80mΩ, ADJ Fast Response Current Limited Load Switch

FEATURES

- Compliant to USB Specifications
- Integrated 80mΩ Power MOSFET
- Low Supply Current
- 15uA Typical at Switch On State
- 1uA Typical at Switch Off State
- Wide Input Voltage Range:2.4V to 5.5V
- Fast Transient Response:2us
- Thermal Shutdown Protection
- Hot Plug-In Application (Soft-Start)
- Available in a 5-Pin SOT23-5 Package
- 2kV ESD Rating

APPLICATIONS

- USB Bus/Self Powered Hubs
- Battery-Charger Circuits
- Personal Communication Devices
- Notebook Computers

GENERAL DESCRIPTION

The STI9712 is a cost-effective, low voltage, single P-MOSFET load switch, optimized for self-powered and bus-powered Universal Serial Bus (USB) applications. This switch operates with inputs ranging from 2.4V to 5.5V, making it ideal for both 3V and 5V systems. The switch's low RDS(ON), 80mΩ, meets USB voltage drop requirements. The STI9712 is also protected from thermal overload which limits power dissipation and junction temperatures. Current limit threshold is programmed with a resistor from SET to ground. The quiescent supply current is typically 15uA at switch on state.
The STI9712 is available in SOT23-5 package and is specified over the -40ºC to +85 ºC temperature range

TYPICAL APPILCATION

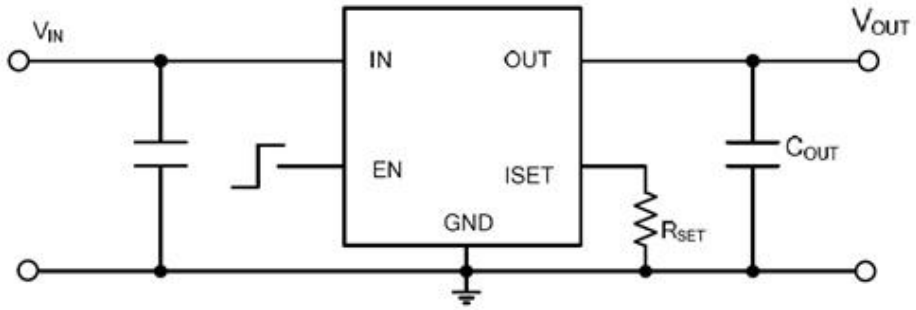
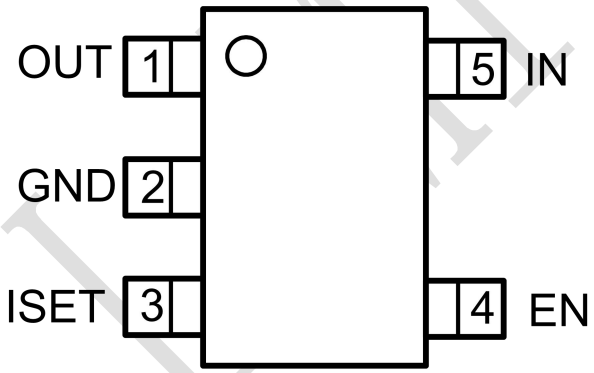


Figure 1. Basic Application Circuit

ABSOLUTE MAXIMUM RATINGS (Note 1)

Parameter	Value	Unit
Input Supply Voltage	-0.3~7	V
EN Voltages	-0.3 ~(Vin+0.30)	V
VSET/VOUT Voltage	-0.3 ~(Vin+0.30)	V
Storage Temperature Range	-65~150	°C
Junction Temperature(Note2)	160	°C
Lead Temperature(Soldering,10s)	260	°C

PACKAGE/ORDER INFORMATION



SOT23-5

Top Mark: S92XXX (S92: Device Code, XXX: Inside Code)

Part Number	Package	Top mark	Quantity/ Reel
STI9712	SOT23-5	S92XXX	3000

PIN FUNCTIONS

Pin	Name	Function
1	OUT	Current limiting load switch output (high side P-channel MOSFET Drain). Connect a 10µF capacitor from OUT to GND for best load transient response.
2	GND	IC ground connection
3	ISET	Current limit set pin. Connect a resistor between this pin and ground to program the desired current limit set point.
4	EN	Load switch enable input. Active high and active low options are available
5	IN	Load switch power supply input pin (high side P-channel MOSFET source). Bypass with a 10µF capacitor from IN to GND.

