

80mΩ Adjustable Current Limited Power Switch

General Description

The ET2016AAM is a current limited P-channel MOSFET power switch designed for high-side load switching applications. This switch operates with inputs ranging from 2.5V to 5.5V, making it ideal for both 3.3V 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 ET2016AAM is also protected from thermal overload which limits power dissipation and junction temperatures. It can be used to control loads that require from 0.4A to 2.0A. Current limit threshold is programmed with a resistor from SET to ground. The quiescent supply current in active mode is only 25µA. In shutdown mode, the supply current decreases to less than 1µA.

The ET2016AAM is available in Pb-free packages and is specified over the -40°C to +105°C ambient temperature range.

Features

- Input Voltage Range: 2.5V to 5.5V
- Programmable Current Limit
- Reverse Current Blocking
- Short-Circuit Response: 2µs
- Very Low Quiescent Current: 25µA (Typ)
- 1µA Max Shutdown Supply Current
- Under-Voltage Lockout
- Thermal Shutdown
- 4kV HBM ESD Rating
- Automotive AEC-Q100 Grade 2 Qualified
- Part No. and Package

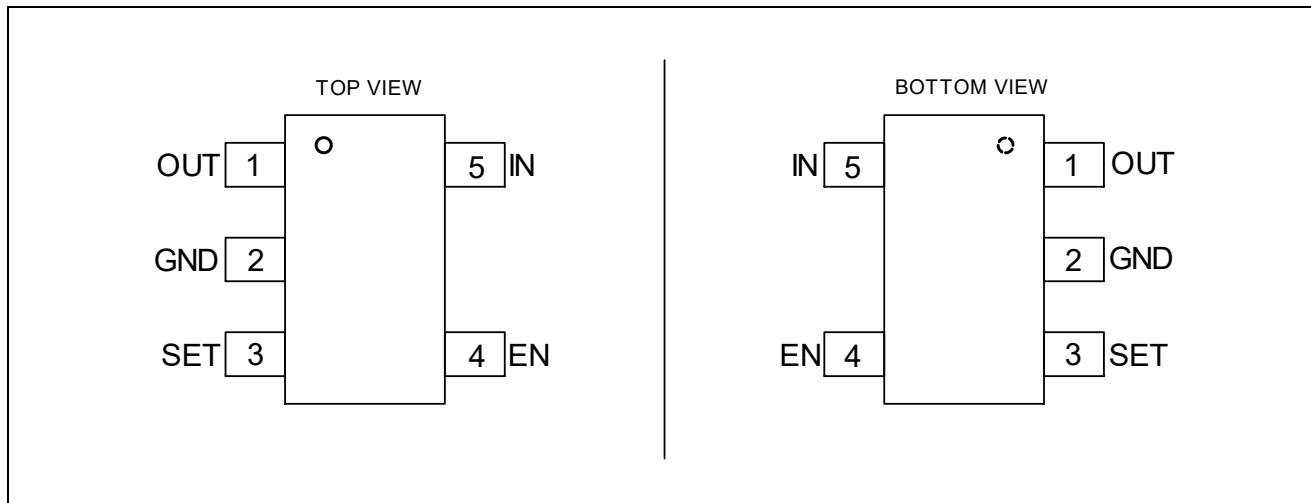
Part No.	Package	MSL
ET2016AAM	SOT23-5	Level 1

