General Description

The AAT4680 Electronic Resettable Fuse is part of the AnalogicTech Application Specific Power MOSFET (ASPM™) line of products. 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 $\overline{\text{FAULT}}$ flag signals an over current or over temperature condition. Quiescent current is typically a low 10µA.

The AAT4680 is available in a 5-pin SOT-23, specified over a -40 to 85°C temperature range.

Features

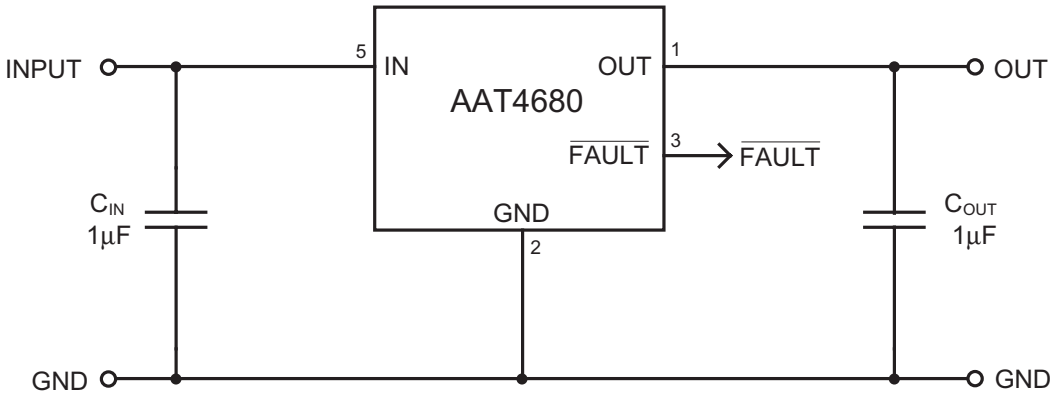
- 500mA steady state load current
- 600mA minimum current limit trip point
- Low quiescent current, typically 10µA
- Over temperature protection
- Fast transient response:
  - < 1µs response to short circuit
- 400mΩ typical $R_{DS(ON)}$
- Undervoltage Lockout
- Temp range -40 to 85°C
- $\overline{\text{FAULT}}$ flag with 3ms blanking
- 5-pin SOT23 package

Applications

- USB ports
- Peripheral ports
- Desktop PCs
- Cell phone ports

Preliminary Information

Typical Application

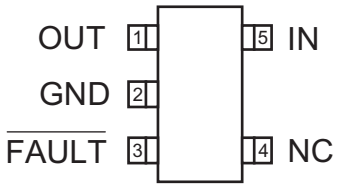


Pin Descriptions

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	NC	Not internally connected
5	IN	P-channel MOSFET source

Pin Configuration

SOT23-5



Absolute Maximum Ratings (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}	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[1] - HBM	5000	V
T_{LEAD}	Maximum Soldering Temperature (at Leads)	300	°C

Note: 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.

Note 1: Human body model is a 100pF capacitor discharged through a 1.5kΩ resistor into each pin.

Thermal Characteristics

Symbol	Description	Value	Units
Θ_{JA}	Maximum Thermal Resistance[2]	150	°C/W
P_D	Maximum Power Dissipation[2]	667	mW

Note 2: Mounted on a demo board.

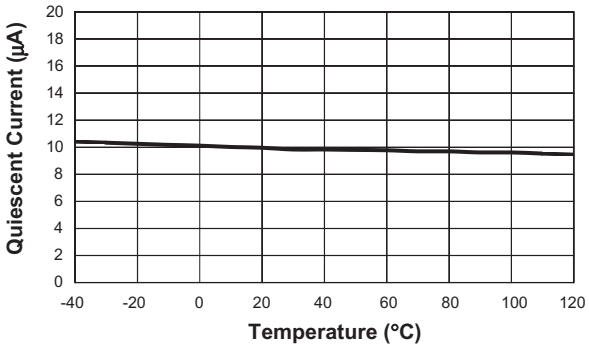
Electrical Characteristics (V_{IN} = 5V, T_A = -40 to 85°C unless otherwise noted. Typical values are at T_A=25°C; **bold** values designate full temperature range)

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}	Undervoltage Lockout	V_{IN} falling		1.5	1.8	V
$V_{UVLO(hys)}$	Undervoltage 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