ESD RATING

Items	Description	Value	Unit
V_{ESD}	Human Body Model for all pins	±2000	V

JEDEC specification JS-001

RECOMMENDED OPERATING CONDITIONS

Items	Description	Min	Max	Unit
Voltage Range	IN	2.4	5.5	V
TA	Operating Temperature Range	-40	85	°C

ELECTRICAL CHARACTERISTICS (Note 3)

(V_{IN}=5V , T_A = -40°C to 80°C, unless otherwise noted. Typical values are at T_A=25°C)

Parameter		Symbol	Conditions	Min	Typ	Max	Unit
Input Voltage Range		Vin		2.4		5.5	V
Switch On Resistance		$R_{DS(ON)}$	Vin=5V		80		mΩ
			Vin=3V		90		mΩ
Operation Quiescent Current		I_Q	Vin=5V,EN=Active, No load		15	40	μA
Off Supply Current		$I_{Q(OFF)}$	Vin=5.5V,EN=Inactive		1		μA
Off Switch Current		$I_{Q(SW\_OFF)}$	Vin=5.5V,EN=Inactive		1		μA
Under-voltage Lockout		V_{UVLO}	Vin Increasing		1.8	2.4	V
Under-voltage Lockout Hysteresis		ΔV_{UVLO}	Vin decreasing		0.1		V
On-resistance Temperature Coefficient		TC			2800		ppm/℃
Current Limit		I_{LIM}	R_{SET}=6.8k	0.75	1	1.25	A
EN Threshold	Logic-Low Voltage	V_{IL}	Vin=2.5V to 5.5V			0.8	V
	Logic-High Voltage	V_{IH}	Vin=2.5V to 5.5V	2			V
Output Leakage Current		I_{LEAK}	EN=Inactive, R_{LOAD}=0Ω		0.5	10	μA
Current Limit Response Time		T_{RESP}	Vin=5V		1		μs
Thermal Shutdown Protection		T_{SD}			140		℃
Thermal Shutdown Hysteresis		ΔT_{SD}			20		℃

Note 1: Absolute Maximum Ratings are those values beyond which the life of a device may be impaired.

Note 2: T_J is calculated from the ambient temperature T_A and power dissipation P_D according to the following formula: $T_J = T_A + (P_D) \times (250°C/W)$.

Note 3: 100% production test at +25°C. Specifications over the temperature range are guaranteed by design and characterization.

Note 4: Dynamic supply current is higher due to the gate charge being delivered at the switching frequency

OPERATION

The STI9712 is a single channel current limiting load switch that is intended to protect against short circuit and over current events by current limiting to a preset level. This device is optimized for self-powered and bus-powered Universal Serial Bus (USB) applications. The switch's low $R_{DS(ON)}$, 80mΩ, meets USB voltage drop requirements; and a flag output is available to indicate fault conditions to the local USB controller.

APPLICATION INFORMATION

Input and Output

VIN (input) is the power source connection to the internal circuitry and the source of the MOSFET. VOUT (output) is the drain of the MOSFET. In a typical application, current flows through the switch from VIN to VOUT toward the load. There is no parasitic body diode between drain and source of the MOSFET in STI9712. If VOUT is greater than VIN, the body voltage of the MOSFET is change from VIN voltage to VOUT voltage.

Soft Start for Hot Plug-In Applications

In order to eliminate the upstream voltage droop caused by the large inrush current during hot-plug events, the “soft-start” feature effectively isolates the power source from extremely large capacitive loads, satisfying the USB voltage droop requirements.

Input Capacitor Selection

The input capacitor CIN protects the power supply from current transients generated by the load attached to the STI9712. When a short circuit is suddenly applied to the output of the STI9712, a large current, limited only by the RDS(ON) of the MOSFET, will flow for less than 2µs before the current limit circuitry activates. In this event, a moderately sized CIN will dramatically reduce the voltage transient seen by the power supply and by other circuitry upstream from the STI9712. The extremely fast short-circuit response time of the STI9712 reduces the size requirement for CIN. CIN should be located as close to the device VIN pin as practically possible. Ceramic, tantalum, or aluminum electrolytic capacitors are appropriate for CIN. There is no specific capacitor ESR requirement for CIN. However, for higher current operation, ceramic capacitors are recommended for CIN 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 Selection

A low-ESR 150µF aluminum electrolytic or tantalum between VOUT and GND is strongly recommended to meet the 330mV maximum droop requirement in the hub VBUS (Per USB 2.0, output ports must have a minimum 120µF of low-ESR bulk capacitance per hub). Standard bypass methods should be used to minimize inductance and resistance between the bypass capacitor and the downstream connector to reduce EMI and decouple voltage droop caused when downstream cables are hot-insertion transients. Ferrite beads in series

with VBUS, the ground line and the 0.1μF bypass capacitors at the power connector pins are recommended for EMI and ESD protection. The bypass capacitor itself should have a low dissipation factor to allow decoupling at higher frequencies.

Current Limit Threshold Set

Current limit threshold is programmed with a resistor from SET to ground marked as RSET. It can be estimated by the following equation:

$$I_{SET} = 6.8 / R_{SET}$$

Such as the following table

I_{SET}	R_{SET}
600mA	11.3K
800mA	8.45K
1000mA	6.8K
1500mA	4.53K
2000mA	3.4K

Thermal Considerations

Since the STI9712 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. Power dissipation can be calculated based on the output current and the RDS(ON) of switch as below.

