## General Description

The AAT4612 SmartSwitch™ is a member of AnalogicTech's Application Specific Power MOSFET™ (ASPM™) product family. It 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 which makes it ideal for both 3V and 5V systems. An integrated current-limiting circuit protects the input supply from large currents which potentially cause the supply to fall out of regulation. In addition, the AAT4612 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 10µA and in shutdown mode, the supply current decreases to less than 1µA.

The AAT4612 is available in a 5-pin SOT23, and an 8-pin SC70JW specified over a -40 to 85°C temperature range.

The AAT4600 Series is a family of adjustable and fixed SmartSwitch™ products with a range of current handling capabilities. Available are single versions with adjustable current limit (AAT4610, AAT4601) as well as fixed current limit (AAT4625), and dual versions with fixed current limit (AAT4626, AAT4670).

## Features

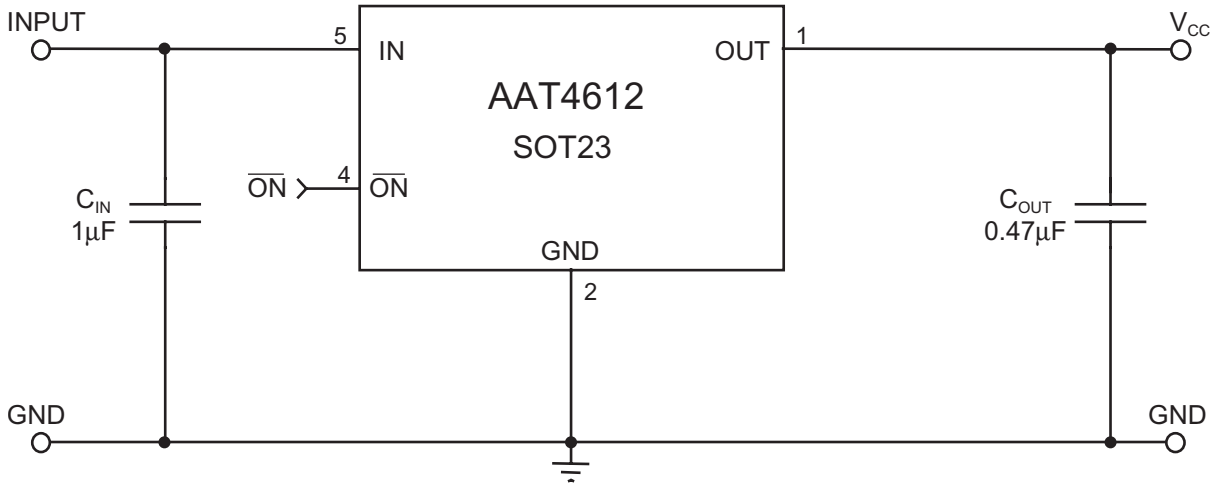
- 2.4V to 5.5V Input voltage range
- 1A current limit trip threshold
- Fast transient response:
  - <1µs response to short circuit
- Low quiescent current
  - 10µA typ
  - 1µA max with Switch off
- 100mΩ typical $R_{DS(ON)}$
- Undervoltage Lockout
- Thermal Shutdown
- Temp range -40 to 85°C
- 4kV ESD Rating
- 5-pin SOT23 package
- 8-pin SC70JW package

## Applications

- Peripheral ports
- Notebook computers
- Personal communication devices
- Hot swap supplies

Preliminary Information

## Typical Application

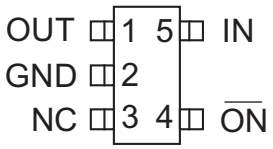


## Pin Descriptions

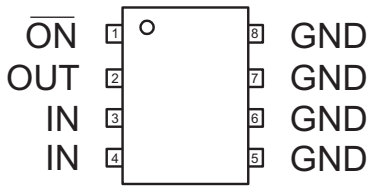
| Pin # | | Symbol | Function |
|---|---|---|---|
| SOT23-5 | SC70JW | | |
| 1 | 2 | OUT | P-channel MOSFET drain |
| 2 | 5, 6, 7, 8 | GND | Ground connection |
| 3 | | NC | Not internally connected |
| 4 | 1 | $\overline{ON}$ | Active low enable Input |
| 5 | 3, 4 | IN | P-channel MOSFET source |