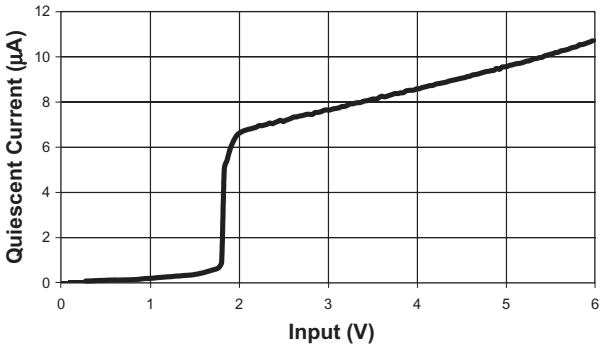
Typical Characteristics

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

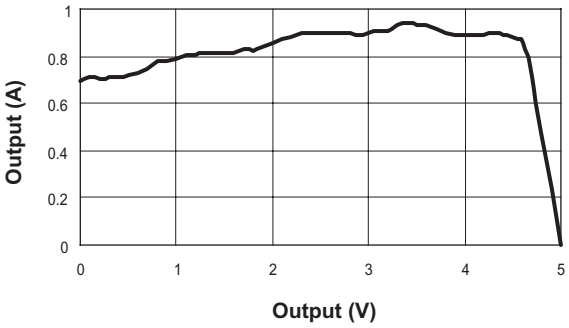
Quiescent Current vs. Temperature



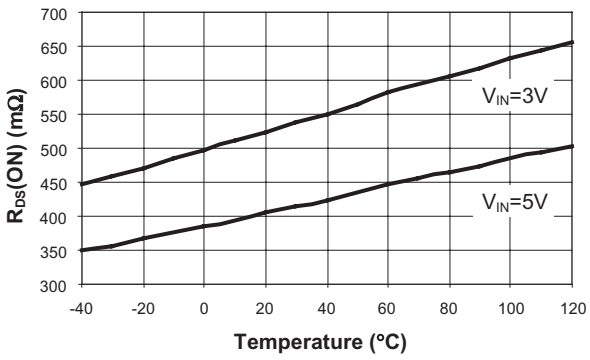
Quiescent Current vs. Input Voltage



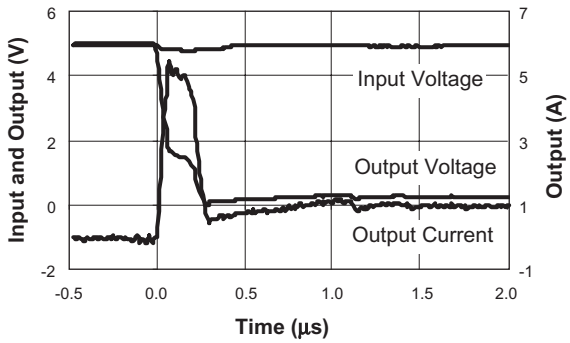
Current Limit vs. Output Voltage



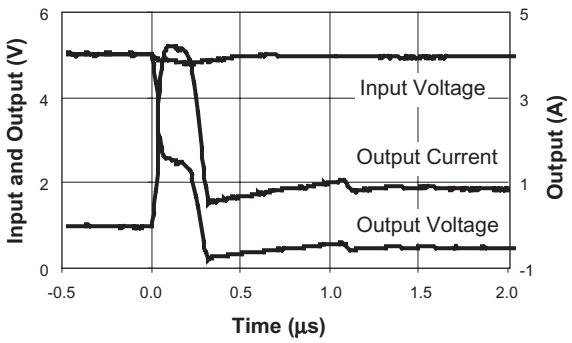
R_{DS}(ON) vs. Temperature



Short Circuit Through 0.3Ω



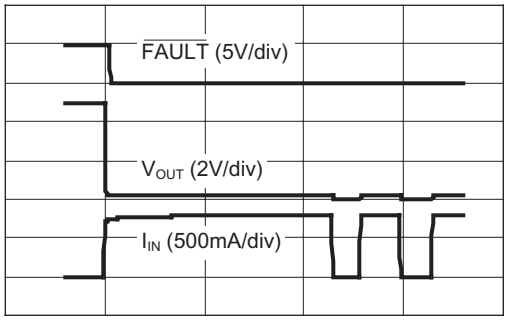
Short Circuit Through 0.6Ω



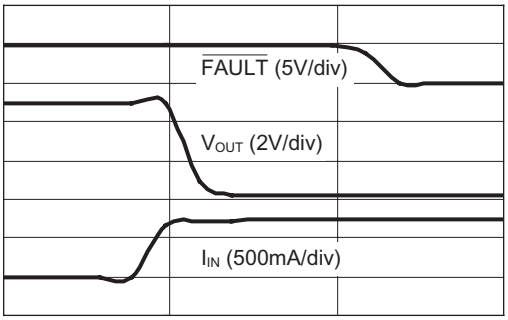
Typical Characteristics

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

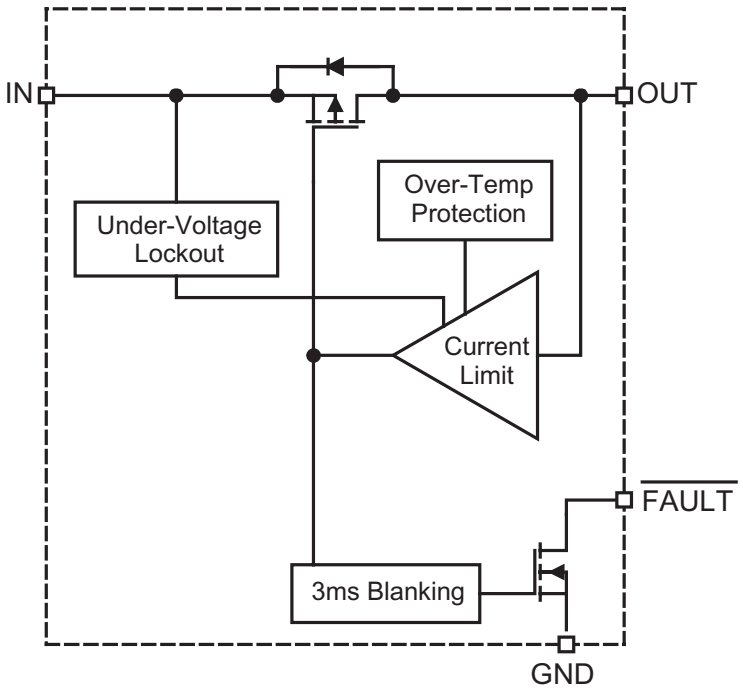
Thermal Shutdown Response



Fault Delay



Functional Block Diagram



Functional Description

The AAT4680 is a single channel electronic resettable fuse that protects against short circuit conditions by current limiting to a preset level. A patented 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 $\overline{\text{FAULT}}$ 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 indefinitely 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 operating 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 peripheral 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 V_{IN} pin as practically possible. Ceramic, tantalum or aluminum electrolytic capacitors may be selected for C_{IN}. There is no specific capacitor 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 down stream 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.

