Single Channel USB Switch with Adjustable Current Limit

FEATURES

- 85mΩ High-Side MOSFET Switch
- 100μA Quiescent Supply Current
- 1μA Maximum Shutdown Supply Current
- 3.0V to 5.5V Input Voltage Range
- Open-Drain Over-Current Flag Output
- Under-Voltage Lockout
- Thermal / Short Circuit Protection
- Adjustable Current Limit : 0.4A ~ 2.0A
- Under Voltage Lockout Ensuring Switch is off at Start Up
- Soft Start prevents large Inrush Current
- Discharge function when shutdown active
- No Reverse Current at Power off
- Enable Active-High or Active-Low Version
- Available in SOT23-6 Package

APPLICATIONS

- USB Power Management
- High-Side Power Protection Switch
- Hot Plug-In Power Supplies
- Battery-Charger Circuits
- Portable Application
- Digital Television

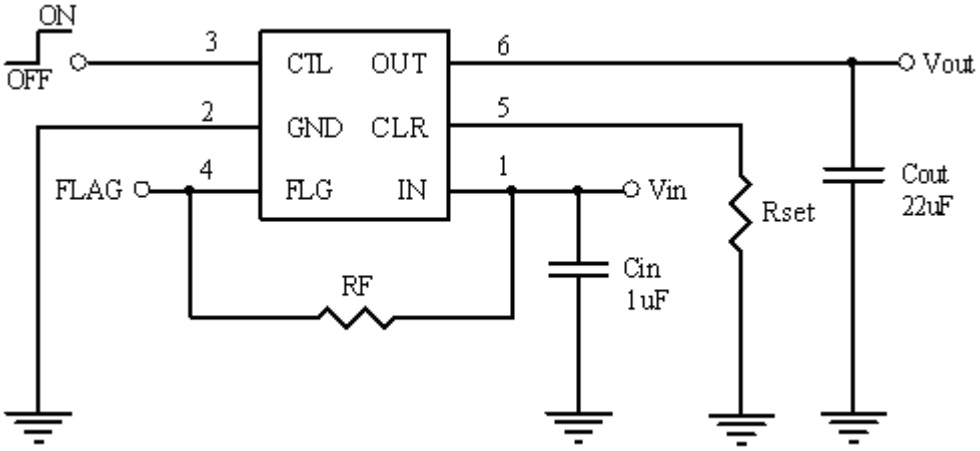
DESCRIPTION

The AIC6170 is an integrated 85mΩ high-side power switch for self-powered and bus-powered Universal Serial Bus (USB) applications. This switch operates with input ranging from 3.0V to 5.5V, making it ideal for 5V systems.

The protection schemes include programmable current limiting with foldback, thermal shutdown and short circuit protection. The AIC6170 is ideal for any system where current limiting and power control are desired. The low quiescent current and small package of the AIC6170 makes it particularly suitable for battery-powered portable devices.

The Guaranteed minimum output rise-time which limits inrush current as well as minimizes EMI during hot plug-in prevents the voltage at upstream port from dropping excessively.

TYPICAL APPLICATION CIRCUIT



Typical Application Circuit

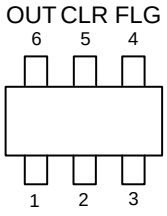
ORDERING INFORMATION

AIC6170XXXXXXX

- PACKING TYPE
  TR: TAPE & REEL
  BG: BAG
- PACKAGE TYPE
  G6: SOT23-6
- G: GREEN PACKAGE
- CONTROL POLARITY
  L: Active Low
  H: Active High
- T: No rush current protection

PIN CONFIGURATION

FRONT VIEW



Example: AIC6170THGG6TR

→ No rush current protection, Active High Version, in SOT23-6 Green package and TAPE & REEL packing

AIC6170TLGG6BG

→ No rush current protection, Active Low Version, in SOT23-6 Green package and Bag packing

- **Marking**

Part No.	Package Code	Package Type	Marking	Control Polarity
AIC6170Tx	GG6	SOT-26	IATxG	x=L for active low, x=H for active high

