Regulatory USB High-Side Power Switch

FEATURES

- 150mΩ (6V Input) High-Side MOSFET Switch
- 0.62A/1.25A Continuous Load Current of USB switch
- 140μA Typical On-State Supply Current of USB switch
- 0.75μA Typical Off-State Supply Current of USB switch
- Fault Flag with 8ms filter eliminates false assertions
- Under voltage Lockout Ensures that Switch is off at Start Up
- USB Switch Output can be Forced Higher than USB Switch Input (Off-State)
- Open-Drain Fault Flag
- Slow Turn ON and Fast Turn OFF
- Control Active-High or Active-Low
- Constant Current Limit / Short Circuit Protection.
- Thermal Shutdown Protection (latching)
- Available in SOP-8 (Exposed Pad) Package

APPLICATIONS

- USB Power Management.
- Hot Plug-In Power Supplies.
- Battery-Charger Circuit.

DESCRIPTION

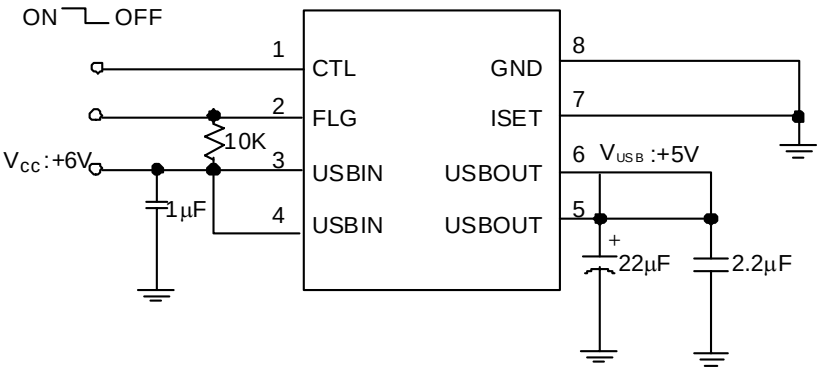
The AIC6166 is a power switch IC integrated a low dropout linear regulator for bus-powered Universal Serial Bus (USB) applications.

The high-side switch of USB power switch is MOSFET with 150mΩ $R_{DS(ON)}$, which meets USB voltage drop requirements for maximum transmission wire length.

Multi-purpose open-drain fault flag output indicates over-current limiting, thermal shutdown, or undervoltage lockout. The output current of USB power switch is typical limited to 0.62A / 1.25A (control by select pin).

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

TYPICAL APPLICATION CIRCUIT



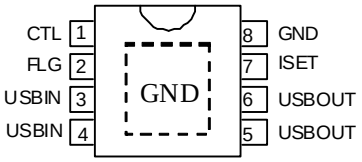
ORDERING INFORMATION

AIC6166X-XXXXXX

- PACKING TYPE
  TR: TAPE & REEL
  TB: TUBE
- PACKAGING TYPE
  R8: SOP-8 Exposed Pad (Heat Sink)
- G: Green Package
- CONTROL POLARITY
  0: Active Low
  1: Active High
- Fault Flag Response Delay Time
  D: Delay 8ms

PIN CONFIGURATION

SOP-8 Exposed Pad (Heat Sink)
TOP VIEW



Example: AIC6166D-0GR8TR

→ With Fault Flag Response Delay Time, Active Low Version, in SOP-8 Exposed Pad (Heat Sink) Green Package & Taping & Reel Packing Type

ABSOLUTE MAXIMUM RATINGS

USB Power Switch Supply Voltage (V_{USBIN})	7.0V
Fault Flag Voltage (V_{FLG})	7.0V
Fault Flag Current (I_{FLG})	50mA
Control Input (V_{CTL}, V_{ENLDO})	-0.3V ~7V
Operating Temperature Range	-40°C~85°C
Junction Temperature	150°C
Storage Temperature Range	-65°C ~ 150°C
Lead Temperature (Soldering, 10sec)	260°C
Thermal Resistance Junction to Case SOP8 Exposed Pad*	15°C/W
Thermal Resistance Junction to Ambient SOP8 Exposed Pad* (Assume no ambient airflow)	60°C/W

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

* The package is placed on a two layers PCB with 2 ounces copper and 2 square inch, connected by 8 vias.

