

### General Description

The AAT4612 SmartSwitch is a current limited P-channel MOSFET power switch designed for high-side load switching applications operating with inputs ranging from 2.4V to 5.5V, making it ideal for both 3V and 5V systems. An integrated current limiting circuit protects the input supply from large currents which could potentially cause the supply to fall out of regulation. In addition, the AAT4612's thermal overload protection limits power dissipation and junction temperatures associated with prolonged periods of operation in current limit. Due to its low  $R_{DS(ON)}$ , the AAT4612 can be used to control loads that require up to 1A even while operating at high ambient temperatures. The ultra-fast current limit response to a sudden short circuit is a mere 500ns which reduces the requirements of local supply bypassing. Quiescent current is a low 10 $\mu$ A and, in shutdown mode, the supply current decreases to less than 1 $\mu$ A.

The AAT4612 is available in a Pb-free 5-pin SOT23 package or a Pb-free 8-pin SC70JW package and is specified over the -40°C to +85°C temperature range.

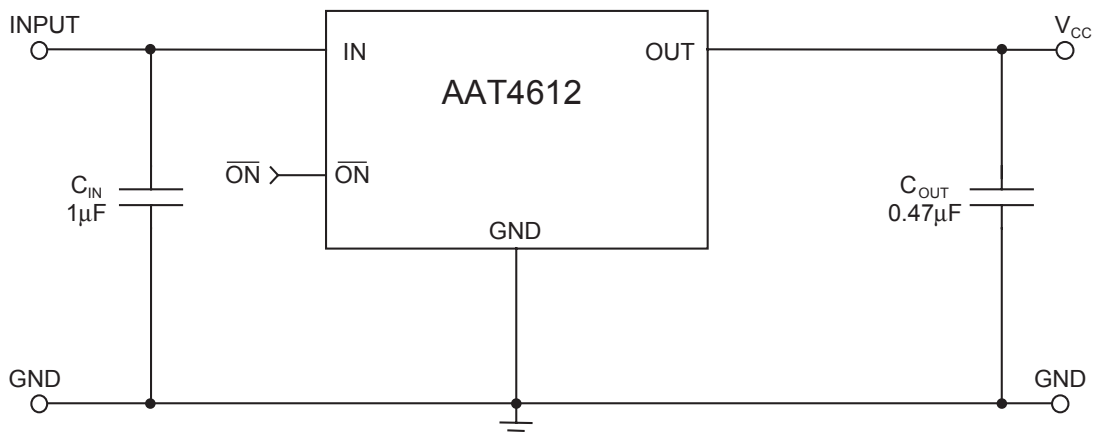
### Features

- Input Voltage Range: 2.4V to 5.5V
- 1A Current Limit Trip Threshold
- Fast Transient Response:
  - <1 $\mu$ s Response to Short Circuit
- Low Quiescent Current:
  - 10 $\mu$ A Typ
  - 1 $\mu$ A Max with Switch Off
- 100m $\Omega$  Typical  $R_{DS(ON)}$
- Under-Voltage Lockout
- Thermal Shutdown
- 4kV ESD Rating
- 5-Pin SOT23 or 8-Pin SC70JW Package
- -40°C to +85°C Temperature Range

### Applications

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

### Typical Application

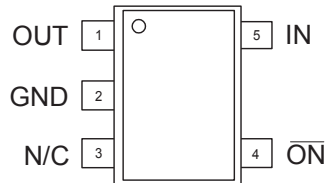


### Pin Descriptions

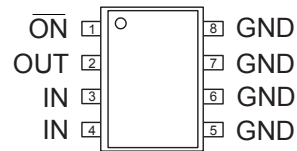
Pin #		Symbol	Function
SOT23-5	SC70JW-8		
1	2	OUT	P-channel MOSFET drain.
2	5, 6, 7, 8	GND	Ground connection.
3		N/C	Not internally connected.
4	1	$\overline{\text{ON}}$	Active low enable input.
5	3, 4	IN	P-channel MOSFET source.

### Pin Configuration

**SOT23-5  
(Top View)**



**SC70JW-8  
(Top View)**



### Absolute Maximum Ratings<sup>1</sup>

$T_A = 25^\circ\text{C}$  unless otherwise noted.

