications

- Hot Swap Supplies
- Notebook Computers
- Peripheral Ports
- Personal Communication Devices

## Typical Application

Skyworks Solutions, Inc. • Phone [781] 376-3000 • Fax [781] 376-3100 • sales@skyworksinc.com • www.skyworksinc.com

201938A • Skyworks Proprietary Information • Products and Product Information are Subject to Change Without Notice. • May 7, 2012

1

## Pin Descriptions

| Pin # | Symbol | Function |
|-------|--------|----------|
| 1 | OUT | P-channel MOSFET drain. Connect a 0.47µF capacitor from OUT to GND. |
| 2 | GND | Ground connection. |
| 3 | SET | Current limit set input. A resistor from SET to ground sets the current limit for the switch. |
| 4 | $\overline{\text{ON}}$ | Enable input. Two versions are available, active-high and active-low. See Ordering Information for details. |
| 5 | IN | P-channel MOSFET source. Connect a 1µF capacitor from IN to GND. |

## Pin Configuration

**SOT23-5**
**(Top View)**

OUT [1]   [5] IN

GND [2]

SET [3]   [4] $\overline{\text{ON}}$
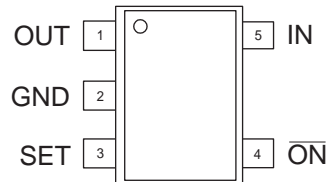
## Absolute Maximum Ratings[1]

$T_A$ = 25°C, unless otherwise noted.

| Symbol | Description | Value | Units |
|---|---|---|---|
| $V_{IN}$ | IN to GND | -0.3 to 6 | V |
| $V_{ON}$ | ON ($\overline{ON}$) to GND | -0.3 to $V_{IN}$ + 0.3 | V |
| $V_{SET}$, $V_{OUT}$ | SET, OUT to GND | -0.3 to $V_{IN}$ + 0.3 | V |
| $I_{MAX}$ | Maximum Continuous Switch Current | 2 | A |
| $T_J$ | Operating Junction Temperature Range | -40 to 150 | °C |
| $T_{LEAD}$ | Maximum Soldering Temperature (at leads) | 300 | °C |
| $V_{ESD}$ | ESD Rating[2] - HBM | 4000 | V |

## Thermal Characteristics[3]

| Symbol | Description | Value | Units |
|---|---|---|---|
| $\Theta_{JA}$ | Thermal Resistance | 150 | °C/W |
| $P_D$ | Power Dissipation | 667 | mW |

---

1. Stresses above those listed in Absolute Maximum Ratings may cause permanent damage to the device. Functional operation at conditions other than the operating conditions specified is not implied. Only one Absolute Maximum Rating should be applied at any one time.
2. Human body model is a 100pF capacitor discharged through a 1.5kΩ resistor into each pin.
3. Mounted on a demo board.

Skyworks Solutions, Inc. • Phone [781] 376-3000 • Fax [781] 376-3100 • sales@skyworksinc.com • www.skyworksinc.com

201938A • Skyworks Proprietary Information • Products and Product Information are Subject to Change Without Notice. • May 7, 2012

3

## Electrical Characteristics

$V_{IN}$ = 5V, $T_A$ = -40°C to +85°C, unless otherwise noted. Typical values are $T_A$ = 25°C.