## Pin Configuration

**SOT23-5**




**SC70JW-8**



## Absolute Maximum Ratings ($T_A$=25°C unless otherwise noted)

| Symbol | Description | Value | Units |
|---|---|---|---|
| $V_{IN}$ | IN to GND | -0.3 to 6 | V |
| $V_{\overline{ON}}$ | $\overline{ON}$ 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 | °C |
| $V_{ESD}$ | ESD Rating[1]—HBM | 4000 | 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 |
|---|---|---|---|
| $\Theta_{JA}$ | Maximum Thermal Resistance [2] (SOT23-5, SC70JW-8) | 150 | °C/W |
| $P_D$ | Maximum Power Dissipation [2] (SOT23-5, SC70JW-8) | 667 | mW |

Note 2: Mounted on a demo board.

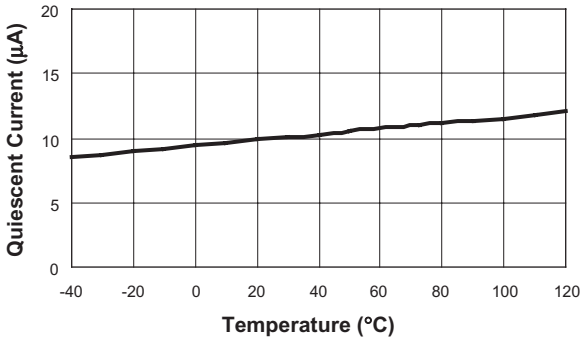
## Electrical Characteristics ($V_{IN}$ = 5V, $T_A$ = -40 to 85°C unless otherwise noted. Typical values are at $T_A$=25°C; **bold** values denote full temperature range)

| Symbol | Description | Conditions | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| $V_{IN}$ | Operation Voltage | | **2.4** | | **5.5** | V |
| $I_Q$ | Quiescent Current | $V_{IN}$ = 5V, $\overline{ON}$ = active, $I_{OUT}$ = 0 | | 10 | **20** | µA |
| $I_{Q(OFF)}$ | Off Supply Current | $\overline{ON}$ = inactive, $V_{IN}$ = 5.5V | | | **1** | µA |
| $I_{SD(OFF)}$ | Off Switch Current | $\overline{ON}$ = inactive, $V_{IN}$ = 5.5V, $V_{OUT}$ = 0 | | 0.1 | **1** | µA |
| $V_{UVLO}$ | Undervoltage Lockout | $V_{IN}$ falling | | 1.9 | | V |
| $V_{UVLO(hys)}$ | Undervoltage Lockout Hysteresis | | | 0.3 | | V |
| $R_{DS(ON)}$ | On-Resistance | $V_{IN}$=5.0V, $T_A$ = 25ºC | | 100 | 150 | mΩ |
| | | $V_{IN}$=3.0V, $T_A$ = 25ºC | | 140 | 180 | |
| $I_{LIM}$ | Current Limit | $V_{OUT}$ = $V_{IN}$ - 0.5V | 1 | 1.5 | 2.0 | A |
| $V_{\overline{ON}(L)}$ | $\overline{ON}$ Input Low Voltage | $V_{IN}$ = 2.7V to 5.5V [3] | | | **0.8** | V |
| $V_{\overline{ON}(H)}$ | $\overline{ON}$ Input High Voltage | $V_{IN}$ = 2.7V ≤ 4.2V | **2.0** | | | V |
| | | $V_{IN}$ = > 4.2V to 5.0V [3] | **2.4** | | | |
| $I_{\overline{ON}(SINK)}$ | $\overline{ON}$ Input leakage | $V_{\overline{ON}}$ = 5.5V | | 0.01 | **1** | µA |
| $t_{RESP}$ | Current Loop Response | $V_{IN}$ = 5V | | 500 | | ns |
| $T_{OFF}$ | Turn-Off Time | $V_{IN}$ = 5V, $R_L$ = 10Ω | | 2.5 | | µs |
| $T_{ON}$ | Turn-On Time | $V_{IN}$ = 5V, $R_L$ = 10Ω | | 1 | | µs |
| OTMP | Over Temperature Shutdown | | | 125 | | °C |