Application

- Automotive Media Players
- Automotive USB Port
- USB Hubs

ET2016AAM

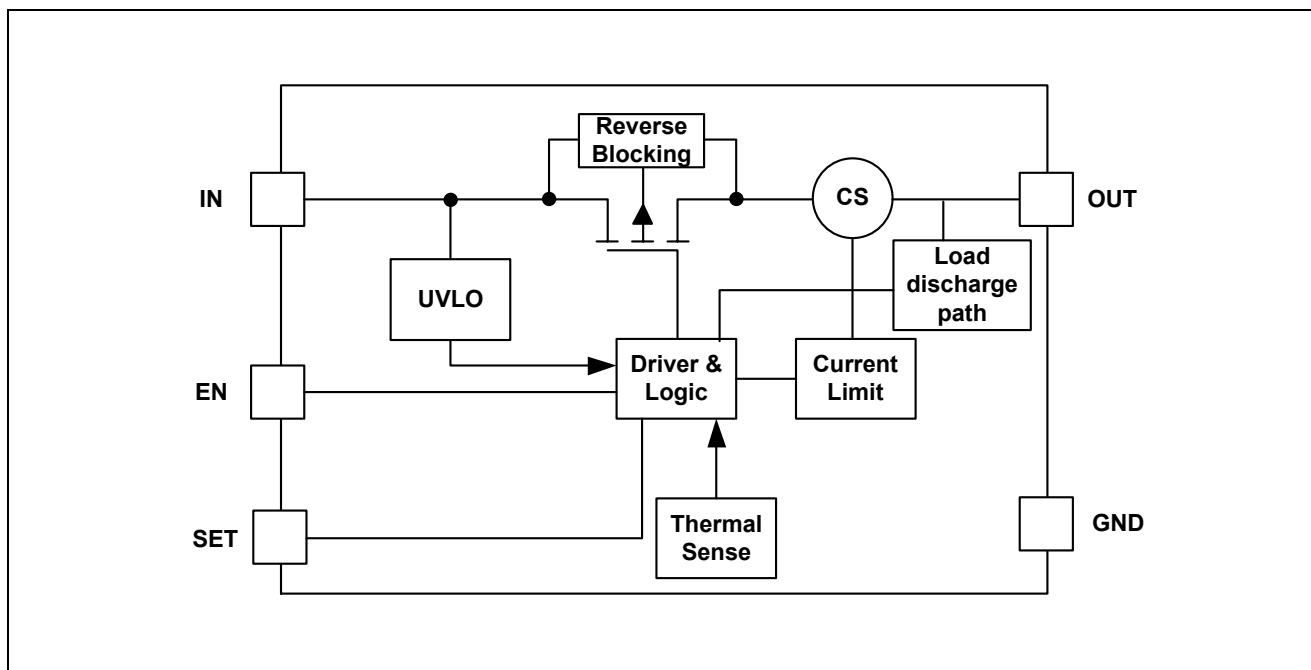
Pin Configuration



Pin Function

Pin	Name	Description
1	OUT	Power output.
2	GND	Ground pin.
3	SET	Current limit programming pin, with a resistor from ISET to ground.
4	EN	Enable input, high enable.
5	IN	Power supply input.

Block Diagram



Operation

ET2016AAM is an integrated power switch with a low $R_{DS(on)}$ P-channel MOSFET, internal gate drive circuit, programmable current limiting. When the ET2016AAM turns on, it can deliver up to 2A continuous current to load. When the device is active, if there is no load, the device only consumes 25uA supply current, which makes the device suitable for battery powered applications.

Power Supply Considerations

A 0.01μF to 0.1μF ceramic bypass capacitor between IN and GND, close to the device, is recommended.

Placing a high-value electrolytic capacitor on the output pin(s) is recommended when the output load is heavy. This precaution reduces power-supply transients that may cause ringing on the input and minimize the input voltage droops. Additionally, bypassing the output with a 0.01μF to 0.1μF ceramic capacitor improves the immunity of the device to short-circuit transients.

Power Dissipation and Junction Temperature

The low on-resistance on the P-channel MOSFET allows the small surface-mount packages to pass large currents. It is good design practice to check power dissipation and junction temperature for each application. Begin by determining the $R_{DS(on)}$ of the P-channel MOSFET relative to the input voltage and operating temperature. Using the highest operating ambient temperature of interest and $R_{DS(on)}$, the power dissipation per switch can be calculated by:

$$P_D = R_{DS(on)} \times I_{OUT}^2 \quad (1)$$

Finally, calculate the junction temperature:

$$T_J = P_D \times R_{\theta JA} + T_A \quad (2)$$

Where:

T_A = Ambient temperature

$R_{\theta JA}$ = Thermal resistance

P_D = Total power dissipation

Compare the calculated junction temperature with the maximum junction temperature which is 150°C. If they are within degrees, either the maximum load current needs to be reduced or another package option will be required.