| Symbol | Description | Conditions | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| $V_{IN}$ | Operation Voltage | | 2.7 | | 5.5 | V |
| $I_Q$ | Quiescent Current | $V_{IN}$ = 5V, ON ($\overline{ON}$) = Active, $I_{OUT}$ = 0 | | 15 | 30 | µA |
| $I_{Q(OFF)}$ | Off-Supply Current | ON ($\overline{ON}$) = Inactive, $V_{IN}$ = 5.5V | | | 1 | µA |
| $I_{SD(OFF)}$ | Off-Switch Current | ON ($\overline{ON}$) = Inactive, $V_{IN}$ = 5.5V, $V_{OUT}$ = 0 | | 0.03 | 15 | µA |
| $V_{UVLO}$ | Under-Voltage Lockout | Rising Edge, 1% Hysteresis | 2.0 | 2.3 | 2.7 | V |
| $R_{DS(ON)}$ | On Resistance | $V_{IN}$ = 5.0V | | 160 | 180 | mΩ |
| | | $V_{IN}$ = 4.5V | | 165 | | |
| | | $V_{IN}$ = 3.0V | | 195 | 230 | |
| $I_{LIM}$ | Current Limit | $R_{SET}$ = 6.8kΩ | 0.75 | 1 | 1.25 | A |
| $I_{LIM(MIN)}$ | Minimum Current Limit | | | 130 | 195 | mA |
| $V_{ON(L)}$ | ON ($\overline{ON}$) Input Low Voltage | | | | 0.8 | V |
| $V_{ON(H)}$ | ON ($\overline{ON}$) Input High Voltage | $V_{IN}$ = 2.7V to 3.6V | 2.0 | | | V |
| | | $V_{IN}$ = 4.5V to 5.5V | 2.4 | | | |
| $I_{ON(SINK)}$ | ON ($\overline{ON}$) Input Leakage | $V_{ON}$ = 5.5V | | 0.01 | 1 | µA |
| $T_{RESP}$ | Current Limit Response Time | $V_{IN}$ = 5V | | 0.8 | | µs |
| $T_{OFF}$ | Turn-Off Time | $V_{IN}$ = 5V, $R_L$ = 10Ω | | 0.4 | 2 | µs |
| $T_{ON}$ | Turn-On Time | $V_{IN}$ = 5V, $R_L$ = 10Ω | | 40 | 200 | µs |

## Typical Characteristics

Unless otherwise noted, $V_{IN}$ = 5V, $T_A$ = 25°C.