Symbol	Description	Value	Units
$V_{IN}$	IN to GND	-0.3 to 6	V
$V_{ON}$	$\overline{ON}$ to GND	-0.3 to 6	V
$V_{OUT}$	OUT to GND	-0.3 to 6	V
$I_{OUT}$	Output Current	Internally Limited	A
$T_J$	Operating Junction Temperature Range	-40 to 150	$^\circ\text{C}$
$V_{ESD}$	ESD Rating <sup>2</sup> —HBM	4000	V
$T_{LEAD}$	Maximum Soldering Temperature (at Leads)	300	$^\circ\text{C}$

### Thermal Characteristics<sup>3</sup>

Symbol	Description	Value	Units
$\theta_{JA}$	Maximum Thermal Resistance (SOT23-5, SC70JW-8)	150	$^\circ\text{C}/\text{W}$
$P_D$	Maximum Power Dissipation (SOT23-5, SC70JW-8)	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 1.5k $\Omega$  resistor into each pin.
3. Mounted on a demo board.

### Electrical Characteristics

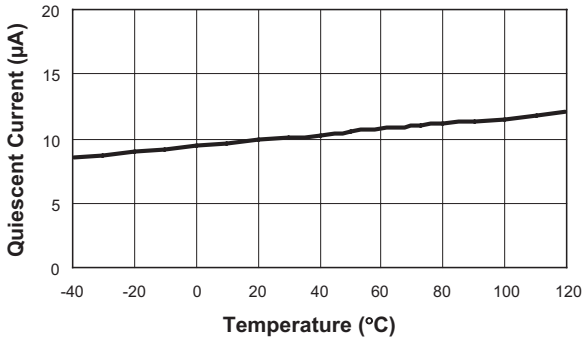
$V_{IN} = 5V$ ,  $T_A = -40^{\circ}C$  to  $+85^{\circ}C$ , unless otherwise noted. Typical values are at  $T_A = 25^{\circ}C$ ; **bold** values denote full temperature range.

Symbol	Description	Conditions	Min	Typ	Max	Units
$V_{IN}$	Operation Voltage		<b>2.4</b>		<b>5.5</b>	V
$I_Q$	Quiescent Current	$V_{IN} = 5V$ , $\overline{ON} = \text{Active}$ , $I_{OUT} = 0$		10	<b>20</b>	$\mu A$
$I_{Q(OFF)}$	Off Supply Current	$\overline{ON} = \text{Inactive}$ , $V_{IN} = 5.5V$			<b>1</b>	$\mu A$
$I_{SD(OFF)}$	Off Switch Current	$\overline{ON} = \text{Inactive}$ , $V_{IN} = 5.5V$ , $V_{OUT} = 0$		0.1	<b>1</b>	$\mu A$
$V_{UVLO}$	Under-Voltage Lockout	$V_{IN}$ Falling		1.9		V
$V_{UVLO(hys)}$	Under-Voltage Lockout Hysteresis			0.3		V
$R_{DS(ON)}$	On Resistance	$V_{IN} = 5.0V$ , $T_A = 25^{\circ}C$		130	175	m $\Omega$
		$V_{IN} = 3.0V$ , $T_A = 25^{\circ}C$		170	225	
$I_{LIM}$	Current Limit	$V_{OUT} = V_{IN}$ to $0.5V$	1	1.5	2.0	A
$V_{\overline{ON}(L)}$	$\overline{ON}$ Input Low Voltage	$V_{IN} = 2.7V$ to $5.5V^1$			<b>0.8</b>	V
$V_{\overline{ON}(H)}$	$\overline{ON}$ Input High Voltage	$V_{IN} = 2.7V \leq 4.2V$	<b>2.0</b>			V
		$V_{IN} = > 4.2V$ to $5.0V^1$	<b>2.4</b>			
$I_{\overline{ON}(SINK)}$	$\overline{ON}$ Input leakage	$V_{\overline{ON}} = 5.5V$		0.01	<b>1</b>	$\mu A$
$t_{RESP}$	Current Loop Response	$V_{IN} = 5V$		500		ns
$T_{OFF}$	Turn-Off Time	$V_{IN} = 5V$ , $R_L = 10\Omega$		2.5		$\mu s$
$T_{ON}$	Turn-On Time	$V_{IN} = 5V$ , $R_L = 10\Omega$		1		$\mu s$
OTMP	Over-Temperature Shutdown			125		$^{\circ}C$