Over Current

A sense FET is employed to check for over-current conditions. When an over-current condition is detected, the device maintains a constant output current and reduces the output voltage accordingly. ET2016AAM will limit the current until the overload condition is removed or the device begins to thermal cycle.

Three possible overload conditions can occur. In the first condition, the output has been shorted before the device is enabled or before VIN has been applied. The ET2016AAM senses the short and immediately switches into a constant-current output.

In the second condition, a short or an overload occurs while the device is enabled. At the instant the overload

occurs, high currents may flow for a short period of time before the current-limit circuit can react .

After the current-limit circuit reached the over-current trip threshold, the device switches into constant-current mode.

In the third condition, the load has been gradually increased beyond the recommended operating current. The current is permitted to rise until the current-limit threshold is reached or until the thermal limit of the device is exceeded. The ET2016AAM is capable of delivering current up to the current-limit threshold without damaging the device. Once the threshold has been reached, the device switches into its constant-current mode.

Thermal Protection

Thermal protection prevents damage to the IC when heavy-overload or short-circuit faults are present for extended periods of time. The ET2016AAM implements a thermal sensing to monitor the operating junction temperature of the power distribution switch. In an over-current or short-circuit condition, the junction temperature rises due to excessive power dissipation.

Once the die temperature rises to approximately 155°C due to over-current conditions, the internal thermal sense circuitry turns the power switch off, thus preventing the power switch from damage. Hysteresis is built into the thermal sense circuit, and after the device has cooled approximately 25°C, the switch turns back on. The switch continues to cycle in this manner until the load fault or input power is removed.

Current Limiting Setting

Current limit is programmable to protect the power source from over current and short circuit conditions. Connect a resistor RSET from SET pin to GND to program the current limit:

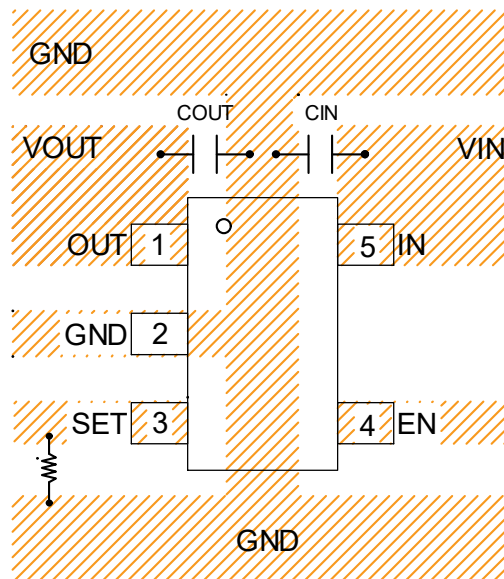
$$I_{LIM}(A) = 6800/R_{SET} \text{ (}\Omega\text{)} \quad (3)$$

The minimum current limit is 0.4A. Current limit beyond 2A is not recommended. The formula is for reference only, please refer to the actual test flow limiting curve.

PCB Layout Guide

PCB layout is very important to achieve stable operation. It is highly recommended to duplicate EVB layout for optimum performance. If change is necessary, please follow these guidelines for reference.

- 1) Keep the path of current short and minimize the loop area formed by Input and output capacitor.
- 2) Output capacitor and IC must be on the same side, The distance of OUT pin and output capacitor <3mm is recommended.
- 3) Bypass ceramic capacitors are suggested to be put close to the IN Pin.
- 4) Connect IN, OUT, and especially GND respectively to a large copper area to cool the chip to improve thermal performance and long-term reliability.