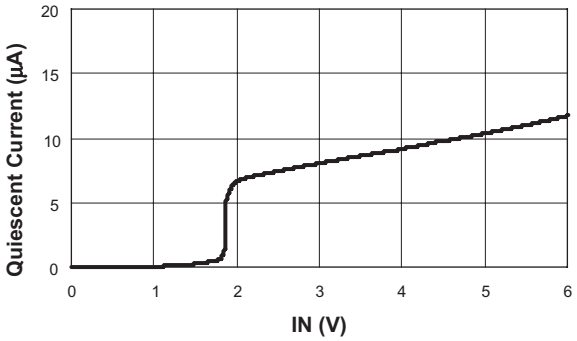
Note 3: For $V_{IN}$ outside this range consult typical $\overline{ON}$ threshold curve.

## Typical Characteristics

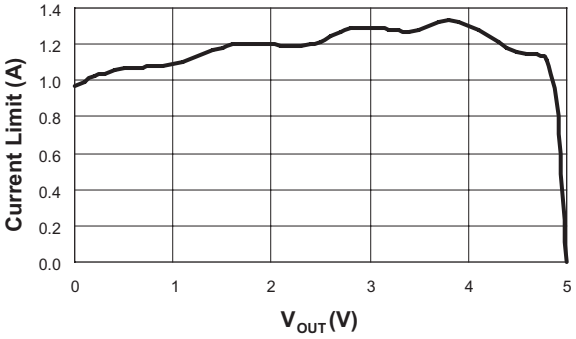
### Quiescent Current vs. Temperature



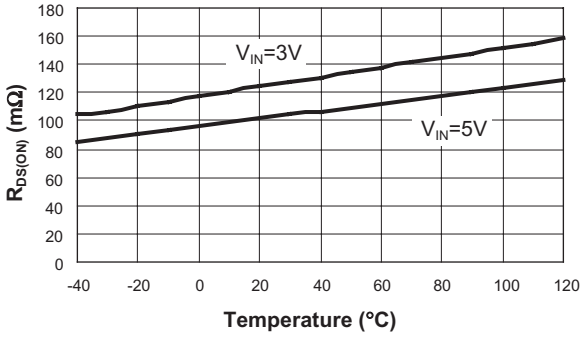

### Quiescent Current vs. Input Voltage



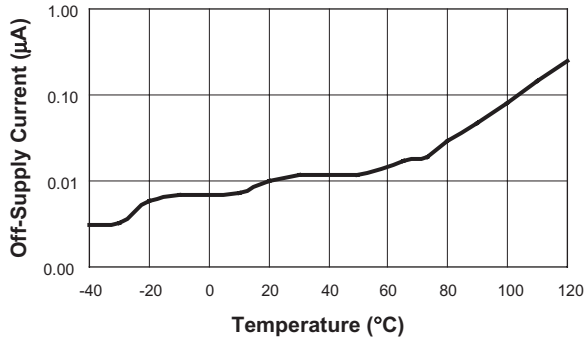

### Current Limit vs. $V_{OUT}$



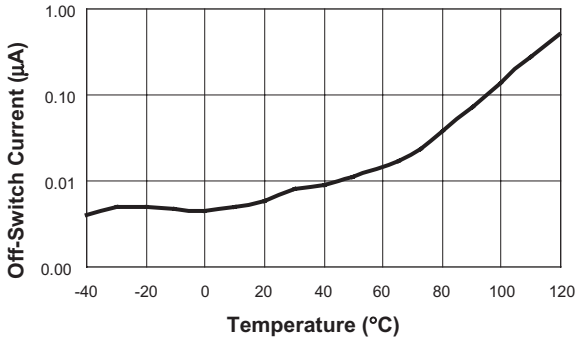

### $R_{DS(ON)}$ vs. Temperature




### Off-Supply Current vs. Temperature

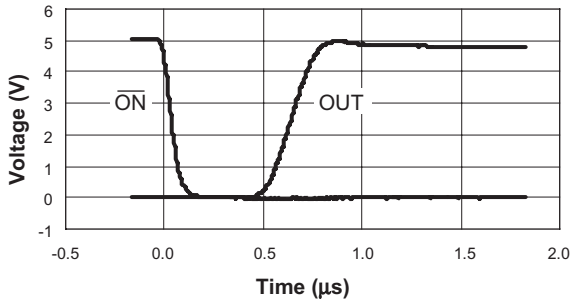



### Off-Switch Current vs. Temperature

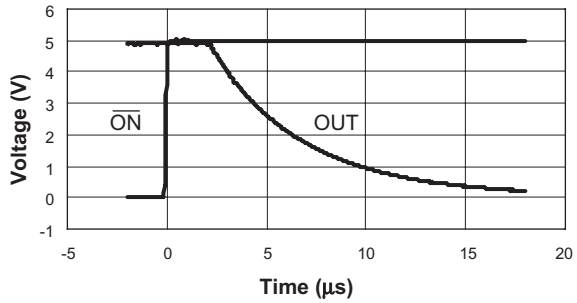


## Typical Characteristics

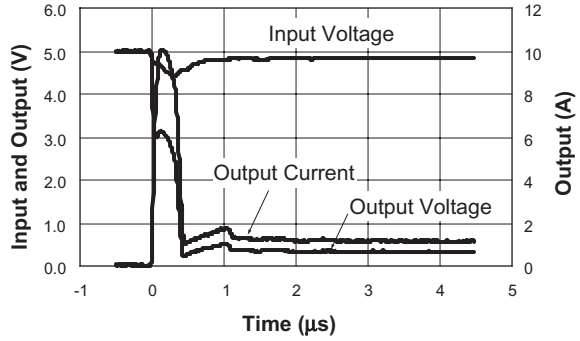