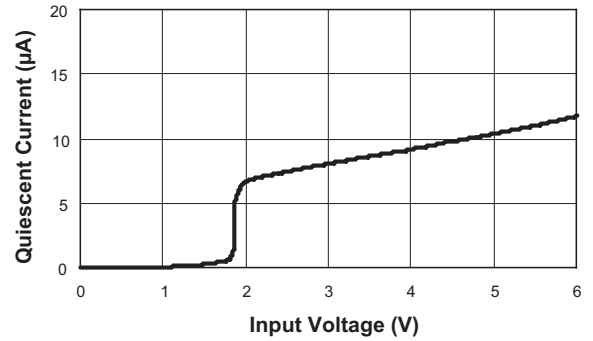
1. For  $V_{IN}$  outside this range, consult typical  $\overline{ON}$  threshold curve.

### Typical Characteristics

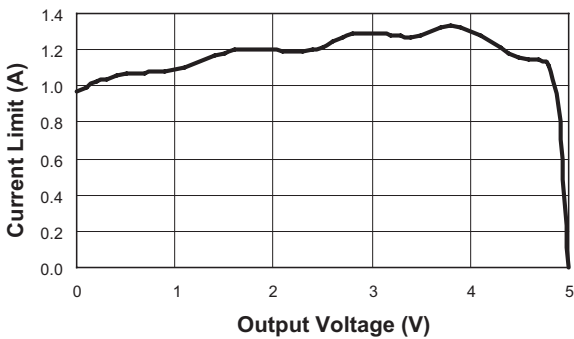
Quiescent Current vs. Temperature



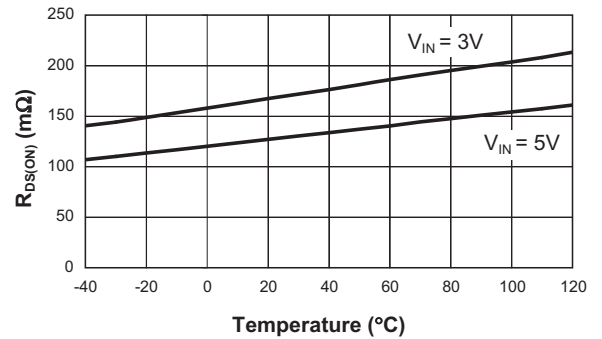
Quiescent Current vs. Input Voltage



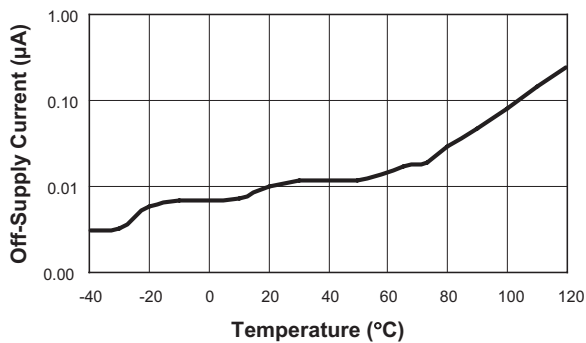
Current Limit vs. Output Voltage



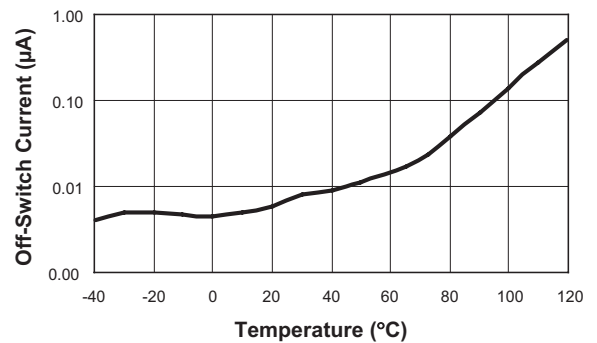
