SmartSwitch™

General Description

The AAT4680 electronic resettable fuse is a member of AnalogicTech's Application Specific Power MOSFET™ (ASPM™) product family. It is a 1A current limited P-channel MOSFET power device that remains fully enhanced as long as the input power supply is above an under-voltage lockout threshold and the load is below the current limit setting. If the load increases above the current limit setting, as is the case during a short circuit, the MOSFET effectively becomes a constant current source equal to the current limit. If the current limit condition persists long enough to heat the MOSFET to an extreme temperature, the device will thermal cycle off and on until the current limit condition is removed. An open drain FAULT flag signals an over-current or over-temperature condition. Quiescent current is typically a low 10µA.

The AAT4680 is available in a Pb-free, 5-pin SOT23 package and is specified over the -40°C to +85°C temperature range.

Features

- 500mA Steady State Load Current
- 600mA Minimum Current Limit Trip Point
- Low Quiescent Current: Typically 10µA
- Over-Temperature Protection
- Fast Transient Tesponse:
  — <1µs Response to Short Circuit
- 400mΩ Typical $R_{DS(ON)}$
- Under-Voltage Lockout
- FAULT Flag with 3ms Blanking
- 5-Pin SOT23 Package
- Temperature Range: -40°C to +85°C

Applications

- Cell Phone Ports
- Desktop PCs
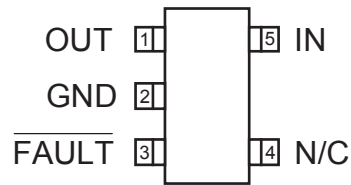- Peripheral Ports
- USB Ports

Typical Application
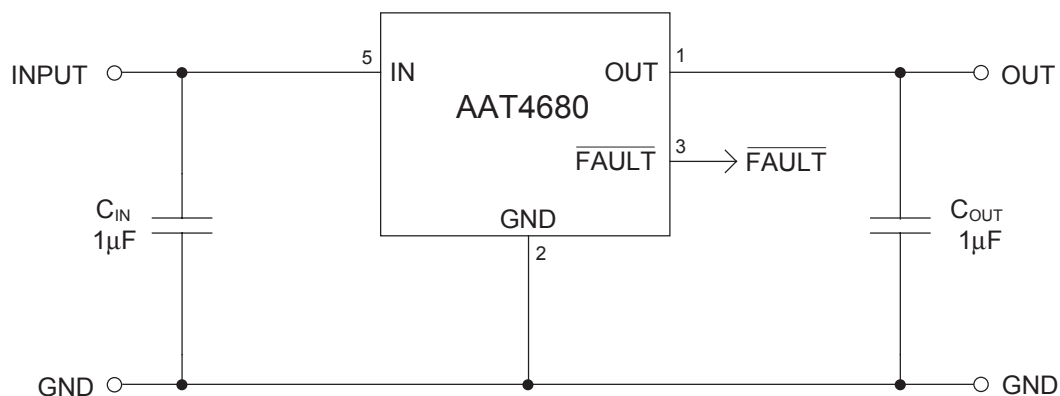
Pin Descriptions

Pin #	Symbol	Function
1	OUT	P-channel MOSFET drain.
2	GND	Ground connection.
3	$\overline{\text{FAULT}}$	Open drain output; signals over-current and over-temperature condition.
4	N/C	Not internally connected.
5	IN	P-channel MOSFET source.

Pin Configuration

SOT23-5

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OUT   [1]        [5]  IN
GND   [2]
FAULT [3]        [4]  N/C
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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_{OUT}	OUT to GND	-0.3 to 6	V
V_{FLG}	$\overline{FAULT}$ to GND	-0.3 to 6	V
I_{OUT}	Output Current	Internally Limited	A
T_J	Operating Junction Temperature Range	-40 to 150	°C
V_{ESD}	ESD Rating[2] - HBM	5000	V
T_{LEAD}	Maximum Soldering Temperature (at Leads)	300	°C

Thermal Characteristics[3]

Symbol	Description	Value	Units
Θ_{JA}	Maximum Thermal Resistance	150	°C/W
P_D	Maximum 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.