**Quiescent Current vs. Temperature**
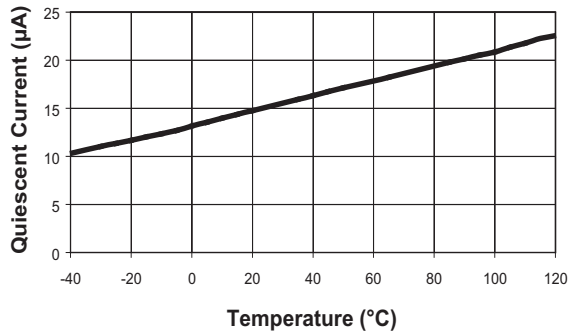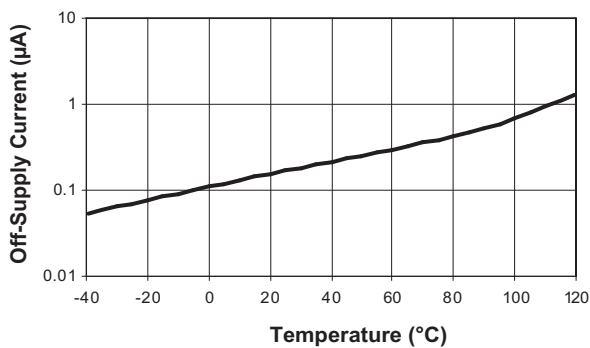


**Quiescent Current vs. Input Voltage**
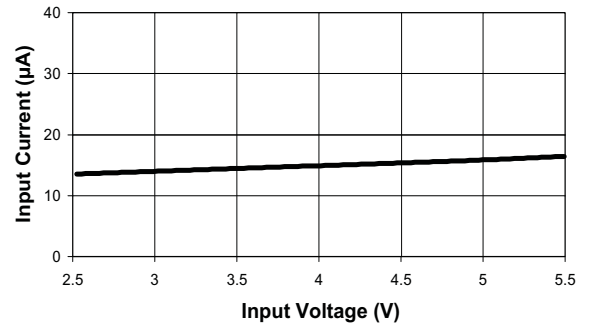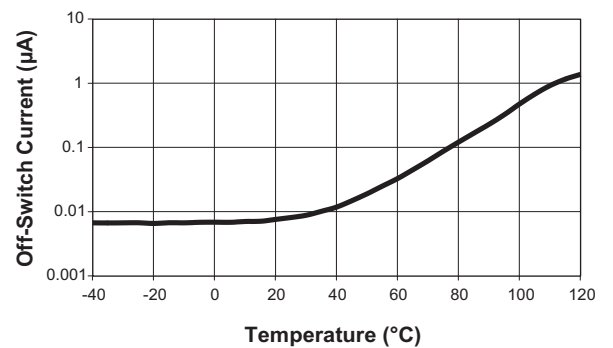


**Output Current vs. Output Voltage**
($R_{SET}$ = 16kΩ)
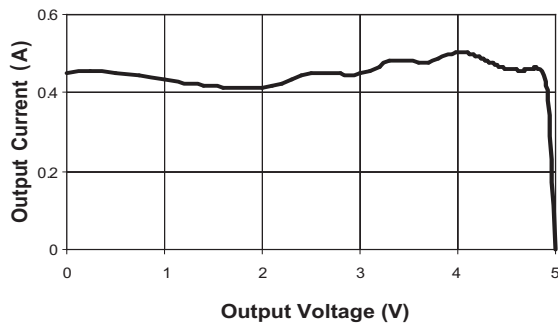


**$R_{DS(ON)}$ vs. Temperature**
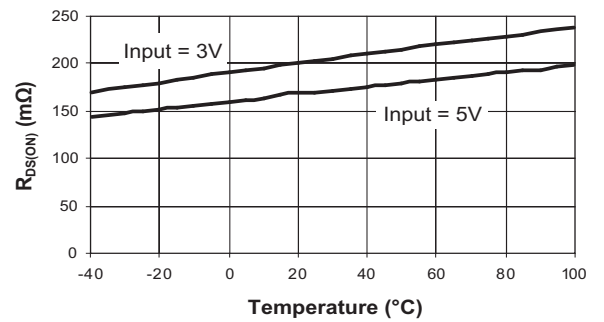


**Off-Supply Current vs. Temperature**
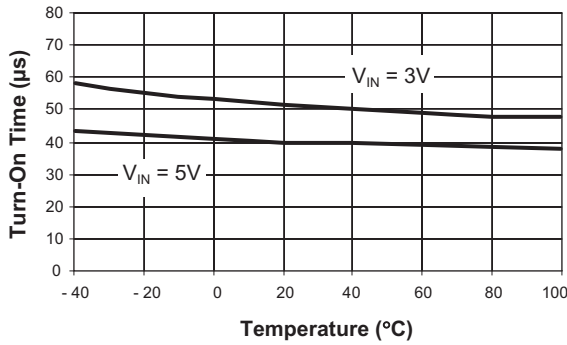


**Off-Switch Current vs. Temperature**

Skyworks Solutions, Inc. • Phone [781] 376-3000 • Fax [781] 376-3100 • sales@skyworksinc.com • www.skyworksinc.com

201938A • Skyworks Proprietary Information • Products and Product Information are Subject to Change Without Notice. • May 7, 2012

5

## Typical Characteristics

Unless otherwise noted, $V_{IN}$ = 5V, $T_A$ = 25°C.