PCB Layout Reference

Absolute Maximum Ratings

Parameter		Rating	Unit
IN, EN, SET Voltage		-0.3 to 6.0	V
OUT Voltage		-0.3 to $V_{IN} + 0.3$	V
Power Dissipation ($T_A = 25^\circ\text{C}$)		500	mW
Package Thermal Resistance (θ_{JA})		250	$^\circ\text{C}/\text{W}$
Operating Junction Temperature (T_J)		-40 to 150	$^\circ\text{C}$
Storage Temperature		-65 to 150	$^\circ\text{C}$
Lead Temperature (Soldering, 10 sec)		300	$^\circ\text{C}$
ESD	Human Body Model (per AEC-Q100-002)	± 4000	V
	Charged Device Model (per AEC-Q100-011)	± 1000	V

Note: Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. Exposure to absolute maximum rated conditions for extended periods may affect device reliability.

Recommended Operating Conditions

Symbol	Parameters	Rating	Unit
V_{IN}	Input Voltage	2.5 to 5.5	V
I_{OUT}	Output Current	0.4 to 2.0	A
T_A	Operating Ambient Temperature	-40 to 105	$^\circ\text{C}$

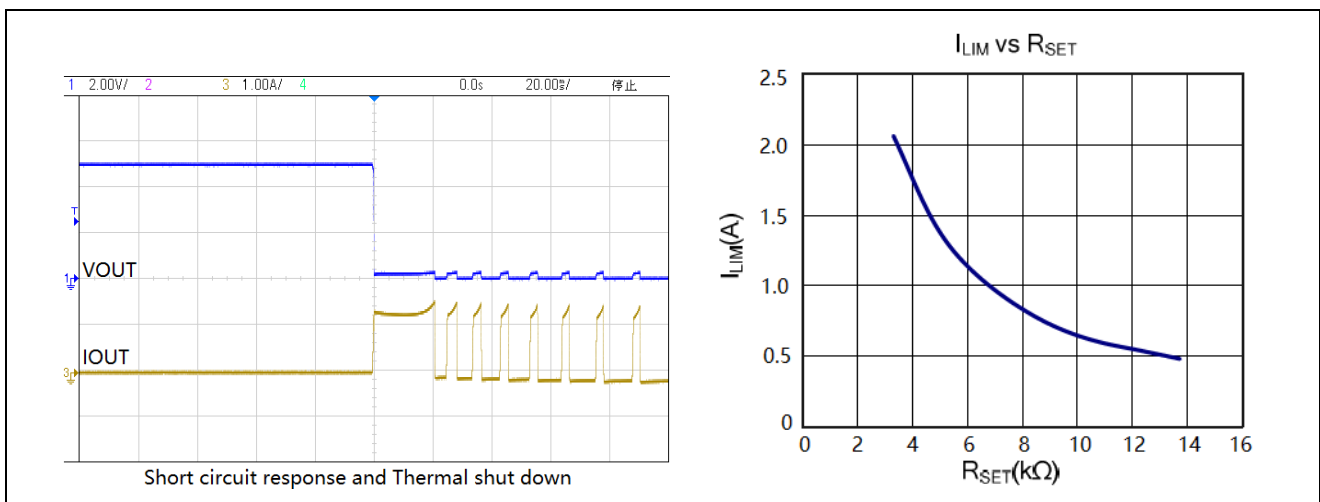
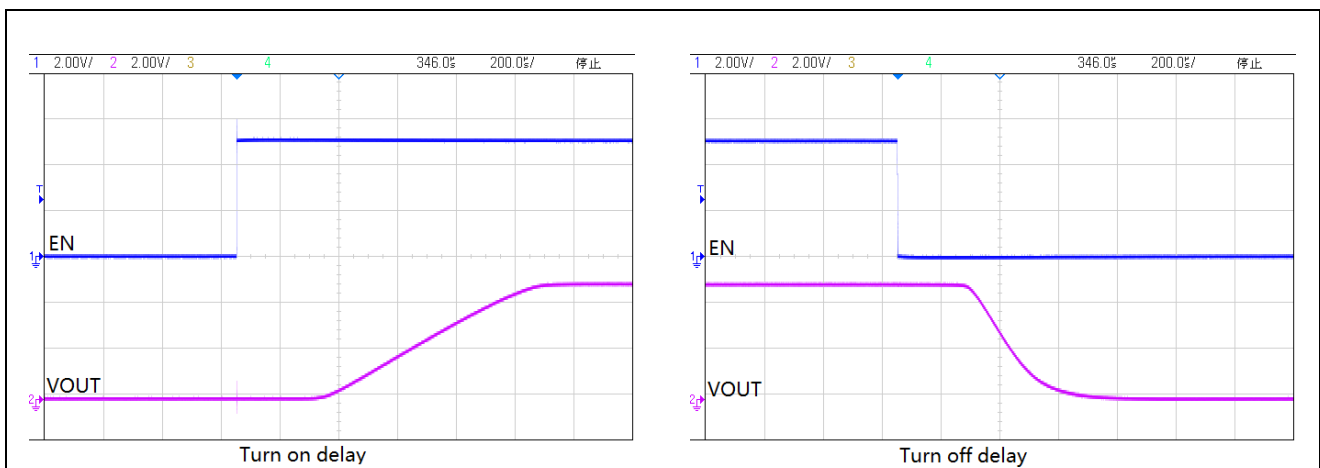
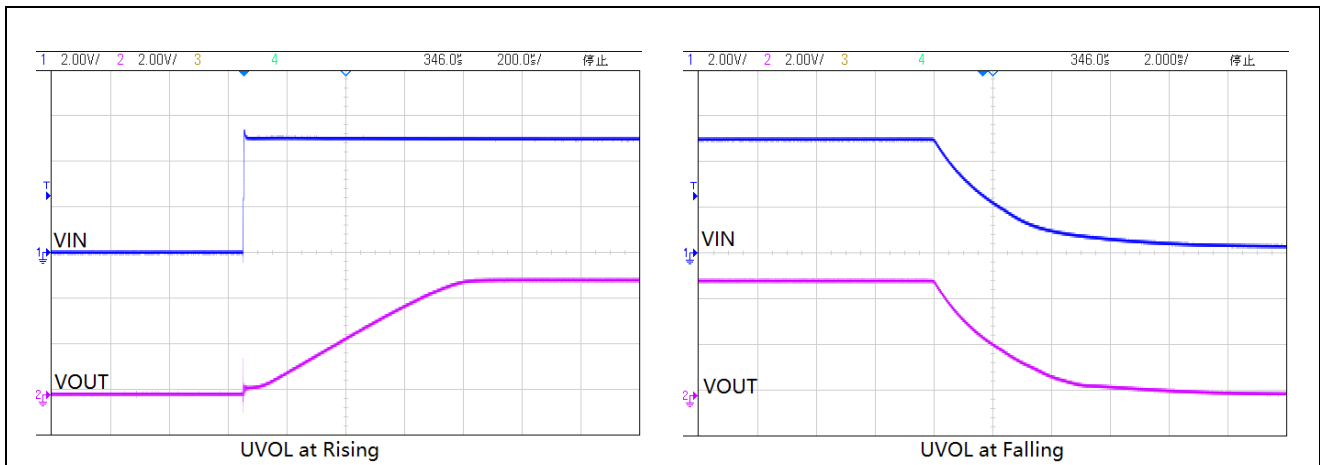
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Electrical Characteristics