4680.2006.05.1.2

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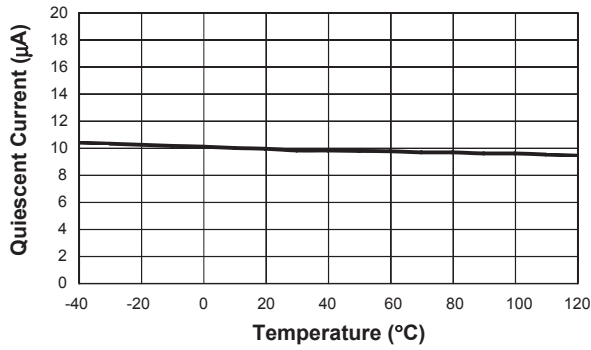## Electrical Characteristics

V_{IN} = 5V, T_A = -40°C to +85°C, unless otherwise noted. Typical values are at T_A = 25°C; **bold** values desig-
nate full temperature range.

| Symbol	Description	Conditions	Min	Typ	Max	Units
V_{IN}	Operation Voltage		**1.8**		**5.5**	V
I_Q	Quiescent Current	V_{IN} = 5V, I_{OUT} = 0		10	**20**	µA
V_{UVLO}	Under-Voltage Lockout	V_{IN} Falling		1.5	1.8	V
$V_{UVLO(HYS)}$	Under-Voltage Lockout Hysteresis			0.3		V
$R_{DS(ON)}$	On Resistance	V_{IN} = 5.0V, T_A = 25°C		400	500	mΩ
		V_{IN} = 3.V, T_A = 25°C		525	650	
I_{LIM}	Current Limit	OUT < IN - 0.5V	0.6	0.875	1.25	A
t_{RESP}	Current Loop Response	V_{IN} = 5V		500		ns
$V_{FAULTLOW}$	$\overline{FAULT}$ Logic Output Low	I_{SINK} = 1mA			**0.4**	V
I_{SINK}	$\overline{FAULT}$ Logic Output High Leakage Current	V_{FAULT} = 5.5V		0.5	**1**	µA
T_{blank}	$\overline{FAULT}$ Blanking Time			3		ms
T_{SD}	Over-Temperature Threshold			125		°C

Typical Characteristics

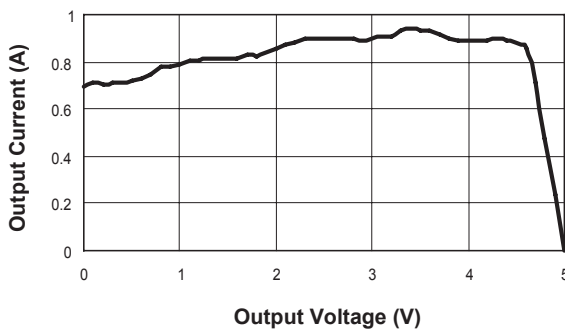Unless otherwise noted, V_{IN} = 5V, T_A = 25°C.