ABSOLUTE MAXIMUM RATINGS

Supply Voltage (V_{IN}) ..... -0.3V ~ 7.0V
CTL Input (V_{CTL}) ..... -0.3V ~ 7.0V
CLR, OUT Voltage ..... -0.3V ~ 7.0V
Fault Flag Voltage (V_{FLG}) ..... -0.3V ~ 7.0V
Fault Flag Current (I_{FLG}) 25mA
Operating Temperature Range ..... -40°C ~ 85°C
Junction Temperature ..... 125°C
Storage Temperature Range ..... -65°C ~ 150°C
Lead Temperature (Soldering, 10sec) ..... 260°C
Thermal Resistance, θ_{JA} (Junction to Ambient) SOT23-6 ..... 250°C/W
Thermal Resistance, θ_{JC} (Junction to Case) SOT23-6 ..... 115°C/W
(Assume no Ambient Airflow, no Heatsink)

Absolute Maximum Ratings are those values beyond which the life of a device may be impaired.

■ ELECTRICAL CHARACTERISTICS

(V_{IN}= 5V, C_{IN} =C_{OUT} = 1μF, T_A=25°C, unless otherwise specified.) (Note 1)

PARAMETERS	CONDITIONS	MIN.	TYP.	MAX.	UNIT
Supply Current			100	200	μA
Shutdown Supply Current			0.1	1	μA
Input Voltage Range		3.0		5.5	V
Output MOSFET Resistance			85	110	mΩ
Output Turn-On Rise Time	R_L = 10Ω each Output		800		μS
Output Turn-Off Fall Time	R_L = 10Ω each Output		0.7	20	μS
Control Input Threshold		0.4	0.8	1.2	V
Current Limit	R_{SET} = 1.1KΩ	1804	2048	2294	mA
	R_{SET} = 1.5KΩ	1406	1538	1684	
	R_{SET} = 2KΩ	1092	1179	1258	
	R_{SET} = 3KΩ	732	810	878	
	R_{SET} = 6.47KΩ	352	398	448	
Output Leakage Current	CTL='0', V_{OUT} =0V		0.5	1	μA
Over Temperature Shutdown Threshold	T_J Increasing T_J Decreasing		145 125		°C
Under Voltage Lockout		2.0	2.4	2.9	V
Under Voltage Lockout Hysteresis		50	200	400	mV
Over Current Flag Response Delay	Apply V_{OUT} = 0V until FLG low	4	9	25	ms
FLG Output Low Voltage				0.4	V
FLG Off-State Current				1	μA

Note1:Specifications are production tested at T_A=25°C. Specifications over the -40°C to 85°C operating temperature range are assured by design, characterization and correlation with Statistical Quality Controls (SQC).