$R_{DS(ON)}$  vs. Temperature



Off-Supply Current vs. Temperature

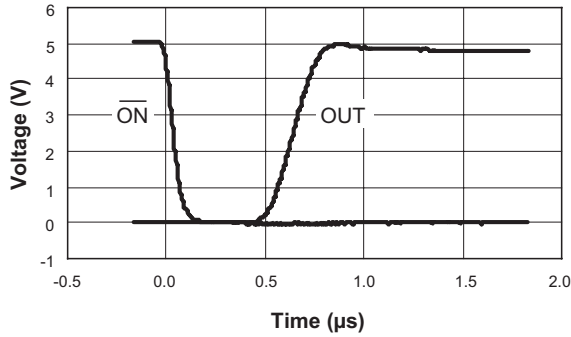


Off-Switch Current vs. Temperature

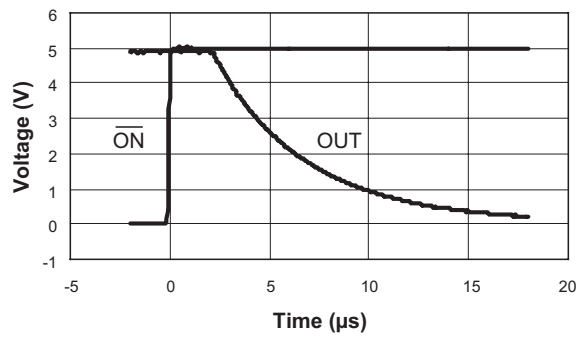


### Typical Characteristics

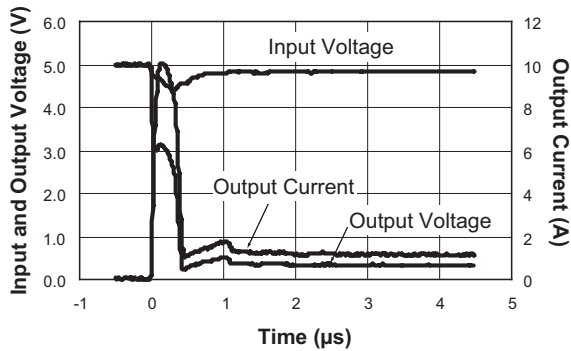
**Turn-On**  
( $R_L = 10\Omega$ ;  $C_L = 0.47\mu F$ )



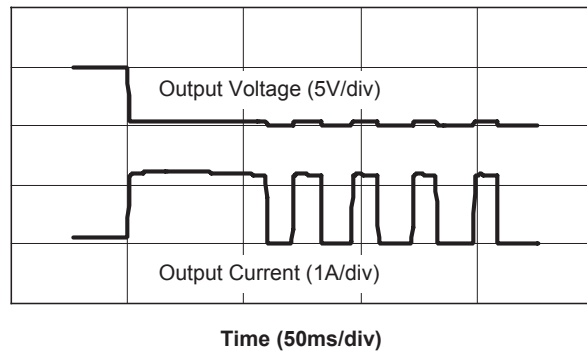
**Turn-Off**  
( $R_L = 10\Omega$ ;  $C_L = 0.47\mu F$ )