**Turn-On**
**$R_L$=10Ω, $C_L$=0.47µF**



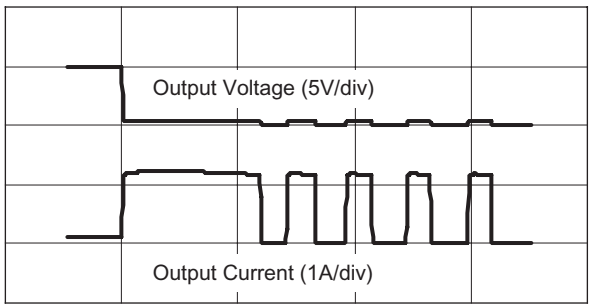

**Turn-Off**
**$R_L$=10Ω, $C_L$=0.47µF**



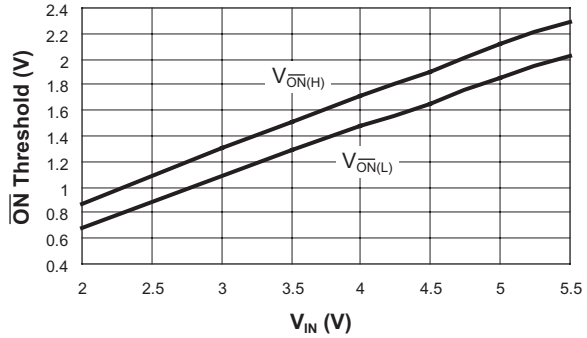

**Short Circuit through 0.3 Ω**



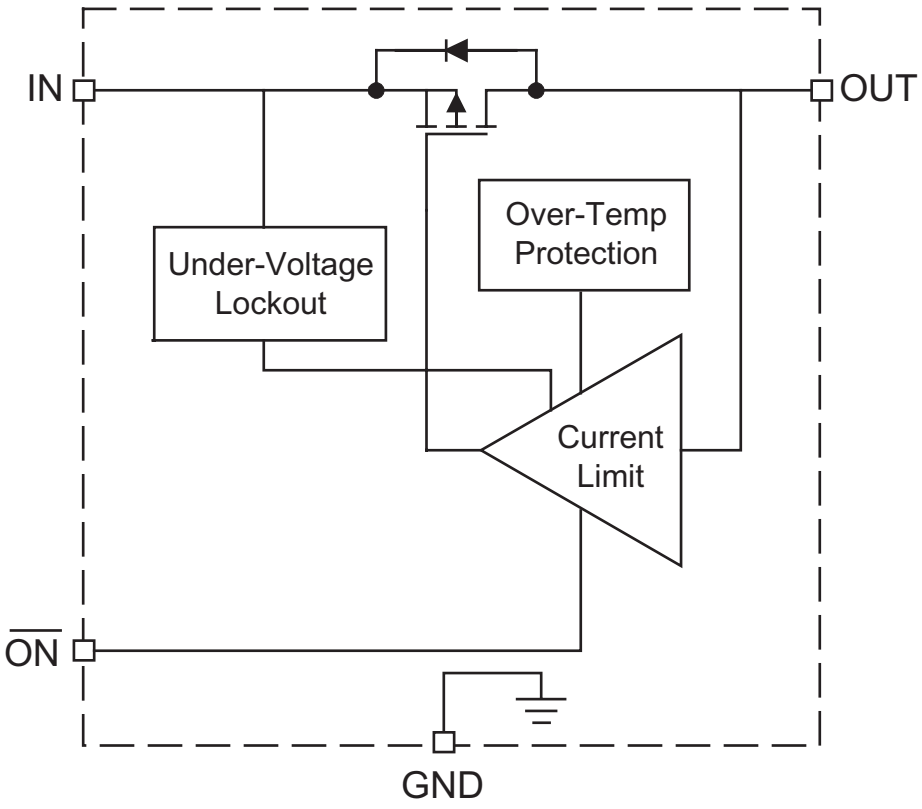

**Thermal Shutdown Response**




**$\overline{ON}$ Threshold vs. $V_{IN}$**



## 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 micro second 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 1µs before the current limit circuitry activates. (See characteristic curve "Short Circuit Through 0.3Ω.") 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 $V_{IN}$ 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 0.47µF 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 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.