ELECTRICAL CHARACTERISTICS

(C_{USBIN} = 1μF, C_{USBOUT} = 2.2μF, V_{USBIN}= 6V, T_A=25°C, unless otherwise specified.) (Note 1)

PARAMETERS	CONDITIONS	MIN.	TYP.	MAX.	UNIT
USB POWER SWITCH					
Supply Current	Control Active High, USB switch output OFF, USBOUT=Open Control Active Low, USB switch output OFF, USBOUT=Open		0.75	5	μA
	Control Active High, USB switch output ON, USBOUT=Open Control Active Low, USB switch output ON, USBOUT=Open		140	190	μA
Control Input Threshold	Control Active High, USB switch output ON Control Active Low, USB switch output OFF	2.4			V
	Control Active High, USB switch output OFF Control Active Low, USB switch output ON			0.8	V
USB Input Voltage	V_{USBIN}	5.3		7	V
Control Input Current	V_{CTL} =V_{USBIN} or GND		0	100	nA
Control Input Capacitance			1		PF
Dropout Voltage	V_{USBOUT} = 5V, I_{USBOUT} = 0.5A		90	190	mV
Dropout Voltage	V_{USBOUT} = 5V, I_{USBOUT} = 1A		280	380	mV
Output Turn-On Rise Delay	R_L = 10Ω		2.2	3.2	mS
Output Turn-On Rise Time	R_L = 10Ω	2	3.8	7	mS
Output Turn-Off Delay	R_L = 10Ω		0.8	20	μS
Output Turn-Off Fall Time	R_L = 10Ω		0.7	20	μS
Output Leakage Current				10	μA
Current Limit Threshold	ISET > 2.4V	0.5	0.62	0.75	A
Current Limit Threshold	ISET < 0.8V	1.0	1.25	1.5	A
Over Current Flag Response Delay	Apply V_{OUT} = 0V until FLG low	3	8	12	mS
Error Flag Output Resistance	V_{USBIN} = 6V, I_L =10 mA		10	25	Ω
Error Flag Off Current	V_{FLG} = 5V		0.01	1	μA

Undervoltage Lockout Threshold	V_{USBIN} rising	2.2	2.6	3	V
Undervoltage Lockout Hysteresis			200		mV
Thermal Protection					
Thermal Shutdown Temperature (Note 2)			135		℃

Note 1: 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).

The AIC6166 requires minimum C_{USBIN} = 0.8μF and C_{USBOUT} = 1μF to maintain stability. For best performance, typically use C_{USBIN} = 1μF, C_{USBOUT} = 2.2μF (ceramic) + 22μF (aluminum).

Note 2: When thermal shutdown, the IC performs the function of latching in OFF state. It can resume operation by turning off once (min. 1uS) and then turn on using the CTL pin (with Typ. 25℃ Thermal Shutdown Hysteresis), or by restoring power to the USBIN pin.