**Turn-On vs. Temperature**



**Turn-Off vs. Temperature**
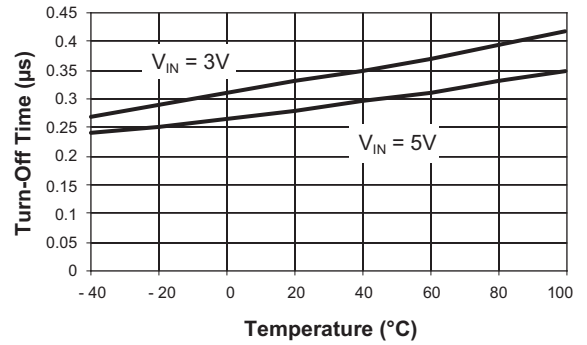


**Turn On**
($R_L$ = 10Ω; $C_L$ = 0.47µF; $I_{OUT}$ = $I_{LIMIT}$)
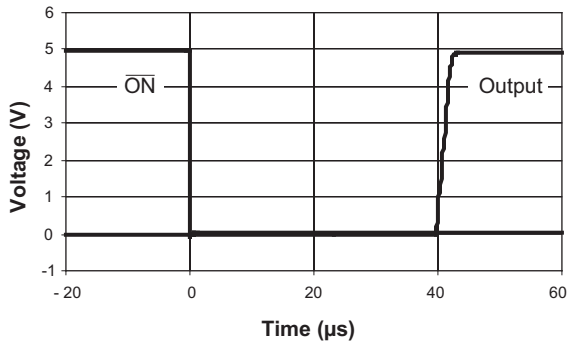


**Turn Off**
($R_L$ = 10Ω; $I_{OUT}$ = $I_{LIMIT}$)
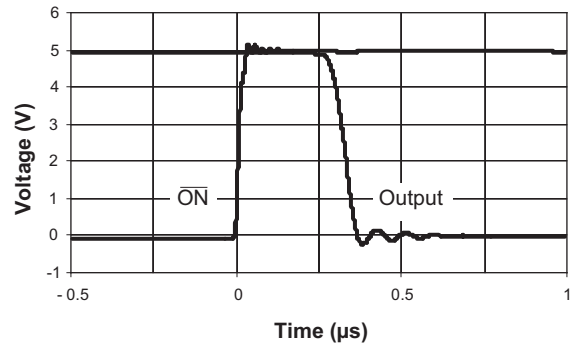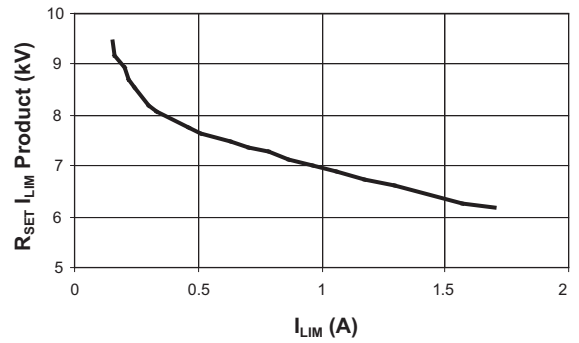


**Short-Circuit Through 0.3Ω**
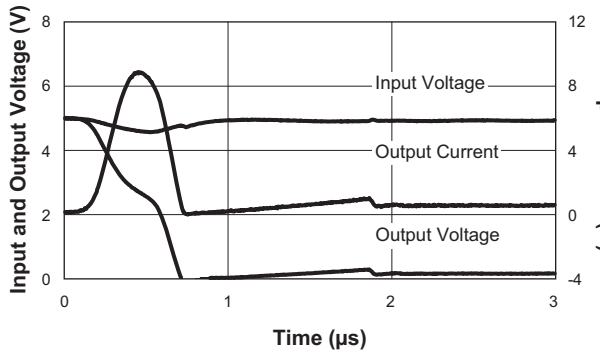


**Short-Circuit Through 0.6Ω**
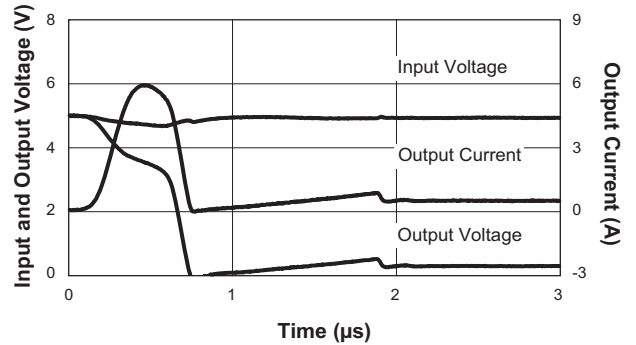
## Typical Characteristics

Unless otherwise noted, $V_{IN}$ = 5V, $T_A$ = 25°C.

**$R_{SET}$ vs. $I_{LIM}$**
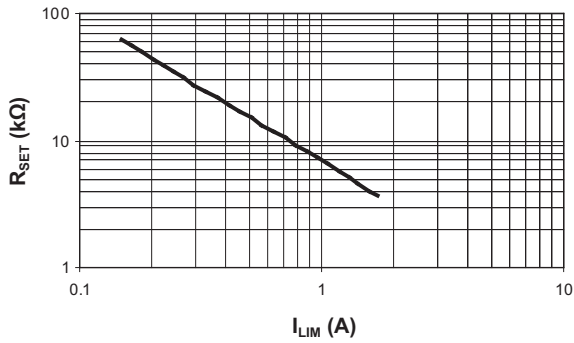


**$R_{SET}$ Coefficient vs. $I_{LIM}$**



**Current Limit vs. Temperature**
**($R_{SET}$ = 22.1kΩ; $V_{IN}$ - $V_{OUT}$ = 0.5V)**

Skyworks Solutions, Inc. • Phone [781] 376-3000 • Fax [781] 376-3100 • sales@skyworksinc.com • www.skyworksinc.com
201938A • Skyworks Proprietary Information • Products and Product Information are Subject to Change Without Notice. • May 7, 2012