TYPICAL PERFORMANCE CHARACTERISTICS

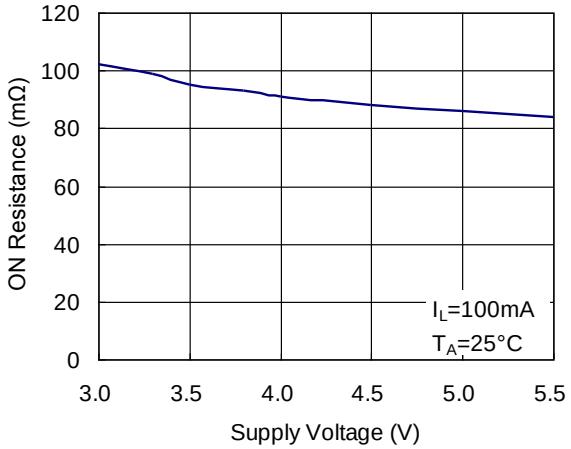


Fig. 1 ON Resistance vs. Supply Voltage

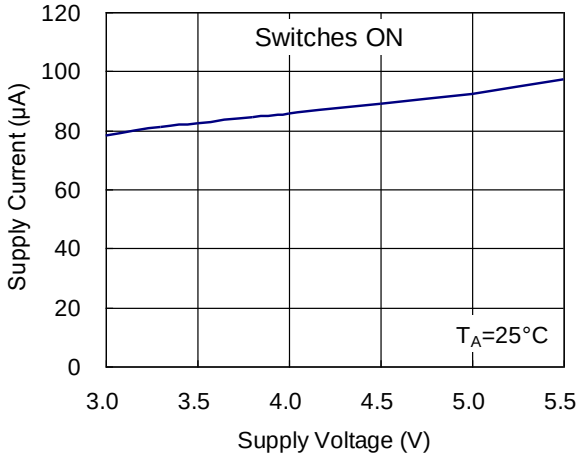


Fig. 2 Supply Current vs. Supply Voltage

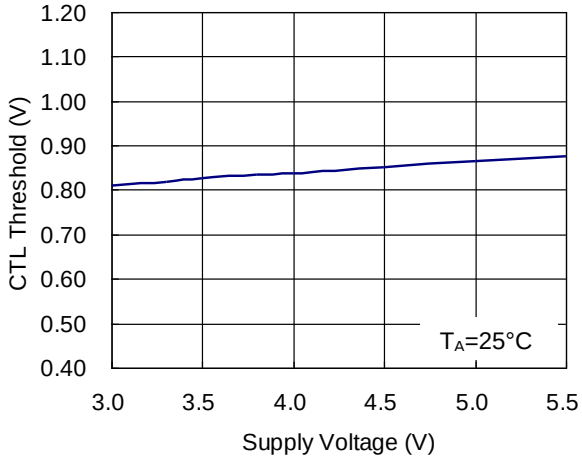


Fig. 3 CTL Threshold vs. Supply Voltage

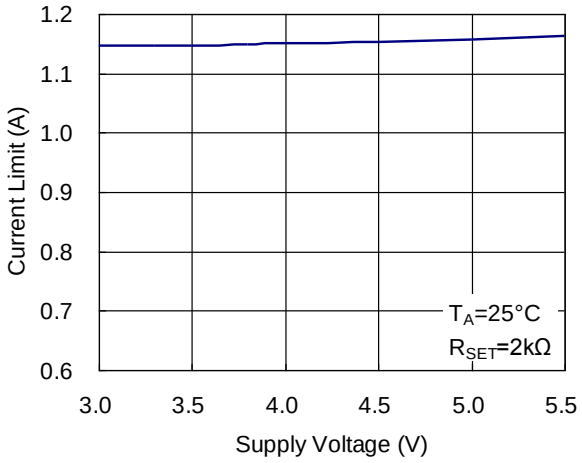


Fig. 4 Current Limit vs. Supply Voltage

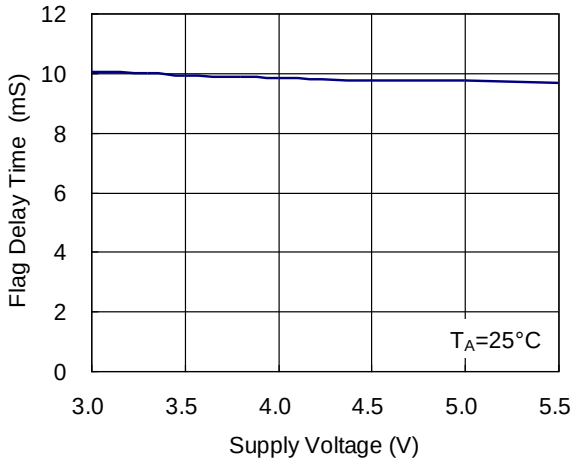


Fig. 5 Flag Delay Time vs. Supply Voltage

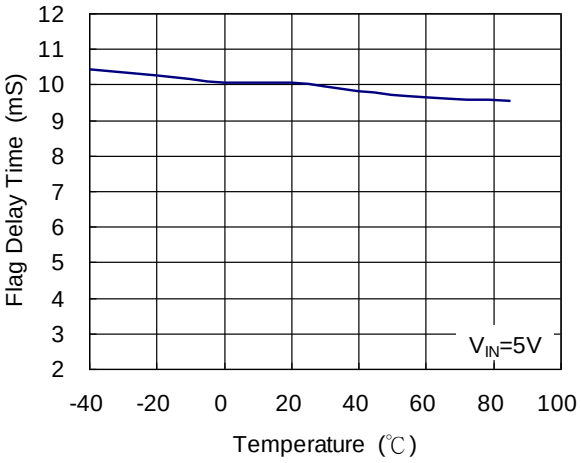


Fig. 6 Flag Delay Time vs. Temperature

TYPICAL PERFORMANCE CHARACTERISTICS(Continued)