$\overline{\text{FAULT}}$ Output

A $\overline{\text{FAULT}}$ flag is provided to alert a system if the AAT4680 load is not receiving sufficient voltage to operate properly. If current limit or over temperature circuits in any combination are active for more than approximately three milliseconds, $\overline{\text{FAULT}}$ 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 $\overline{\text{FAULT}}$ flag when they are initially attached. Pull up resistances of 1kΩ to 100kΩ are recommended. Since $\overline{\text{FAULT}}$ 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.

$$T_J(MAX) = I_{MAX}^2 \times R_{DS(ON)}(MAX) \times R_{\theta JA} + T_A(MAX)$$

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.

$$I_{MAX} = \sqrt{\frac{T_{SD}(MIN) - T_A(MAX)}{R_{DS(ON)}(MAX) \times R_{\theta JA}}}$$

$T_{SD}(MIN)$ 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,

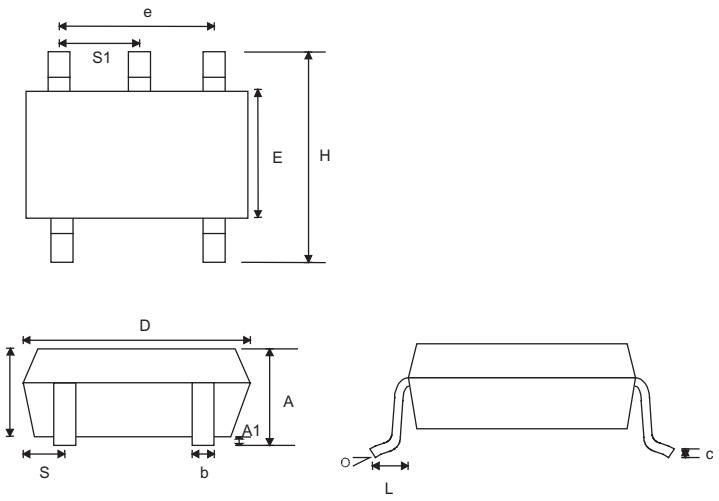
$$I_{MAX} = \sqrt{\frac{115 - 85}{600 \times 150}} = 575 \text{ mA}$$

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

Ordering Information

Package	Marking	Part Number	
		Bulk	Tape and Reel
SOT23-5		N/A	AAT4680IGV-T1

Package Information



Dim	Millimeters		Inches	
	Min	Max	Min	Max
A	0.95	1.45	0.037	0.057
A1	0.05	0.15	0.002	0.006
A2	0.90	1.30	0.035	0.051
b	0.35	0.50	0.014	0.019
c	0.08	0.20	0.003	0.078
D	2.84	3.00	0.112	0.112
E	1.50	1.70	0.059	0.067
e	1.90		0.0748	
H	2.60	3.00	0.102	0.118
L	0.35	0.55	.0137	.0216
S	0.47	0.55	0.019	.0216
S1	.95		0.037	
Θ	0°	10°	0°	10°

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