7
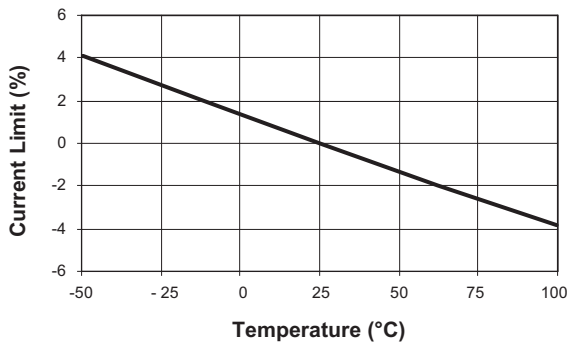
## Functional Block Diagram
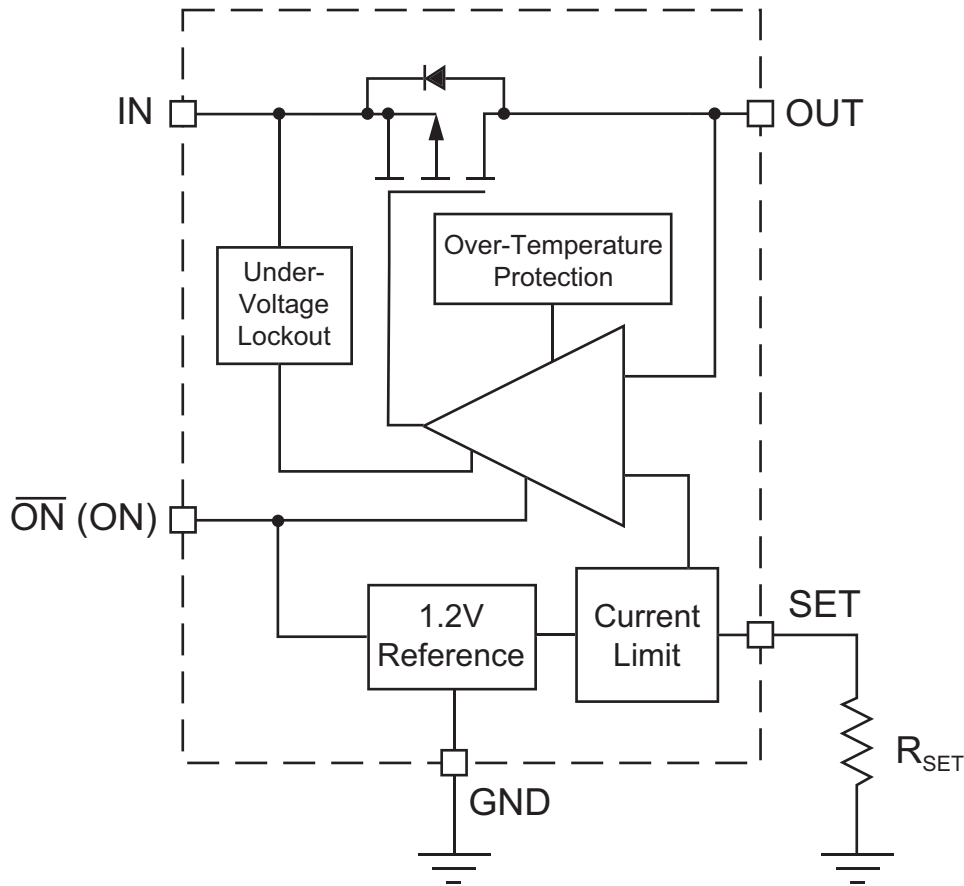