TYPICAL PERFORMANCE CHARACTERISTICS

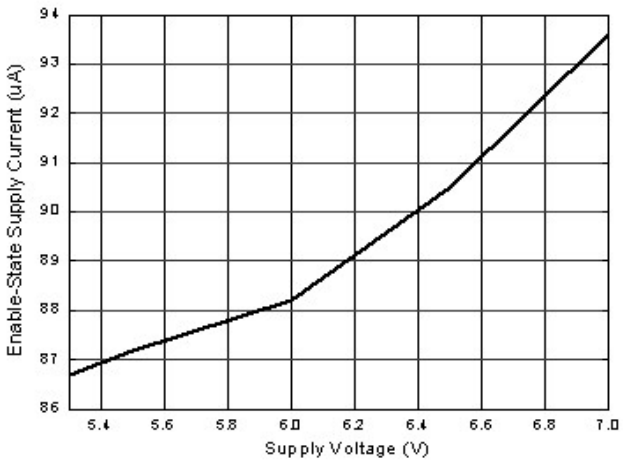


Fig. 1 Quiescent Current VS Input Voltage

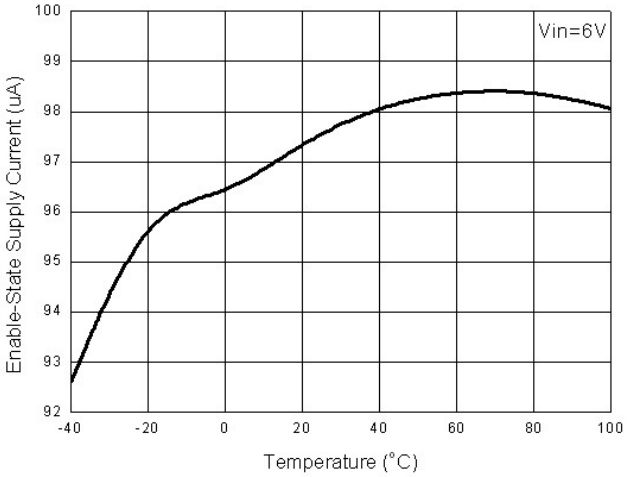


Fig. 2 Quiescent Current VS Temperature

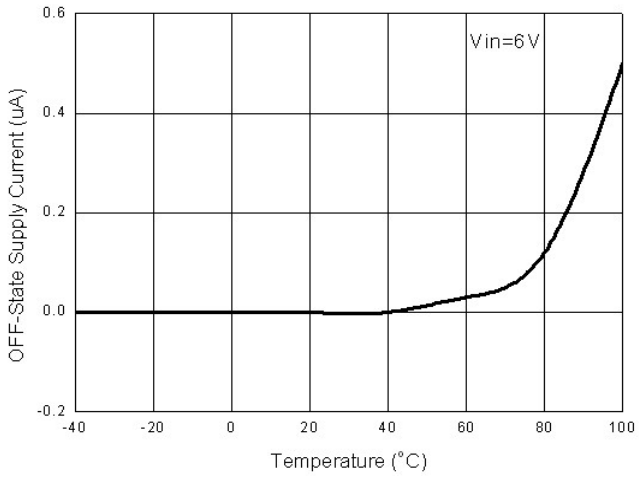


Fig. 3 Shut-down Current VS Temperature

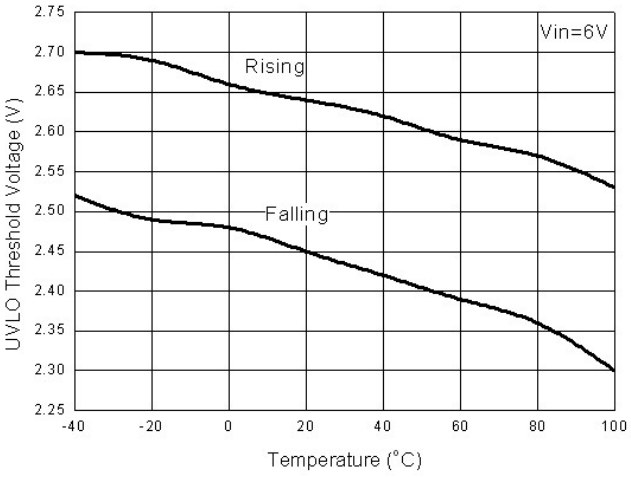