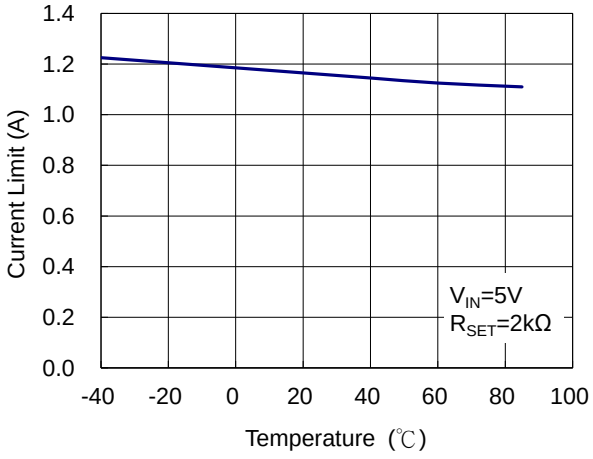


Fig. 7 Current Limit vs. Temperature

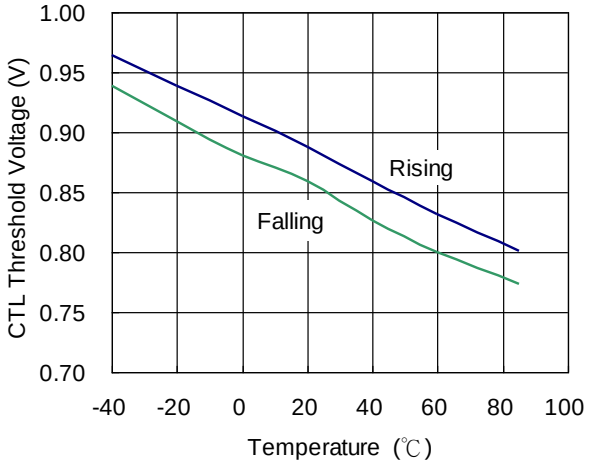


Fig. 8 CTL Threshold vs. Temperature

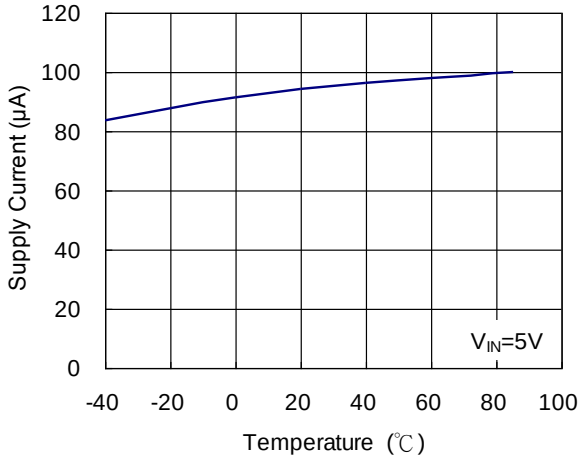


Fig. 9 Supply Current vs. Temperature

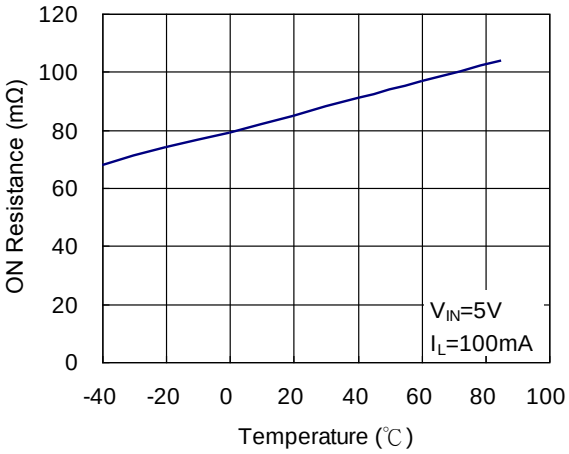