## Applications Information

### Setting Current Limit

In most applications, the variation in $I_{LIM}$ must be taken into account when determining $R_{SET}$. The $I_{LIM}$ variation is due to processing variations from part to part, as well as variations in the voltages at IN (Pin 5) and OUT (Pin 1) and the operating temperature. See charts "Current Limit vs. Temperature" and "Output Current vs. Output Voltage." Together, these three factors add up to a ±25% tolerance (see $I_{LIM}$ specification in Electrical Characteristics section). In Figure 1, a cold device with a statistically higher current limit and a hot device with a statistically lower current limit, both with $R_{SET}$ equal to 10.5kΩ, are shown. While the chart, "$R_{SET}$ vs. $I_{LIM}$" indicates an $I_{LIM}$ of 0.7A with an $R_{SET}$ of 10.5kΩ, this figure shows that the actual current limit will be at least 0.525A and no greater than 0.880A.
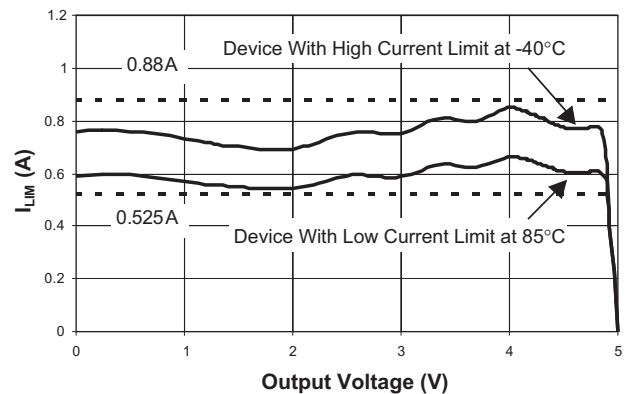


**Figure 1: Current Limit Using 10.5kΩ.**

To determine $R_{SET}$, start with the maximum current drawn by the load and multiply it by 1.33 (typical $I_{LIM}$ = minimum $I_{LIM}$ / 0.75). This is the typical current limit value. Next, refer to "$R_{SET}$ vs. $I_{LIM}$" and find the $R_{SET}$ that corresponds

to the typical current limit value; choose the largest resistor available that is less than or equal to it. For greater precision, the value of $R_{SET}$ may also be calculated using the $I_{LIM} R_{SET}$ product found in the chart "$R_{SET}$ Coefficient vs. $I_{LIM}$." The maximum current is derived by multiplying the typical current for the chosen $R_{SET}$ in the chart by 1.25. Some standard resistor values are listed in Table 1.

| $R_{SET}$ (kΩ) | Current Limit (Typ) (mA) | Device Will Not Current Limit Below (mA) | Device Always Current Limits Below (mA) |
|---|---|---|---|
| 40.2 | 200 | 150 | 250 |
| 30.9 | 250 | 188 | 313 |
| 24.9 | 300 | 225 | 375 |
| 22.1 | 350 | 263 | 438 |
| 19.6 | 400 | 300 | 500 |
| 17.8 | 450 | 338 | 563 |
| 16.2 | 500 | 375 | 625 |
| 14.7 | 550 | 413 | 688 |
| 13.0 | 600 | 450 | 750 |
| 10.5 | 700 | 525 | 875 |
| 8.87 | 800 | 600 | 1000 |
| 7.50 | 900 | 675 | 1125 |
| 6.81 | 1000 | 750 | 1250 |
| 6.04 | 1100 | 825 | 1375 |
| 5.49 | 1200 | 900 | 1500 |
| 4.99 | 1300 | 975 | 1625 |
| 4.64 | 1400 | 1050 | 1750 |

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

Example: A USB port requires 0.5A. 0.5A multiplied by 1.33 is 0.665A. From the chart "$R_{SET}$ vs. $I_{LIM}$," $R_{SET}$ should be less than 11kΩ. 10.5 kΩ is a standard value that is slightly less than, but very close to, 11kΩ. The chart gives approximately 0.7A as a typical $I_{LIM}$ value for 10.5kΩ. Multiplying 0.7A by 0.75 and 1.25 shows that the AAT4611 will limit the load current to greater than 0.525A but less than 0.875A.

## Operation in Current Limit

When a heavy load is applied to the output of the AAT4611, the load current is limited to the value of $I_{LIM}$ determined by $R_{SET}$ (see Figure 2). Since the load is demanding more current than $I_{LIM}$, the voltage at the output drops. This causes the AAT4611 to dissipate a larger-than-normal quantity of power, and causes the die temperature to increase. When the die temperature exceeds an over-temperature limit, the AAT4611 will shut down until is has cooled sufficiently, at which point it will start up again. The AAT4611 will continue to cycle on and off until the load is removed, power is removed, or until a logic high level is applied to $\overline{ON}$ (Pin 4).

## Enable Input

In many systems, power planes are controlled by integrated circuits which run at lower voltages than the power plane itself. The enable input $\overline{ON}$ (Pin 4) of the AAT4611 has low and high threshold voltages that accommodate this condition. The threshold voltages are compatible with 5V TTL and 2.5V to 5V CMOS.