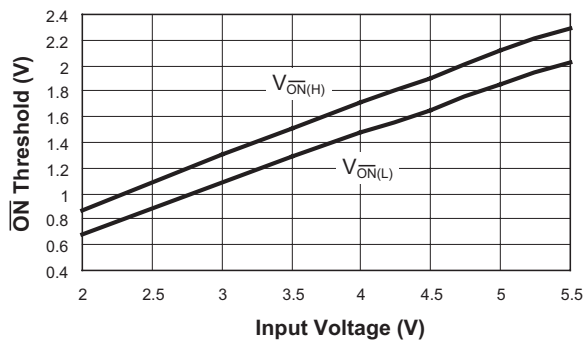
**Short Circuit Through 0.3 $\Omega$**



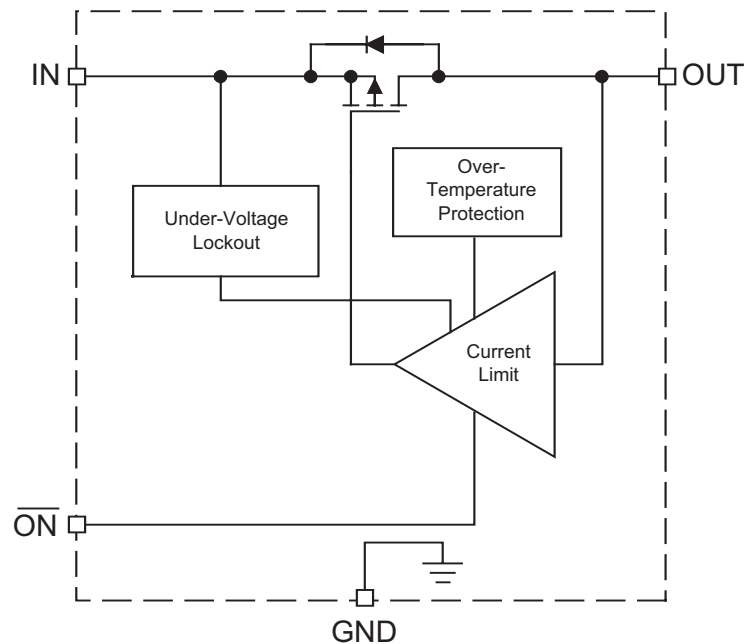
**Thermal Shutdown Response**



**$\overline{ON}$  Threshold vs. Input Voltage**



### Functional Block Diagram



### Functional Description

The AAT4612 is a single channel current limited load switch that protects against short circuits by current limiting to a preset level. A patented fast acting current limit loop limits the current in a fraction of a microsecond and instantly resets to low impedance once the short-circuit condition is removed. The AAT4612 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 AAT4612 operates with input voltages ranging from 2.4V to 5.5V which, along with its extremely low operating current, makes it ideal for battery-powered applications. In cases where the input voltage drops below 2.4V, the AAT4612 MOSFET is protected from entering the saturated region of operation by being automatically shut down by an under-voltage lockout circuit.

The AAT4612 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 AAT4612. When a short circuit is suddenly applied to the output of the AAT4612, a large current, limited only by the  $R_{DS(ON)}$  of the MOSFET, will flow for less than  $1\mu s$  before the current limit circuitry activates. (See characteristic curve "Short Circuit Through  $0.3\Omega$ .".) In this event, a moderately sized  $C_{IN}$  will dramatically reduce the voltage transient seen by the power supply and by other circuitry upstream from the AAT4612. The extremely fast short-circuit response time of the AAT4612 reduces the size requirement of  $C_{IN}$ .

$C_{IN}$  should be located as close to the device IN pin as practically possible. Ceramic, tantalum, or aluminum electrolytic capacitors are appropriate 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 capacitance of approximately  $0.47\mu F$  is required. No matter how large the output capacitor, however, output current is limited to the value set by the AAT4612 current limiting circuitry, so very large output capacitors can be used.

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

#### ON

In many systems, power planes are controlled by integrated circuits which run at lower voltages than the power plane itself. The enable input (ON) of the AAT4612 has low and high threshold voltages

that accommodate this condition. The threshold voltages are compatible with 5V TTL and 2.5V to 5V CMOS systems.

When switching the AAT4612 on into a capacitive load, the AAT4612 will charge the output capacitive load at a rate no greater than the current limit setting.

#### Attaching Loads

Capacitive loads attached to an enabled AAT4612 will charge at a rate no greater than the current limit setting.

#### Thermal Considerations

Since the AAT4612 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.

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

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 AAT4612 at high temperature.  $R_{\theta JA}$  is the thermal resistance between the AAT4612 die and the board onto which it is mounted.  $T_{A(MAX)}$  is the maximum temperature that the PCB under the AAT4612 would be if the AAT4612 were not dissipating power. Equation 1 can be rearranged to solve for  $I_{MAX}$ :

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

$T_{SD(MIN)}$  is the minimum temperature required to activate the AAT4612 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,

$$\text{Eq. 3: } I_{\text{MAX}} = \sqrt{\frac{T_{\text{SD(MIN)}} - T_{\text{A(MAX)}}}{R_{\text{DS(ON)(MAX)}} \cdot R_{\theta JA}}}$$

The AAT4612 is safe to operate at the maximum current level of 0.93A at 85°C.