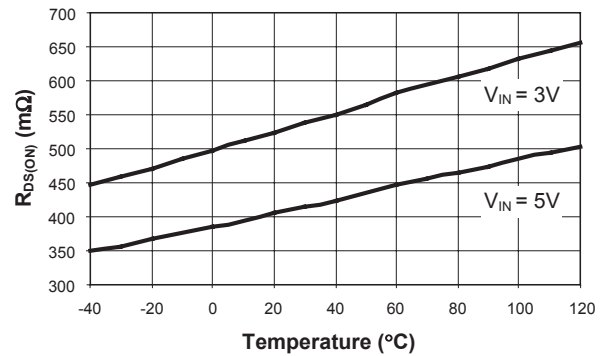**Quiescent Current vs. Temperature**

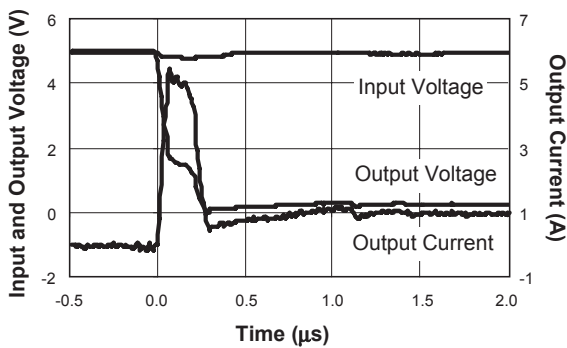**Quiescent Current vs. Input Voltage**
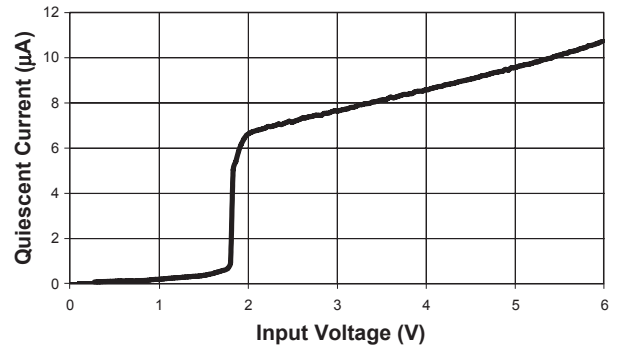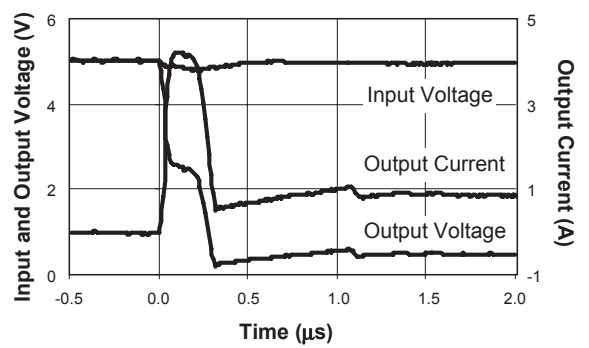
Current Limit vs. Output Voltage

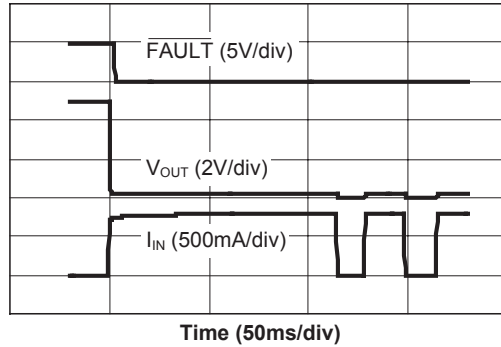**$R_{DS(ON)}$ vs. Temperature**

Short Circuit Through 0.3Ω

Short Circuit Through 0.6Ω

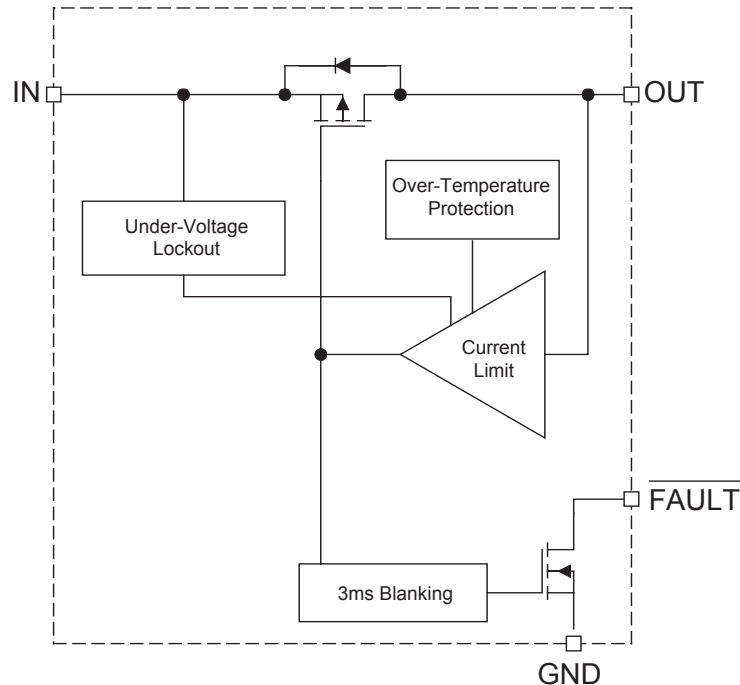## Typical Characteristics

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

Thermal Shutdown Response

FAULT (5V/div)