Fig. 10 ON Resistance vs. Temperature

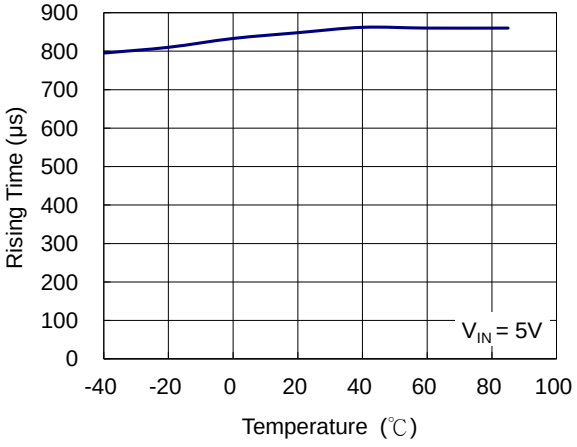
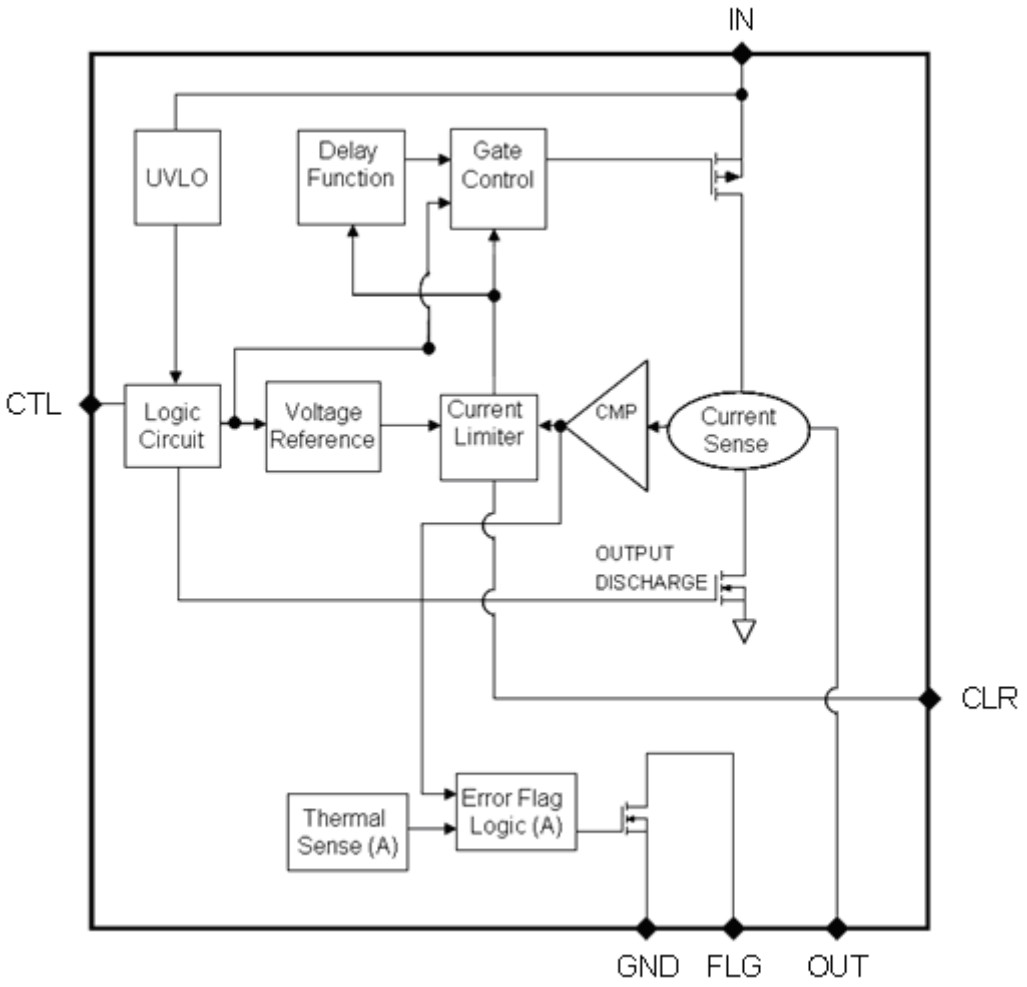


Fig. 11 Rising Time vs. Temperature

FUNCTIONAL BLOCK DIAGRAM



Functional Block Diagram of AIC6170

PIN DESCRIPTIONS

PIN1 IN: Power supply input.