($V_{IN} = +5.0V$, $T_A = -40^{\circ}C$ to $105^{\circ}C$, typical values at $T_A=25^{\circ}C$, unless otherwise stated)

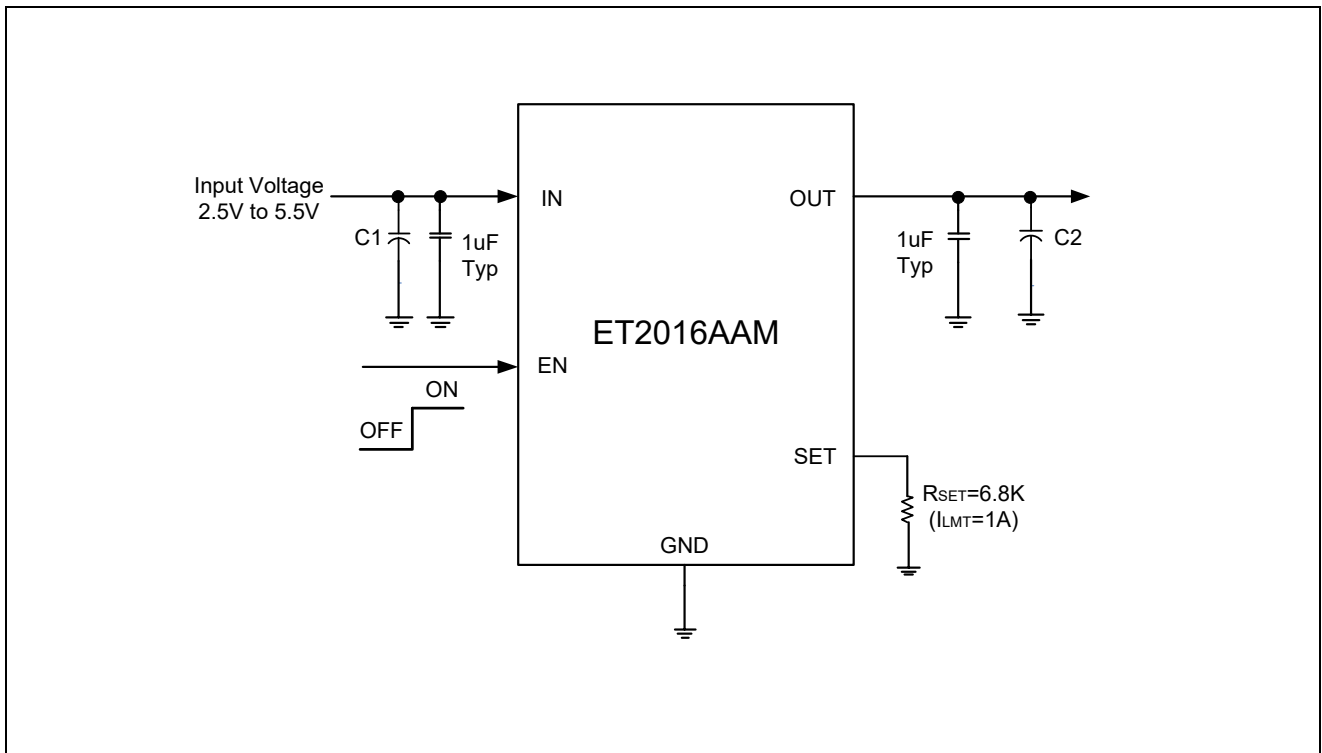
Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_{IN}	Input Voltage Range		2.5		5.5	V
V_{UVLO}	Input UVLO Voltage		1.4	1.8	2.3	V
V_{UVLO_HYS}	UVLO Hysteresis			0.25		V
I_{SHDN}	Input Shutdown Quiescent Current	Disabled, OUT floating or shorted to ground		0.1	1	μA
I_Q	Input Quiescent Current	Enabled, $V_{EN}=V_{IN}$, $I_{OUT}=0A$	10	25	60	μA
$R_{DS(ON)}$	Switch on-resistance	$V_{IN}=5V$, $I_{OUT}=0.6A$	60	80	120	m Ω
I_{LMT}	Current Limit	$V_{IN}=5V$, $V_{OUT}=4.5V$, $R_{SET}=6.8K$	0.75	1	1.25	A
		$V_{IN}=5V$, $V_{OUT}=4.5V$, $R_{SET}=5.6K$	0.91	1.21	1.51	A
		Min Current Limit		0.4		A
V_{IL}	EN Input Logic Low Voltage				0.8	V
V_{IH}	EN Input Logic High Voltage		1.7			V
I_{SINK}	EN Input leakage	$V_{EN} = 5V$		0.01	1	μA
T_{ON}	Output Turn-on Delay Time	$V_{IN} = 5V$, $C_L=1\mu F$, $R_L=100\Omega$	0.2	0.6	1.0	ms
T_R	Output Turn-on Rise Time	$V_{IN} = 5V$, $C_L=1\mu F$, $R_L=100\Omega$	0.2	0.5	0.8	ms
T_{OFF}	Output Turn-off Delay Time	$V_{IN} = 5V$, $C_L=1\mu F$, $R_L=100\Omega$	0.1	0.3	0.5	ms
T_F	Output Turn-off Fall Time	$V_{IN} = 5V$, $C_L=1\mu F$, $R_L=100\Omega$	50	120	200	μs
R_{DIS}	Output Discharge FET $R_{DS(ON)}$	$V_{IN} = 5V$, $V_{EN} = 0V$, $V_{OUT}=5V$	200	400	800	Ω
I_{REV}	Reverse leakage current	$V_{OUT} = 5V$, $V_{IN} = 0V$ measure I_{VOUT}	0.1	1	3	μA
T_{SHDN}	Thermal shutdown threshold	$V_{IN} = 5V$	140	155	165	$^{\circ}C$
T_{HYS}	Thermal shutdown hysteresis	$V_{IN} = 5V$		25		$^{\circ}C$