### $\overline{ON}$

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 5 volt TTL, and 2.5 volt to 5 volt 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.

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

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 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 $I_{MAX}$; 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 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,

$$I_{MAX} = \sqrt{\frac{((115 - 85)}{(188m \times 150))}} = 1\ A$$

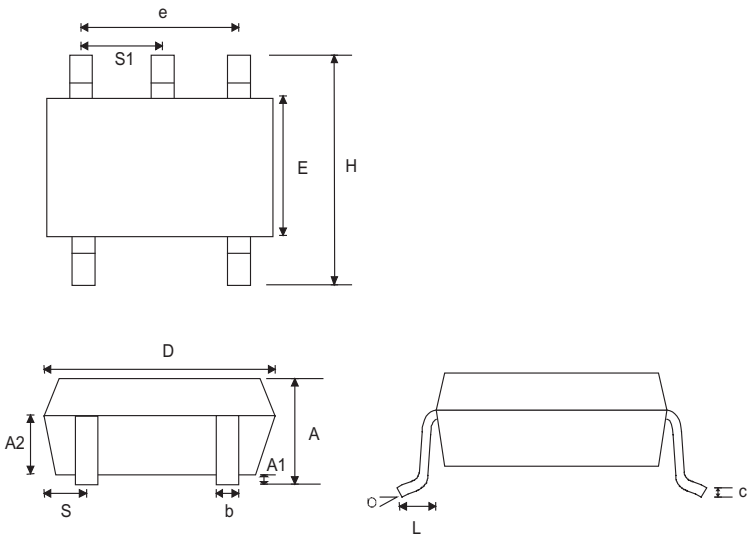
The AAT4612 is safe to operate at the maximum current level of 1A at 85°C.