PIN2 GND: Chip power ground.

PIN3 CTL : Switch Enable.

PIN4 FLG: Fault status. A logic low on this pin indicates the switch is in current limit, or has been shutdown by the thermal protection circuit.

PIN5 CLR: Sets the current limit threshold via a resistor connected between CLR and GND.

PIN6 OUT: MOSFET switch output.

APPLICATION INFORMATION

Flag Output

An error Flag is an open-drained output of an N-channel MOSFET. Flag output is pulled low to signal the following fault conditions: output current limit and thermal shutdown. The current limit flag response delay time is about 9ms.

Current Limit

The AIC6170 has current limit function. It protects the output MOSFET switches from damage resulting from undesirable short circuit conditions or excess inrush current, which is often encountered during hot plug-in. The error flag signals when any current limit conditions occur. The current limit threshold can be set by the resistor, R_{SET}, connecting between CLR pin and GND pin and can be approximated by the following equation.

$$I_{LIMIT(min)} = 2027.9 \times [R_{SET}(k\Omega)]^{-0.931}$$

$$I_{LIMIT(typ)} = 2236.4 \times [R_{SET}(k\Omega)]^{-0.924}$$

$$I_{LIMIT(max)} = 2443 \times [R_{SET}(k\Omega)]^{-0.918}$$

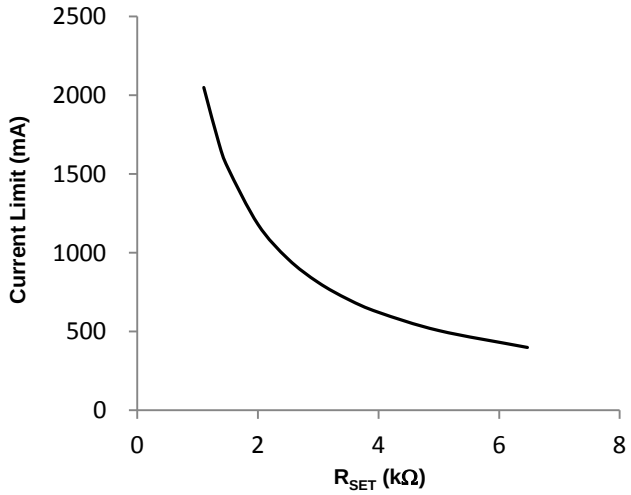


Fig. 12 Current Limit (typical) vs. R_{SET}

Thermal Shutdown

The AIC6170 includes an over temperature protection circuit, which is designed to protect the device. The over temperature shutdown threshold can change according to the state of the current limit protection function. If the current limit protection function does not be activated, the over temperature shutdown threshold is about 145°C. In the current limit protection condition, the over temperature shutdown threshold can reduce to about 125°C. When the junction temperature exceeds the over temperature shutdown threshold, the over temperature protection function turns off the power switch and signals the error flag. The over temperature protection hysteresis prevents the power switch from turning on until the junction temperature has dropped about 20°C.

CTL Control

CTL (Control input) must be driven logic high or logic low for a clearly defined input. Floating the input may cause unpredictable operation.

Under-Voltage Lockout

UVLO (under voltage lockout) prevents the output MOSFET from turning on until input voltage exceeds 2.4V typically. After the switch turns on, if the input voltage drops below 2.2V typically, UVLO shuts off the output MOSFET.

Supply Filtering

A 1μF bypass capacitor from USB IN to GND, located near the device, is strongly recommended to control supply transients. Without a bypass capacitor, an output short may cause sufficient ringing on the input (from supply lead inductance) to damage internal control circuitry.

Transient Requirements

USB supports dynamic attachment (hot plug-in) of peripherals. A current surge is caused by the input capacitance of downstream device. Ferrite beads are

recommended in series with all power and ground connector pins. Ferrite beads reduce EMI and limit the inrush current during hot-attachment by filtering high-frequency signals.