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

Although the devices are rated for 1.5A of output current, but the application may limit the amount of output current based on the total power dissipation and the ambient temperature. The final operating junction temperature for any set of conditions can be estimated by the following thermal equation:

$$P_{D(MAX)} = (T_{J(MAX)} - T_A) / \theta_{JA}$$

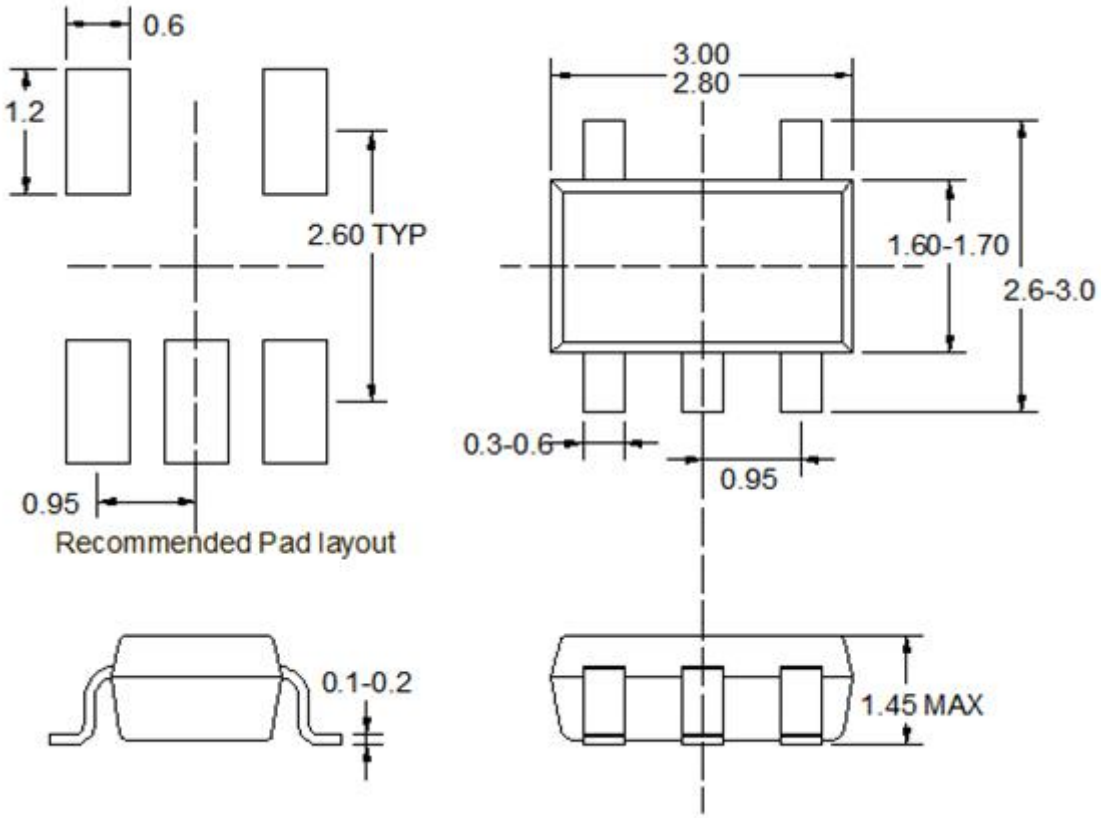
Where $T_{J(MAX)}$ is the maximum operation junction temperature 125℃, TA is the ambient temperature and the θ_{JA} is the junction to ambient thermal resistance. The junction to ambient thermal resistance θ_{JA} is layout dependent. For SOT-23-5 and TSOT-23-5 packages, the thermal resistance θ_{JA} is 250°C/W .The maximum power dissipation at TA = 25℃ is 0.4W for SOT-23-5 and TSOT-23-5 Packages.

Layout Consideration

For best performance of the STI9712, the following guidelines must be strictly followed.

- Keep all VBUS traces as short and wide as possible and at least 2 ounce copper for all VBUS traces.
- Place a ground plane under all circuitry to lower both resistance and inductance and improve DC and transient performance.
- Locate the output capacitor as close to the connectors as possible to lower impedance(mainly inductance) between the port and the capacitor and improve transient performance.
- Input and output capacitor should be placed closed to the IC and connected to ground plane to reduce noise coupling.
- Locate the ceramic bypass capacitors as close as possible to the Vin Pins and Vout pins of STI9712.

PACKAGE INFORMATION



SOT23-5

Note:

1) All dimensions are in millimeters.

2) Package length does not include mold flash, protrusion or gate burr.

3) Package width does not include inter lead flash or protrusion.

4) Lead popularity (bottom of leads after forming) shall be 0.10 millimeters max.

5) Pin 1 is lower left pin when reading top mark from left to right.