### Ordering Information

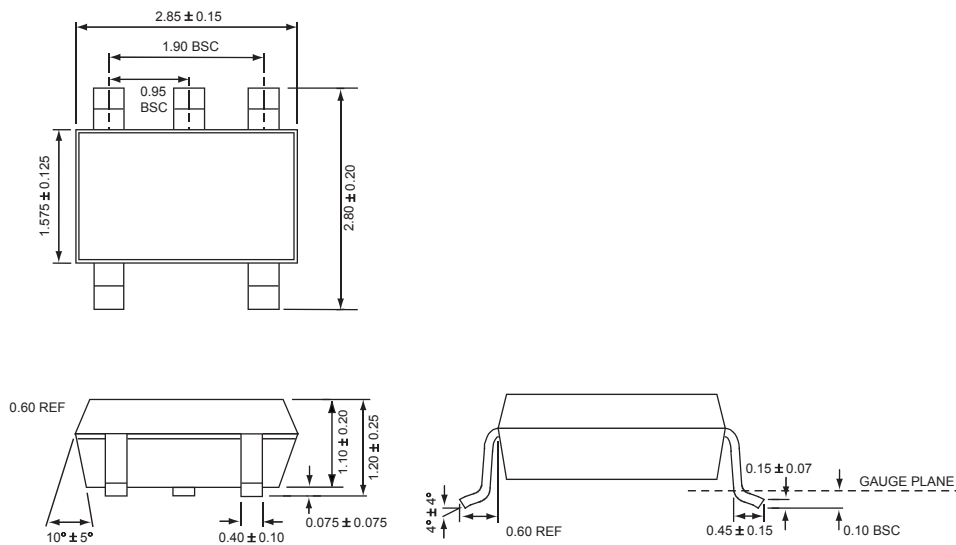
Package	Marking <sup>1</sup>	Part Number (Tape and Reel) <sup>2</sup>
SOT23-5	ATXYY	<b>AAT4612IGV-T1</b>
SC70JW-8	ATXYY	AAT4612IJS-T1



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

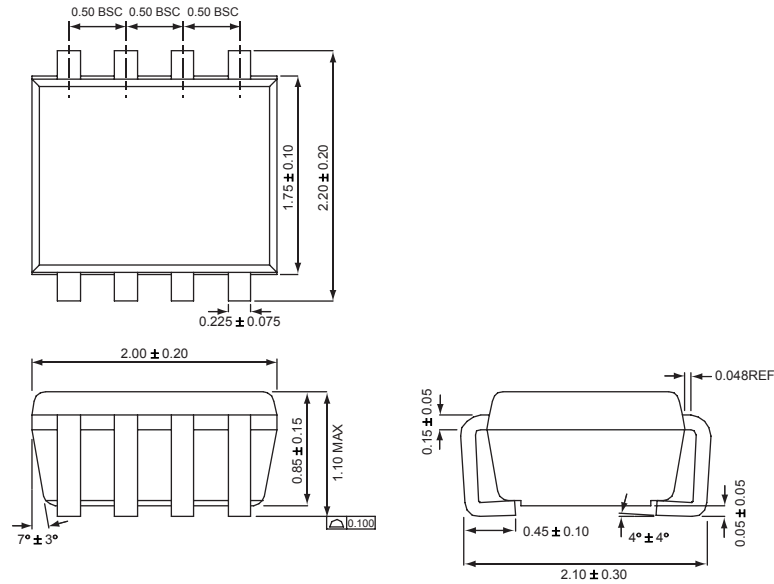
#### SOT23-5



All dimensions in millimeters.

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

### SC70JW-8



All dimensions in millimeters.

© Advanced Analogic Technologies, Inc.

AnalogicTech cannot assume responsibility for use of any circuitry other than circuitry entirely embodied in an AnalogicTech product. No circuit patent licenses, copyrights, mask work rights, or other intellectual property rights are implied. AnalogicTech reserves the right to make changes to their products or specifications or to discontinue any product or service without notice. Customers are advised to obtain the latest version of relevant information to verify, before placing orders, that information being relied on is current and complete. All products are sold subject to the terms and conditions of sale supplied at the time of order acknowledgement, including those pertaining to warranty, patent infringement, and limitation of liability. AnalogicTech warrants performance of its semiconductor products to the specifications applicable at the time of sale in accordance with AnalogicTech's standard warranty. Testing and other quality control techniques are utilized to the extent AnalogicTech deems necessary to support this warranty. Specific testing of all parameters of each device is not necessarily performed.

AnalogicTech and the AnalogicTech logo are trademarks of Advanced Analogic Technologies Incorporated. All other brand and product names appearing in this document are registered trademarks or trademarks of their respective holders.

**Advanced Analogic Technologies, Inc.**  
 830 E. Arques Avenue, Sunnyvale, CA 94085  
 Phone (408) 737-4600  
 Fax (408) 737-4611