Fig. 4 UVLO Threshold Voltage VS Temperature

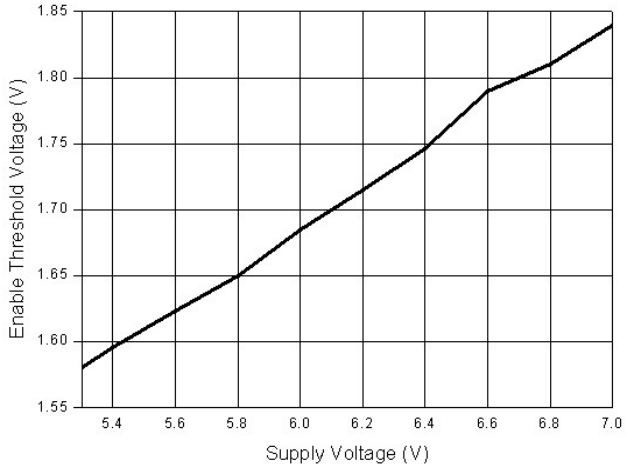


Fig. 5 Enable Threshold Voltage VS Input Voltage

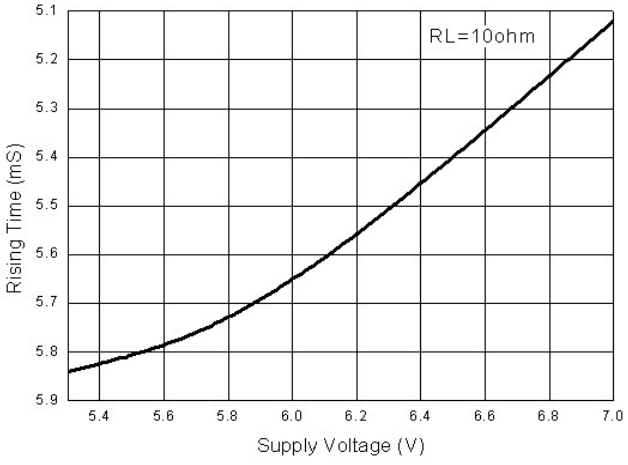


Fig. 6 Rising Time VS Input Voltage

TYPICAL PERFORMANCE CHARACTERISTICS

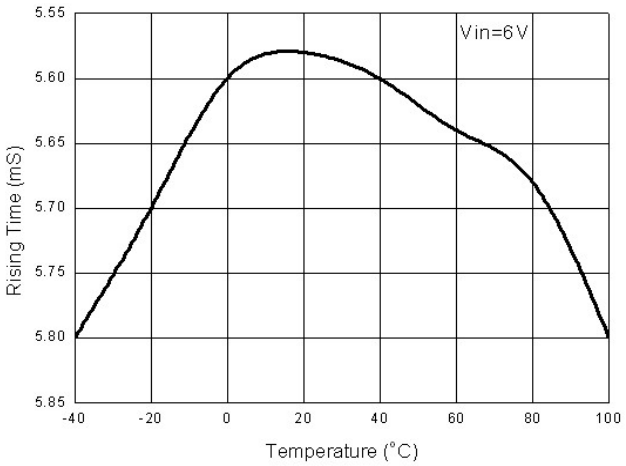


Fig. 7 Rising Time VS Temperature

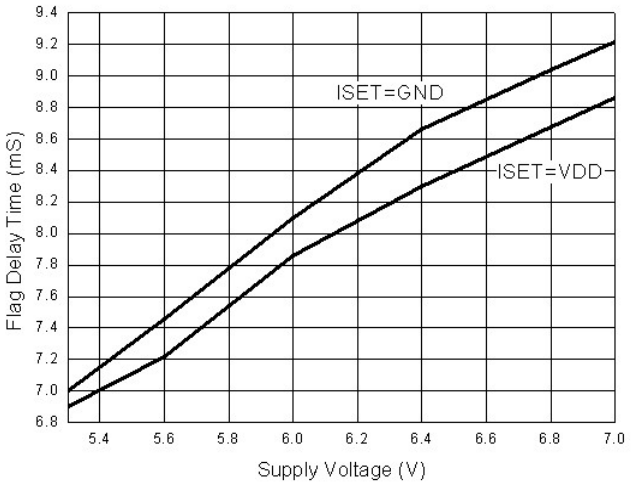