V_{OUT} (2V/div)

I_{IN} (500mA/div)

Time (50ms/div)

Fault Delay

FAULT (5V/div)

V_{OUT} (2V/div)

I_{IN} (500mA/div)

Time (2ms/div)
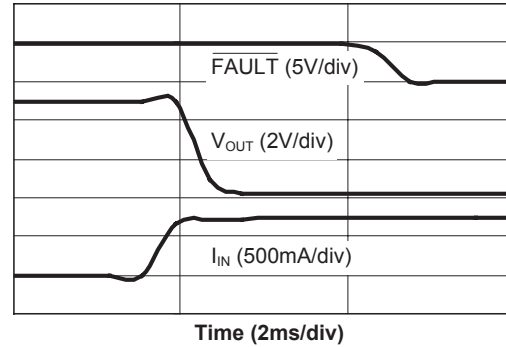
Functional Block Diagram

Functional Description

The AAT4680 is a single channel electronic reset-table fuse that protects against short-circuit conditions by current limiting to a preset level. A patent-ed fast acting current limit loop limits load current in a fraction of a microsecond and instantly resets to low impedance once the short-circuit condition is removed. A current limit condition is reported by the open drain FAULT output after a three millisecond blanking interval. The blanking prevents false reporting during the charging of a capacitive load, which typically occurs when a load is connected.

The AAT4680 is internally protected from thermal damage by an over-temperature detection circuit. If the die temperature reaches the internal thermal limit, the power device is switched off until the die temperature cools to a level below the thermal limit threshold. The device will thermal cycle indefinite-ly until the over-current condition is removed. The AAT4680 operates with input voltages ranging from 1.8V to 5.5V which, along with extremely low oper-ating current, makes it ideal for battery-powered applications. In cases where the input voltage drops below 1.8V, the AAT4680 internal MOSFET is protected from entering the saturated region of operation by being automatically shut down by an under-voltage lockout circuit.

The AAT4680 is ideally suited for protection of peri-pheral ports such as USB, RS232, and parallel ports.

Applications Information

Input Capacitor

The input capacitor, C_{IN}, protects the power supply from current transients generated by the load attached to the AAT4680. If a short circuit is suddenly applied to the output of the AAT4680, there is a 500 nanosecond long period during which a large current can flow before current limit circuitry activates. (See characteristic curve "Short Circuit Through 0.3Ω.") In this event, a properly sized input capacitor can dramatically reduce the voltage transient seen by the power supply and other circuitry upstream from the AAT4680.

C_{IN} should be located as close to the device VIN pin as practically possible. Ceramic, tantalum, or aluminum electrolytic capacitors may be selected for C_{IN}. There is no specific capacitor equivalent series resistance (ESR) requirement for C_{IN}. However, for higher current operation, ceramic capacitors are recommended for C_{IN} due to their inherent capability over tantalum capacitors to withstand input current surges from low impedance sources such as batteries in portable devices.

Output Capacitor

In order to insure stability while current limit is active, a small output capacitance of approximately 1µF is required. No matter how big the output capacitor, output current is limited to the value set by the AAT4680 current limiting circuitry, allowing very large output capacitors to be used.

For example, USB ports are specified to have at least 120µF of capacitance downstream from their controlling power switch. The current limiting circuit will allow an output capacitance of 1000µF or more without disturbing the upstream power supply.

Attaching Loads

Capacitive loads attached to the AAT4680 will charge at a rate no greater than the current limit setting.

$\overline{FAULT}$ Output

A $\overline{FAULT}$ flag is provided to alert a system if the AAT4680 load is not receiving sufficient voltage to operate properly. If current limit or over-tempera-ture circuits in any combination are active for more than approximately three milliseconds, $\overline{FAULT}$ is pulled to ground through approximately 100Ω. Removal of voltage or current transients of less than two milliseconds prevents capacitive loads connected to the AAT4680 output from activating the $\overline{FAULT}$ flag when they are initially attached. Pull-up resistances of 1kΩ to 100kΩ are recommended. Since $\overline{FAULT}$ is an open drain terminal, it may be pulled up to any voltage rail less than the maximum operating voltage of 5.5V, allowing for level shifting between circuits.