Short Circuit Transient

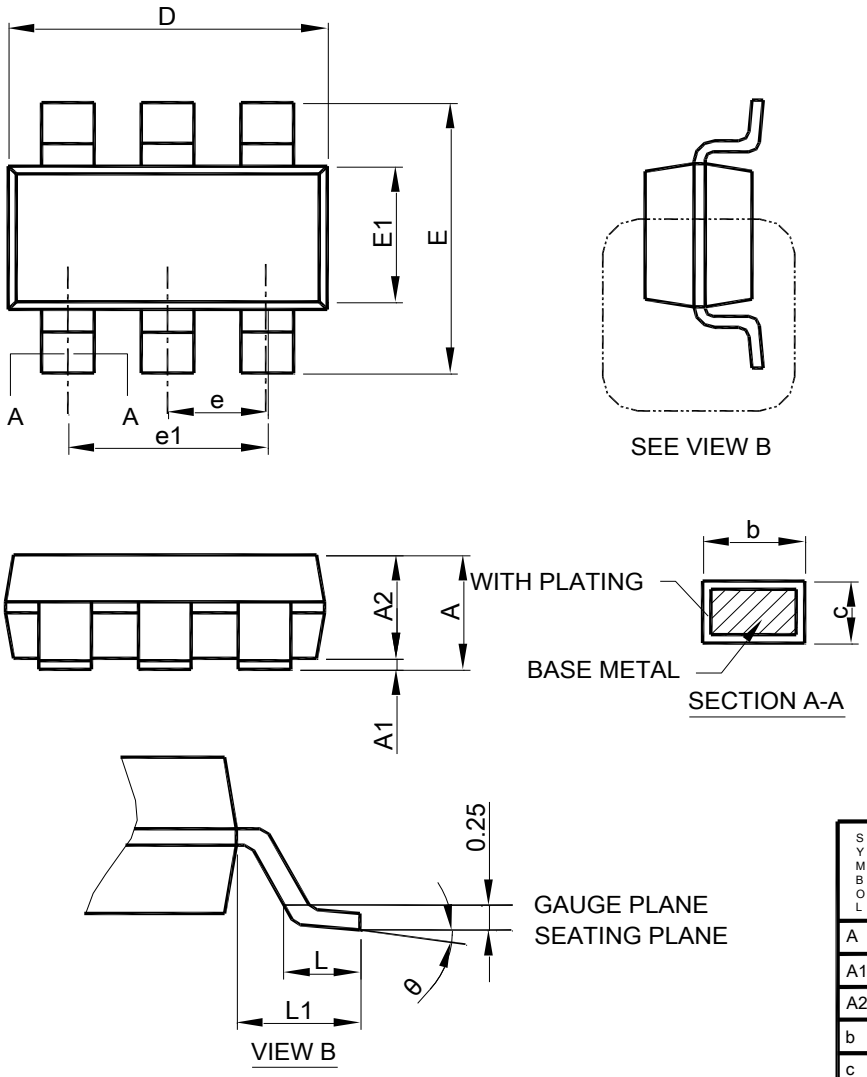
Bulk capacitance provides the short-term transient current needed during a hot-attachment event. A 22μF/10V ceramic capacitor mounted close to downstream connector each port should provide transient drop protection.

Printed Circuit Layout

1. The power circuitry of USB printed circuit boards requires a customized layout to maximize thermal dissipation and to minimize voltage drop and EMI.
2. R_{SET} should be set as closed to CLR pin as possible.

PHYSICAL DIMENSIONS

- **SOT23-6**



SYMBOL	SOT23-6	
	MILLIMETERS	
	MIN.	MAX.
A	0.95	1.45
A1	0.00	0.15
A2	0.90	1.30
b	0.30	0.50
c	0.08	0.22
D	2.80	3.00
E	2.60	3.00
E1	1.50	1.70
e	0.95 BSC	
e1	1.90 BSC	
L	0.30	0.60
L1	0.60 REF	
θ	0°	8°

Note : 1. Refer to JEDEC MO-178AB.
2. Dimension "D" does not include mold flash, protrusions or gate burrs. Mold flash, protrusion or gate burrs shall not exceed 10 mil per side.
3. Dimension "E1" does not include inter-lead flash or protrusions.
4. Controlling dimension is millimeter, converted inch dimensions are not necessarily exact.