Fig. 8 Flag Delay Time VS Input Voltage

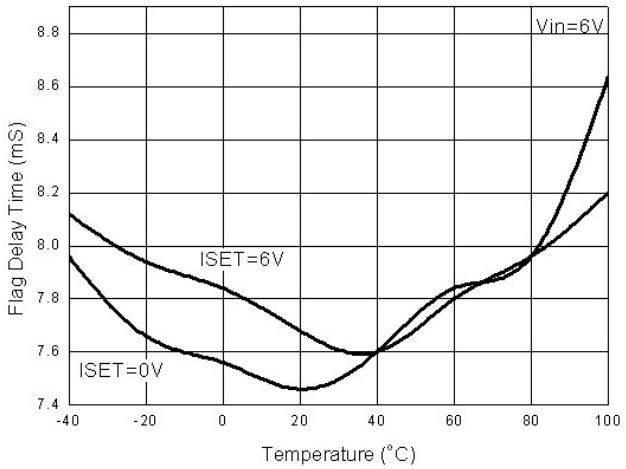


Fig. 9 Flag Delay Time VS Temperature

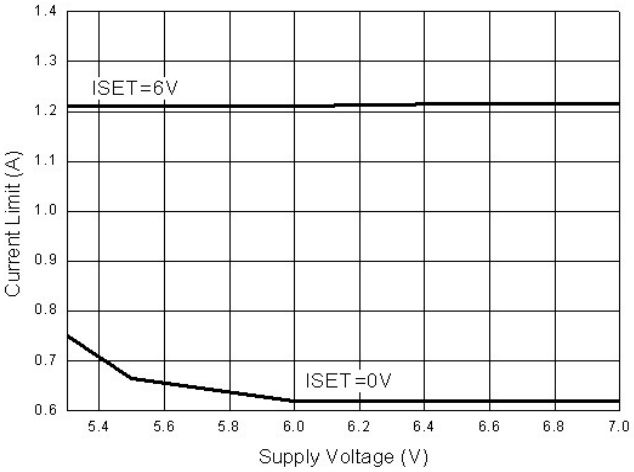


Fig. 10 Current Limit VS Input Voltage

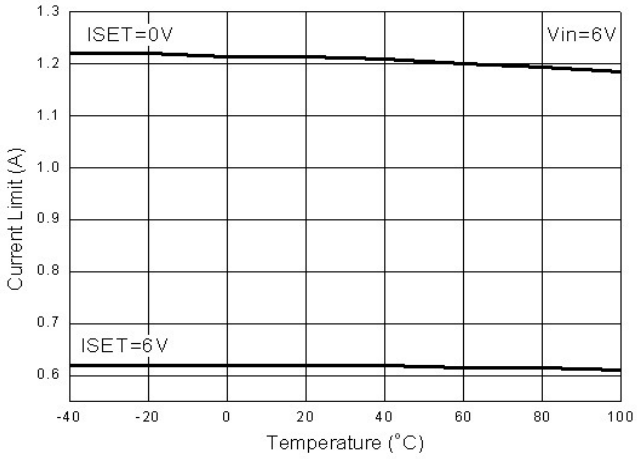


Fig. 11 Current Limit VS Temperature

TYPICAL PERFORMANCE CHARACTERISTICS