Typical Performance Characteristics



ET2016AAM

Application Circuits

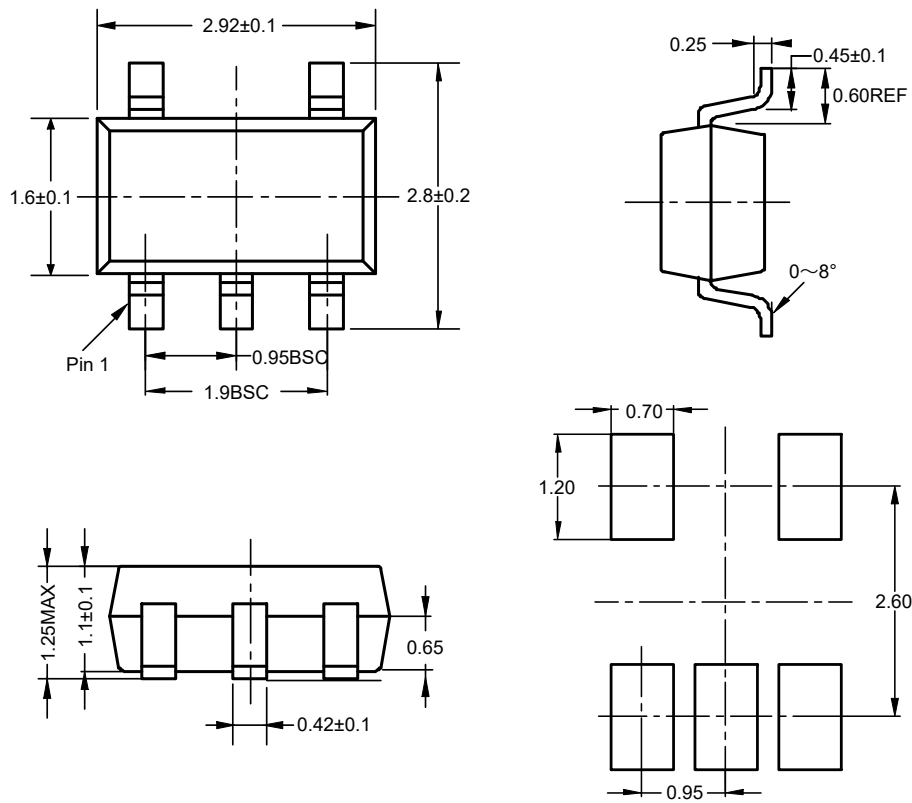


Note: Tantalum or Aluminum Electrolytic capacitors (C1 and C2) may be required for USB applications.

ET2016AAM

Package Dimension

SOT23-5



Recommended Land Pattern

Unit: mm

Revision History and Checking Table

Version	Date	Revision Item	Modifier	Function & Spec Checking	Package & Tape Checking
1.0	2016-04-22	Original version	Liu Yi Guo	Liu Yi Guo	Zhuji
1.1	2024-08-28	AM version, Update format	Wu He Song	Liuyg	Liuji