## Ordering Information

| Package | Marking | Part Number | |
|---|---|---|---|
| | | Bulk | Tape and Reel |
| SOT23-5 | | N/A | AAT4612IGV-T1 |
| SC70JW-8 | | N/A | AAT4612IJS-T1 |

## Package Information

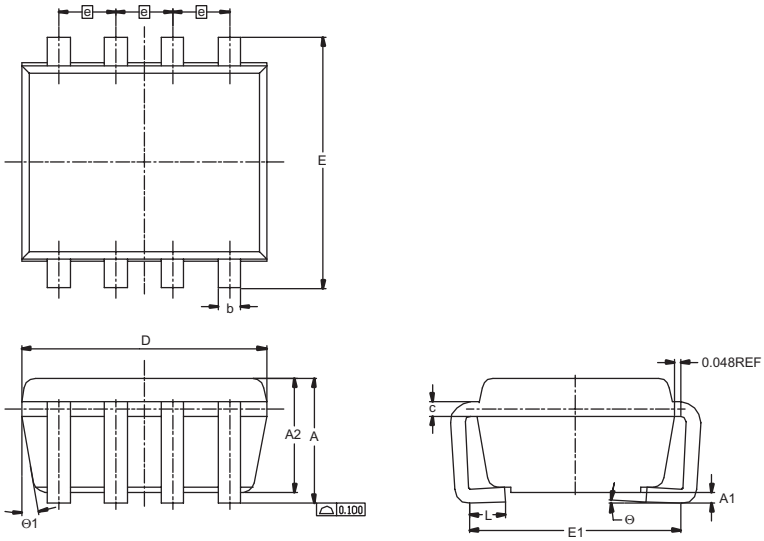
**SOT23-5**




| Dim | Millimeters | | Inches | |
|---|---|---|---|---|
| | Min | Max | Min | Max |
| A | 1.00 | 1.30 | 0.039 | 0.051 |
| A1 | 0.00 | 0.10 | 0.000 | 0.004 |
| A2 | 0.70 | 0.90 | 0.028 | 0.035 |
| b | 0.35 | 0.50 | 0.014 | 0.020 |
| c | 0.10 | 0.25 | 0.004 | 0.010 |
| D | 2.70 | 3.10 | 0.106 | 0.122 |
| E | 1.40 | 1.80 | 0.055 | 0.071 |
| e | 1.90 | | 0.075 | |
| H | 2.60 | 3.00 | 0.102 | 0.118 |
| L | 0.37 | | 0.015 | |
| S | 0.45 | 0.55 | 0.018 | 0.022 |
| S1 | 0.85 | 1.05 | 0.033 | 0.041 |
| Θ | 1° | 9° | 1° | 9° |

Note:
1. PACKAGE BODY SIZES EXCLUDE MOLD FLASH PROTRUSIONS OR GATE BURRS.
2. TOLERANCE 0.1000mm (4mil) UNLESS OTHERWISE SPECIFIED
3. COPLANARITY: 0.1000mm
4. DIMENSION L IS MEASURED IN GAGE PLANE.
5. CONTROLLING DIMENSION IS MILLIMETER; CONVERTED INCH DIMENSIONS ARE NOT NECESSARILY EXACT.

**SC70JW-8**




| Dim | Millimeters | | Inches | |
|---|---|---|---|---|
| | Min | Max | Min | Max |
| E | 2.10 BSC | | 0.083 BSC | |
| E1 | 1.75 | 2.00 | 0.069 | 0.079 |
| L | 0.23 | 0.40 | 0.009 | 0.016 |
| A | | 1.10 | | 0.043 |
| A1 | 0 | 0.10 | | 0.004 |
| A2 | 0.70 | 1.00 | 0.028 | 0.039 |
| D | 2.00 BSC | | 0.079 BSC | |
| e | 0.50 BSC | | 0.020 BSC | |
| b | 0.15 | 0.30 | 0.006 | 0.012 |
| c | 0.10 | 0.20 | 0.004 | 0.008 |
| Θ | 0 | 8º | 0 | 8º |
| Θ1 | 4º | 10º | 4º | 10º |

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