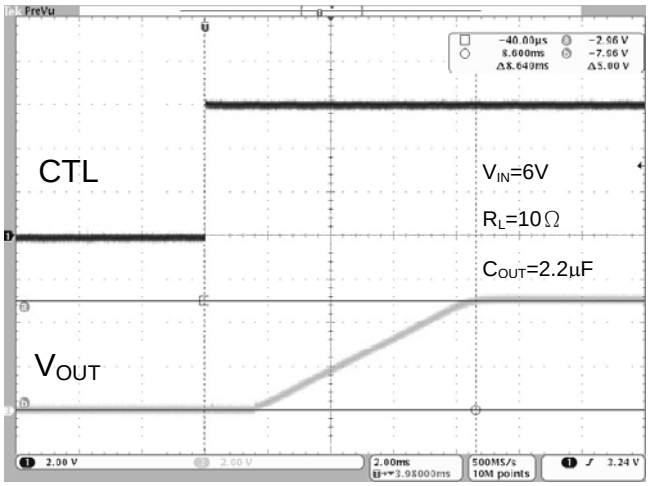


Fig. 12 Turn-On Time

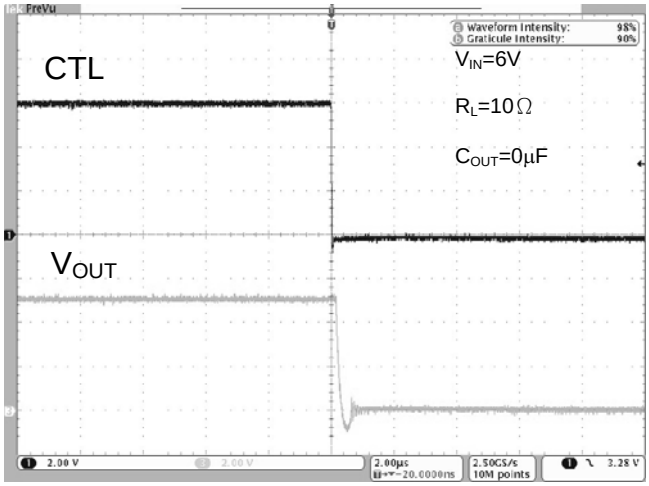


Fig. 13 Turn-Off Time

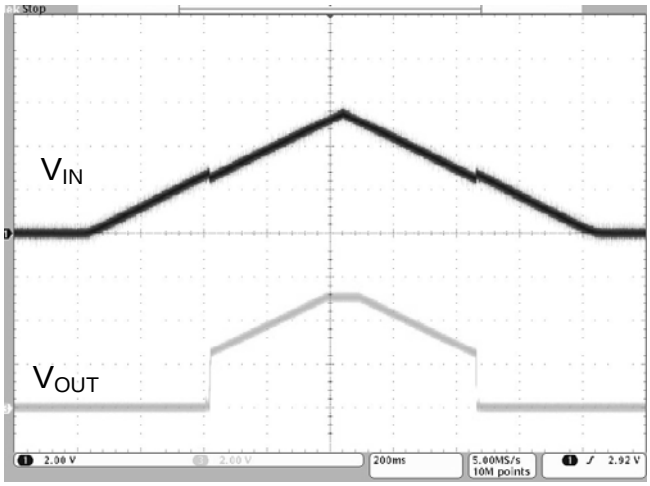


Fig. 14 UVLO Protection

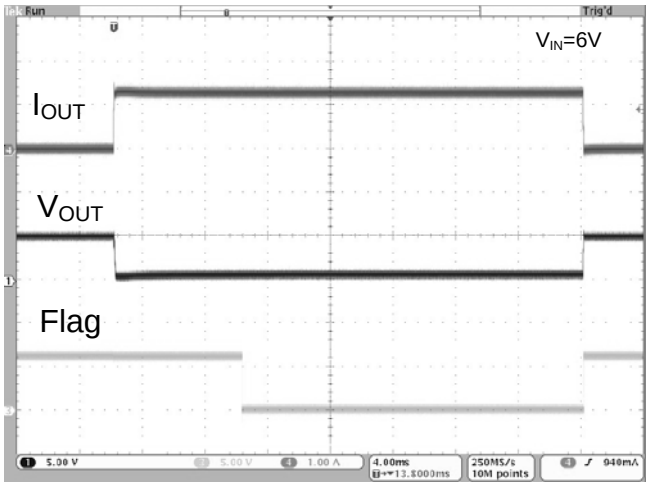


Fig. 15 Current Limit Event (Iset=GND)

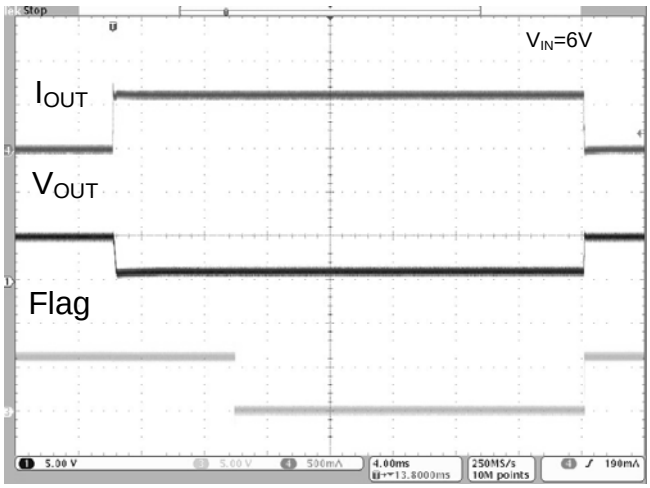


Fig. 16 Current Limit Event (Iset=Vin)