Thermal Considerations

Since the AAT4680 has internal current limit and over-temperature protection, junction temperature is rarely a concern. However, if the application requires large currents in a hot environment, it is possible that temperature, rather than current limit, will be the dominant regulating condition. In these applications, the maximum current available without risk of an over-temperature condition must be calculated. The maximum internal temperature while current limit is not active can be calculated using Equation 1.

Eq. 1: $T_{J(MAX)} = I_{MAX}^2 \cdot R_{DS(ON)(MAX)} \cdot R_{\Theta JA} + T_{A(MAX)}$

In Equation 1, I_{MAX} is the maximum current required by the load. $R_{DS(ON)(MAX)}$ is the maximum rated $R_{DS(ON)}$ of the AAT4680 at high temperature. $R_{\theta JA}$ is the thermal resistance between the AAT4680 die and the board onto which it is mounted. $T_{A(MAX)}$ is the maximum temperature that the PCB under the AAT4680 would be if the AAT4680 were not dissipating power. Equation 1 can be rearranged to solve for I_{MAX}; Equation 2.

Eq. 2: $I_{MAX} = \sqrt{\dfrac{T_{SD(MIN)} - T_{A(MAX)}}{R_{DS(ON)(MAX)} \cdot R_{\Theta JA}}}$

$T_{SD(MIN)}$ is the minimum temperature required to activate the AAT4680 over-temperature protection. With typical specification of 125°C, 115°C is a safe minimum value to use.

For example, if an application is specified to operate in 50°C environments, the PCB operates at temperatures as high as 85°C. The application is sealed and its PCB is small, causing $R_{\theta JA}$ to be approximately 150°C/W. Using Equation 2:

Eq. 3: $\quad I_{MAX} = \sqrt{\dfrac{115 - 85}{600 \cdot 150}} = 575mA$

To prevent thermal limiting, the operating load current in the application must be less than 575mA.

Ordering Information

Package	Marking[1]	Part Number (Tape and Reel)[2]
SOT23-5	BWXYY	**AAT4680IGV-T1**

Pb-free

All AnalogicTech products are offered in Pb-free packaging. The term "Pb-free" means semiconductor products that are in compliance with current RoHS standards, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. For more information, please visit our website at http://www.analogictech.com/pbfree.

Package Information
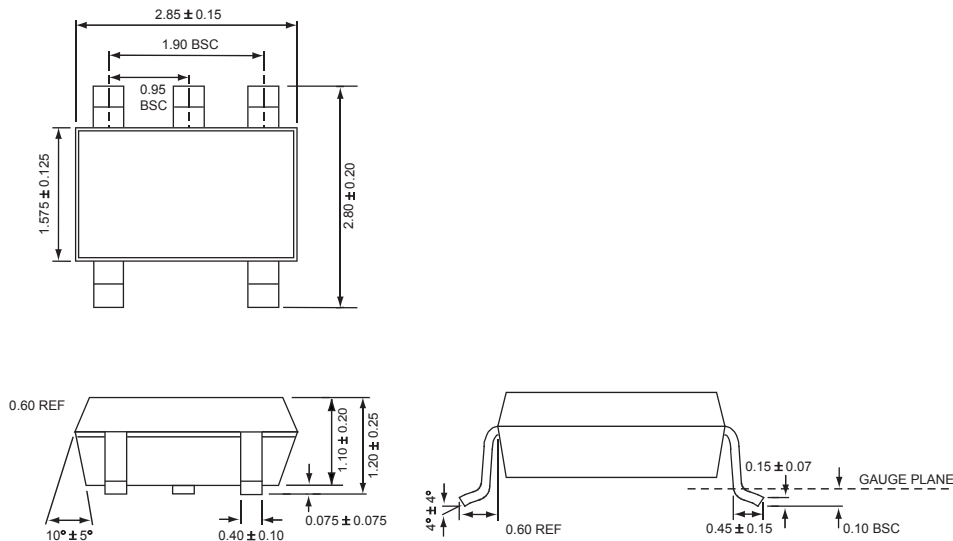
All dimensions in millimeters.

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

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