## Reverse Voltage

The AAT4611 is designed to control current flowing from IN to OUT. If a voltage is applied to OUT which is greater than the voltage on IN, large currents may flow. This could cause damage to the AAT4611.
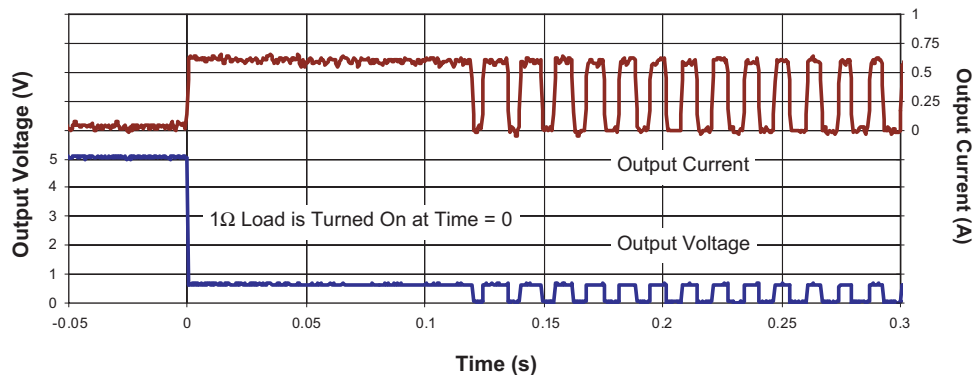


**Figure 2: Overload Operation.**

## Ordering Information

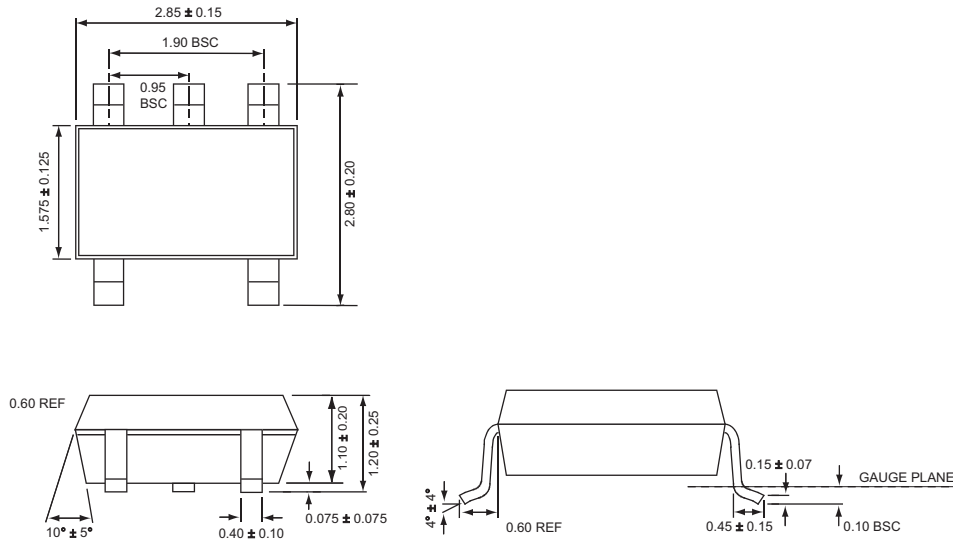| Package | Enable | Marking[1] | Part Number (Tape and Reel)[2] |
|---|---|---|---|
| SOT23-5 | $\overline{\text{ON}}$ (active low) | CLXYY | **AAT4611IGV-T1** |
| SOT23-5 | ON (active high) | | |

Skyworks Green™ products are compliant with all applicable legislation and are halogen-free. For additional information, refer to *Skyworks Definition of Green™*, document number SQ04-0074.

## Package Information

**SOT23-5**



All dimensions in millimeters.

1. XYY = assembly and date code.
2. Sample stock is generally held on part numbers listed in **BOLD**.

10

Skyworks Solutions, Inc. • Phone [781] 376-3000 • Fax [781] 376-3100 • sales@skyworksinc.com • www.skyworksinc.com
201938A • Skyworks Proprietary Information • Products and Product Information are Subject to Change Without Notice. • May 7, 2012