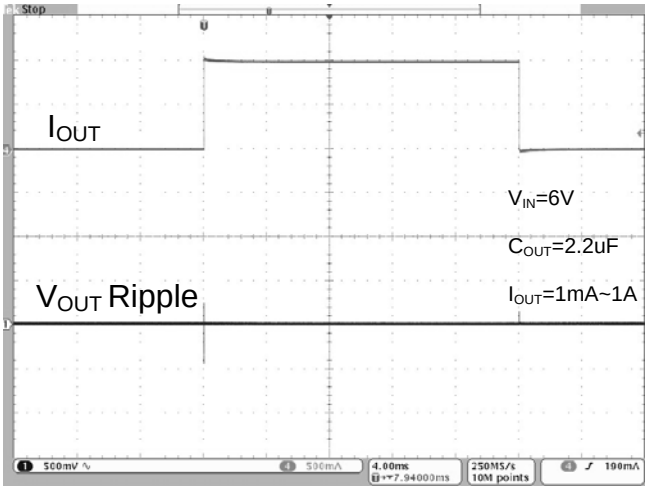
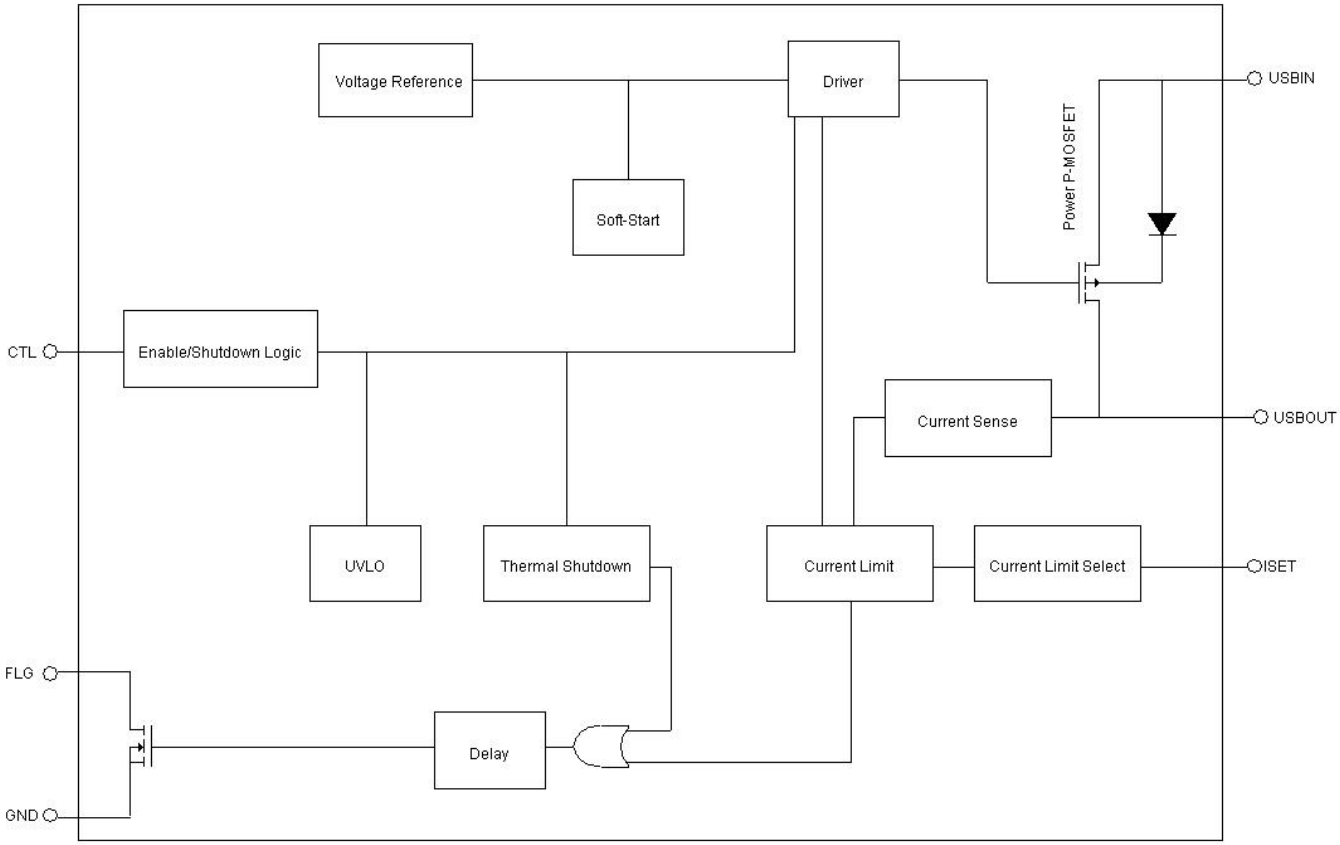


Fig. 17 Load Transition

BLOCK DIAGRAM



PIN DESCRIPTIONS

PIN 1: CTL - Controls the turn-on/turn-off of USB power switch with TTL as a control input. Active high for AIC6166-1 and active low for AIC6166-0.

PIN 2: FLG - An active-low and open-drained fault flag output. FLG is an indicator for current limit when CTL is active. In normal mode operation (CTL is active), it also can indicate thermal shutdown.

PIN 3: USBIN - USB power supply input pin.

PIN 4: USBIN - USB power supply input pin.

PIN 5: USBOUT - USB switch output.

PIN 6: USBOUT - USB switch output.

PIN 7: ISET - Current limit setting pin. Connect to GND for 1.25A current limit. Connect to USBIN for 0.62A current limit

PIN 8: GND - Chip power ground.

APPLICATION INFORMATION

- **Error Flag**

An error Flag is an open-drained output of an N-channel MOSFET. FLG output is pulled low to signal the following fault conditions: output current limit and thermal shutdown. The Fault Flag response delay time is 8ms.

- **Current Limit**

The current limit threshold is preset internally. 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.

- **Thermal Shutdown**

When temperature of AIC6166 exceeds 150°C for any reasons, the thermal shutdown function turns the MOSFET switch off and signals the error flag. When thermal shutdown, the IC performs the function of latching in OFF state. It can resume operation by turning off once (min. 1μS) and then turn on using the CTL pin, or by restoring power to the USBIN pin.

- **Supply Filtering**

A 1μF bypass capacitor from USBIN 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.

- **Output Capacitance**

Linear regulators require output capacitors to maintain stability and transient response. A 2.2μF output capacitor can satisfy most AIC6166 applications. For getting better load transient, a 4.7μF output capacitor is recommended.

- **Dropout Voltage**

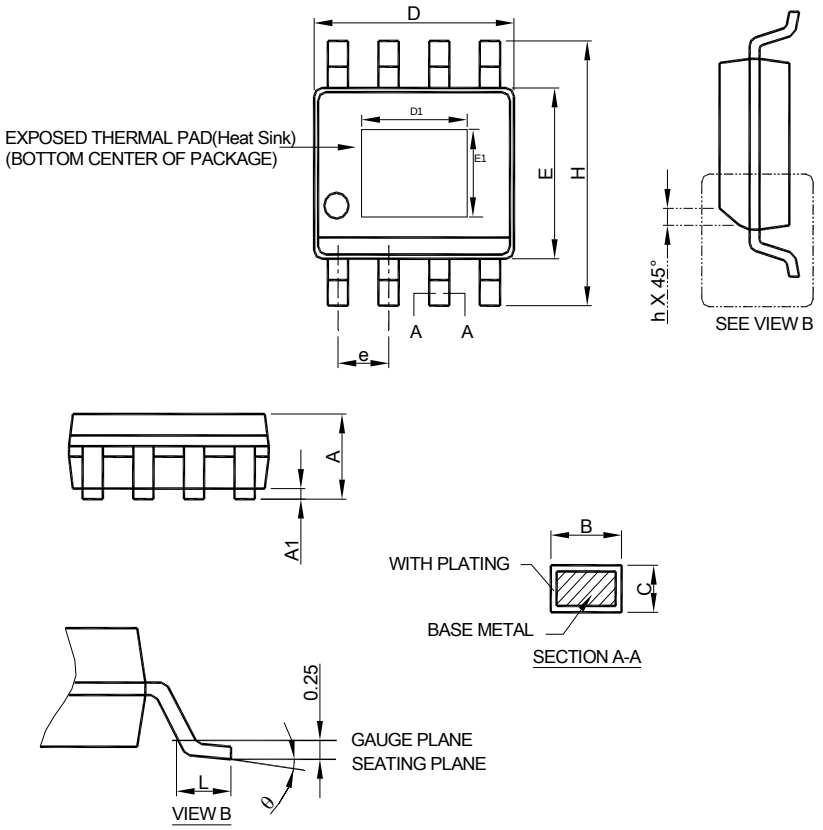
The dropout voltage is defined as the difference between input voltage and output voltage at which the output voltage drops 100mV. Below this value, the output voltage will fall while the input voltage reduces. It depends on the load current and junction temperature.

- **Printed Circuit Layout**

The power circuitry of USB printed circuit boards requires a customized layout to maximize thermal dissipation and to minimize voltage drop and EMI.

PHYSICAL DIMENSIONS (unit: mm)

- **SOP-8 Exposed Pad (Heat Sink)**



SYMBOL	SOP-8 Exposed Pad(Heat Sink)	
	MILLIMETERS	
	MIN.	MAX.
A	1.35	1.75
A1	0.00	0.15
B	0.31	0.51
C	0.17	0.25
D	4.80	5.00
E	3.80	4.00
e	1.27 BSC	
H	5.80	6.20
h	0.25	0.50
L	0.40	1.27
q	0°	8°
D1	1.5	3.5
E1	1.0	2.55

Note : 1. Refer to JEDEC MS-012E.
2. Dimension "D" does not include mold flash, protrusions or gate burrs. Mold flash, protrusion or gate burrs shall not exceed 6 mil per side .
3. Dimension "E" does not include inter-lead flash or protrusions.
4. Controlling dimension is millimeter, converted inch dimensions are not necessarily exact.

Note: