SGM2560
Dual-Channel
Power Distribution Switch

GENERAL DESCRIPTION

The SGM2560 is a high-side MOSFET switch optimized for general-purpose power distribution requiring circuit protection. A built-in charge pump is used to drive the MOSFET that is free of parasitic body diode to eliminate any reversed current flow across the switch.

The SGM2560 is internally current limited and has thermal shutdown that protects the device and load.

The SGM2560 offers "smart" thermal shutdown that reduces current consumption in fault modes. When a thermal shutdown fault occurs, the output is latched off until the faulty load is removed. Removing the load or toggling the enable input will reset the device output.

This device employs soft-start circuitry that minimizes inrush current in applications where highly capacitive loads are employed.

The $\overline{\text{FAULT}}$ output asserts low during over-current and thermal shutdown conditions. Transient faults are internally filtered.

The SGM2560 is available in Green SOIC-8 and TDFN-3×3-8L packages. It is rated over the -40℃ to +85℃ temperature range.

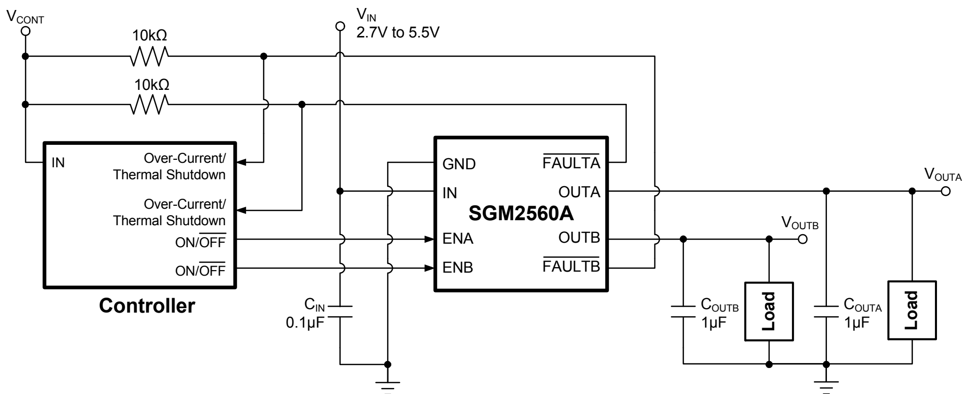
FEATURES

- **90mΩ (TYP) High-side MOSFET per Channel**
- **1.1A Current Limit**
- **Input Voltage Range: 2.7V to 5.5V**
- **Low Quiescent Current: 28μA (Dual-Channel)**
- **Soft-Start Function**
- **Short-Circuit Protection with Thermal Shutdown**
- **Thermally Isolated Channels**
- **Fault Status Flag with 4ms Filter Eliminates False Assertions**
- **Under-Voltage Lockout Protection for V_{IN}**
- **No Reversed Leakage Current**
- **1.8V Logic-Compatible Inputs**
- **Available in the Green SOIC-8 and TDFN-3×3-8L Packages**

APPLICATIONS

USB Peripherals
General Purpose Power Switching
ACPI Power Distribution
Notebook PCs
PDAs
PC Card Hot Swap

TYPICAL APPLICATION



PACKAGE/ORDERING INFORMATION

MODEL	PIN-PACKAGE	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKAGE OPTION
SGM2560A (Active High)	SOIC-8	-40℃ to +85℃	SGM2560AYS8G/TR	SGM 2560AYS8 XXXXX	Tape and Reel, 2500
	TDFN-3×3-8L	-40℃ to +85℃	SGM2560AYTDB8G/TR	SGM 2560ADB XXXXX	Tape and Reel, 4000
SGM2560B (Active Low)	SOIC-8	-40℃ to +85℃	SGM2560BYS8G/TR	SGM 2560BYS8 XXXXX	Tape and Reel, 2500
	TDFN-3×3-8L	-40℃ to +85℃	SGM2560BYTDB8G/TR	SGM 2560BDB XXXXX	Tape and Reel, 4000

NOTE: **XXXXX** = Date Code and Vendor Code.

ABSOLUTE MAXIMUM RATINGS

Input Supply Voltage Range.................................... -0.3V to 6V
$\overline{\text{FAULT}}$ Voltage 6V
$\overline{\text{FAULT}}$ Current 25mA
Output Voltage 6V
Output Current ....Internally Limited
Enable Input .... -0.3V to V_{IN}
Junction Temperature……..............................Internally Limited
Operating Temperature Range............................-40℃ to +85℃
Storage Temperature Range..............................-65℃ to +150℃
Package Thermal Resistance
SOIC-8, θ_{JA}……………………………………………160°C/W
TDFN-3×3-8L, θ_{JA}………………………………………65°C/W
Lead Temperature (Soldering, 10s) ....260℃
ESD Susceptibility
HBM..2000V
MM.. 200V

NOTE:
Stresses beyond those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

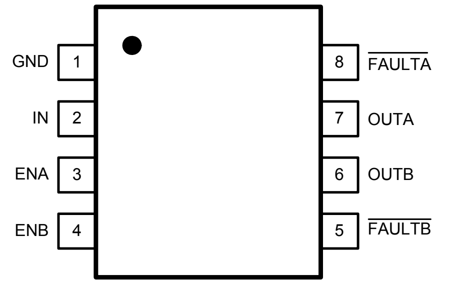
CAUTION

This integrated circuit can be damaged by ESD if you don’t pay attention to ESD protection. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

SGMICRO reserves the right to make any change in circuit design, specification or other related things if necessary without notice at any time. Please contact SGMICRO sales office to get the latest datasheet.

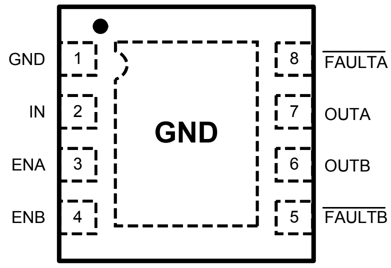
PIN CONFIGURATIONS (TOP VIEW)

SGM2560A



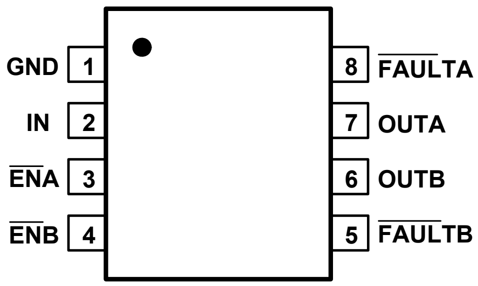
SOIC-8

SGM2560A



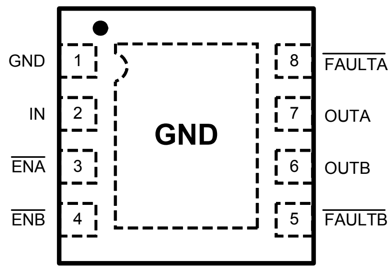
TDFN-3×3-8L

SGM2560B



SOIC-8

SGM2560B

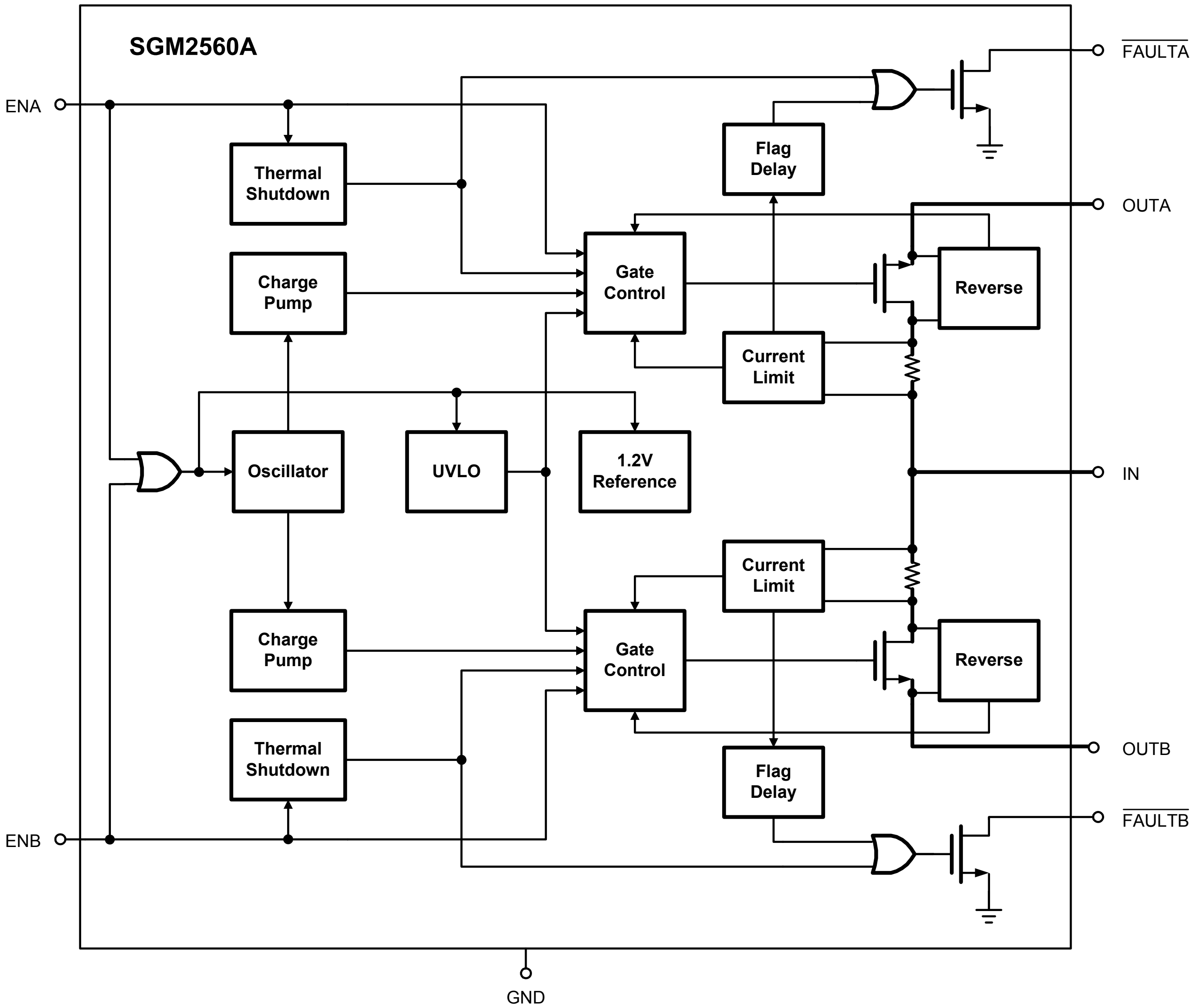


TDFN-3×3-8L

PIN DESCRIPTION

PIN	NAME	FUNCTION
1	GND	Ground.
2	IN	Power Input Voltage.
3	ENA/$\overline{\text{ENA}}$	Channel A Enable. 1.8V logic-compatible enables input. Active HIGH for SGM2560A (ENA) and active LOW for SGM2560B ($\overline{\text{ENA}}$).
4	ENB/$\overline{\text{ENB}}$	Channel B Enable. 1.8V logic-compatible enables input. Active HIGH for SGM2560A (ENB) and active LOW for SGM2560B ($\overline{\text{ENB}}$).
5	$\overline{\text{FAULTB}}$	Fault Flag B. Active LOW, open-drain output. Indicates over-current or thermal shutdown conditions. Over-current conditions must last longer than t_D in order to assert $\overline{\text{FAULTB}}$.
6	OUTB	Channel B Output Voltage.
7	OUTA	Channel A Output Voltage.
8	$\overline{\text{FAULTA}}$	Fault Flag A. Active LOW, open-drain output. Indicates over-current or thermal shutdown conditions. Over-current conditions must last longer than t_D in order to assert $\overline{\text{FAULTA}}$.

FUNCTION BLOCK DIAGRAM

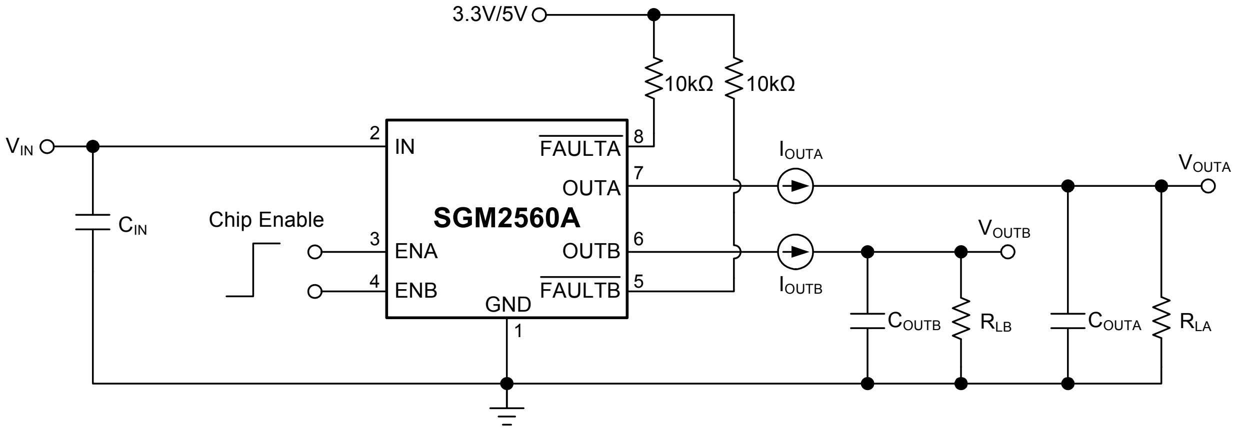


ELECTRICAL CHARACTERISTICS

(V_{IN} = 5V, Full = -40℃ to +85℃. Typical values are at T_A = +25℃, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	TEMP	MIN	TYP	MAX	UNITS
Input Voltage Range	V_{IN}		25℃	2.7		5.5	V
Quiescent Supply Current	I_Q	Switch on, OUT = open	25℃		28	55	μA
Shutdown Supply Current	I_{SD}	Switch off, OUT = open	Full		0.1	1	μA
Output Leakage Current	$I_{LEAKAGE}$	Switch off, V_{OUT} = 0V	25℃		0.1	18	μA
Off Current in Latched Thermal Shutdown		Output current during thermal shutdown state	25℃		30		μA
Enable Input Threshold	V_{IH}		25℃	1.6			V
	V_{IL}					0.6	
Enable Input Current	I_{EN}	V_{ENA} = V_{ENB} = 0V to 5V	Full		0.1	1.6	μA
Switch Resistance	$R_{DS(ON)}$	V_{IN} = 5V, I_{OUT} = 500mA, TDFN-3×3-8L	Full		90	150	mΩ
		V_{IN} = 3.3V, I_{OUT} = 500mA, TDFN-3×3-8L	Full		95	155	
		V_{IN} = 5V, I_{OUT} = 500mA, SOIC-8	Full		100	160	
		V_{IN} = 3.3V, I_{OUT} = 500mA, SOIC-8	Full		105	165	
Output Turn-On Delay Time	t_{ON}	R_L = 10Ω, C_{OUT} = 1μF, Figure 1	Full		1.9	3.9	ms
Output Turn-On Rise Time	t_R	R_L = 10Ω, C_{OUT} = 1μF, Figure 2	Full		1.4	2.7	ms
		R_L = 10Ω, C_{OUT} = 1μF, V_{IN} = 3.3V, Figure 2	25℃		1.5		
Output Turn-Off Delay Time	t_{OFF}	R_L = 10Ω, C_{OUT} = 1μF, Figure 1	Full		45	90	μs
Output Turn-Off Fall Time	t_F	R_L = 10Ω, C_{OUT} = 1μF, Figure 2	Full		25	60	μs
Current Limit Threshold	I_{LIM}	Ramped Load	25℃	0.75	1.10	1.45	A
Short-Circuit Output Current	I_{SHORT}	V_{OUT} = 0V, enabled into short-circuit	25℃	0.6	0.9	1.2	A
Short-Circuit Response Time	t_{SHORT}	V_{OUT} = 0V to I_{OUT} = I_{SHORT}, when output is short-circuited	25℃		16		μs
Over-Current $\overline{FAULT}$ Response Delay Time	t_D	V_{IN} = 5V, apply V_{OUT} = 0V until $\overline{FAULT}$ Low	25℃	1.7	4	6.5	ms
Under-Voltage Lockout Threshold	UVLO	V_{IN} Rising	Full	2.25	2.4	2.55	V
		V_{IN} Falling	Full	2	2.15	2.3	
$\overline{FAULT}$ Output Resistance	$R_{\overline{FAULT}}$	V_{IN} = $V_{\overline{FAULT}}$ = 5V, $I_{\overline{FAULT}\_SINK}$ = 10mA	25℃		15		Ω
		V_{IN} = $V_{\overline{FAULT}}$ = 3.3V, $I_{\overline{FAULT}\_SINK}$ = 10mA	Full		16	35	
$\overline{FAULT}$ Leakage Current	$I_{\overline{FAULT}}$	V_{IN} = $V_{\overline{FAULT}}$ = 5V	Full		0.1	2	μA
Channel Thermal Shutdown in Current Limit		T_J increasing			140		℃
Channel Thermal Shutdown in Current Limit Hysteresis					20		
Both Channels Thermal Shutdown Threshold		T_J increasing, if either channel T_J > 160℃, both channel outputs will be shut off.			160		
Both Channels Thermal Shutdown Hysteresis					15		

TEST CIRCUIT



TIMING DIAGRAMS

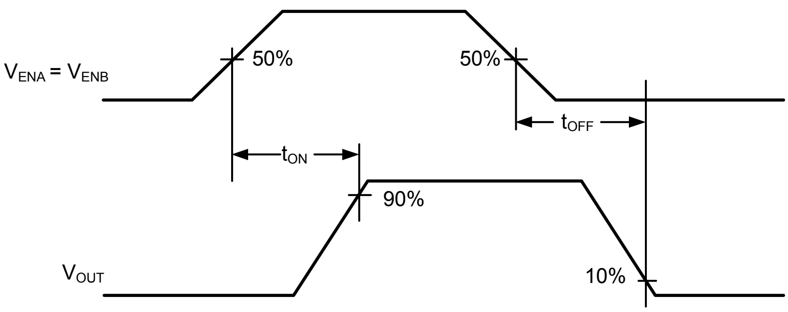


Figure 1. SGM2560A Switch Turn-On and Turn-Off Delay Times

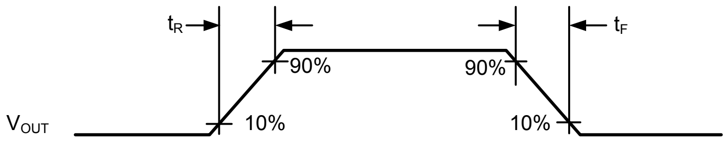
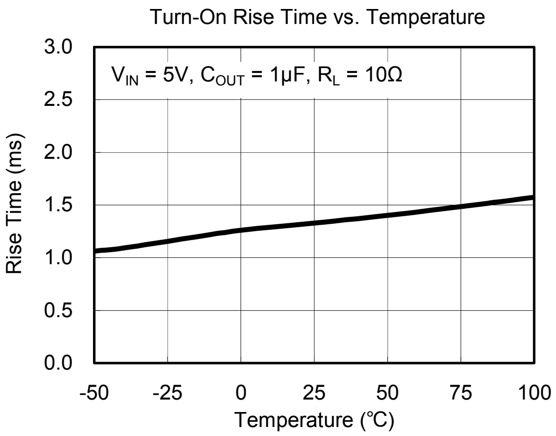
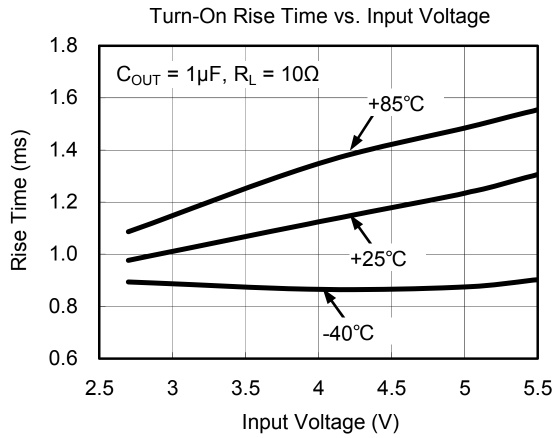


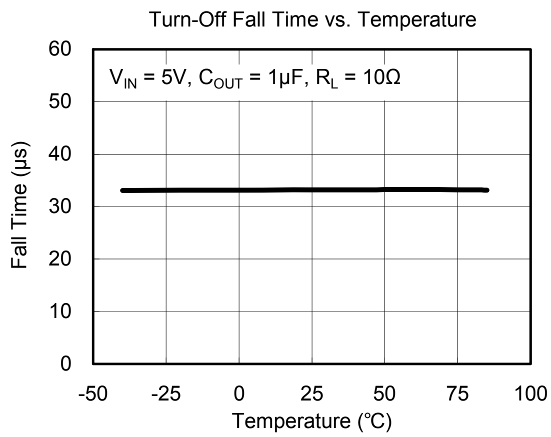
Figure 2. SGM2560A Output Turn-On Rise and Turn-Off Fall Times

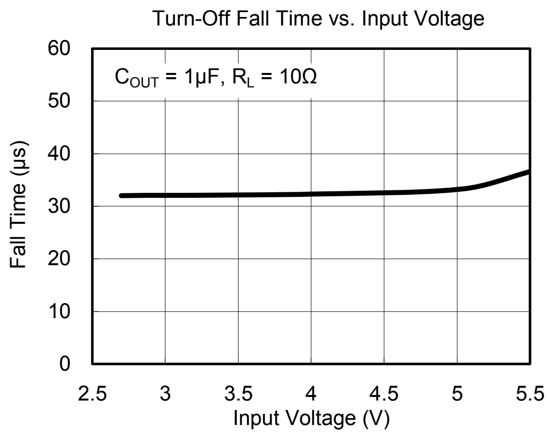
TYPICAL PERFORMANCE CHARACTERISTICS

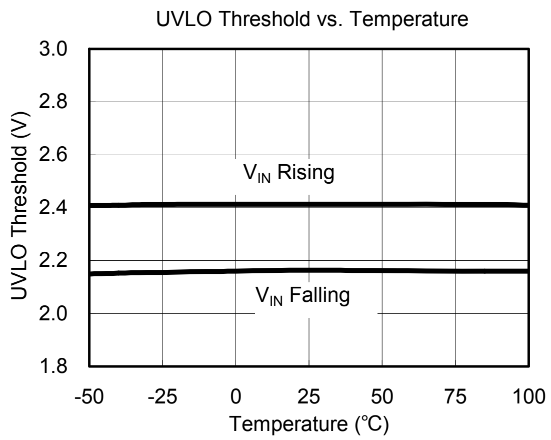
V_{IN} = 5V, T_A = 25℃, unless otherwise noted.

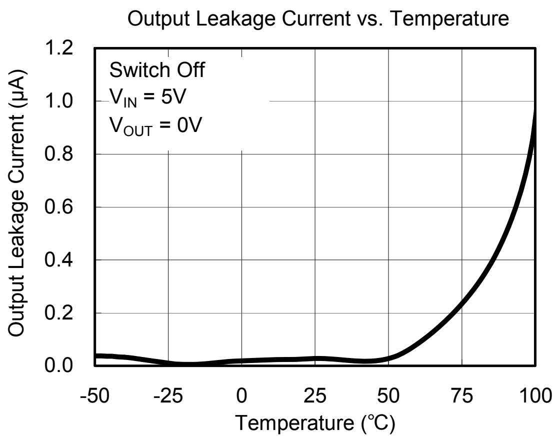






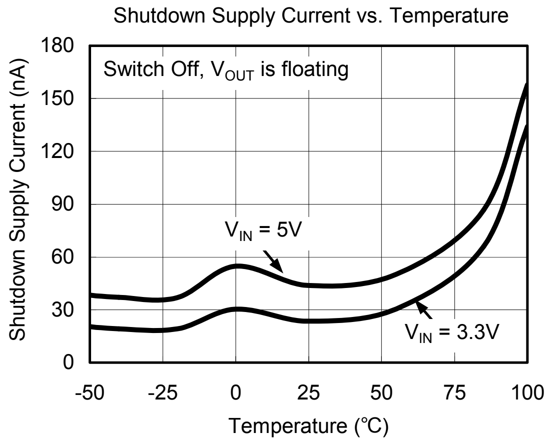


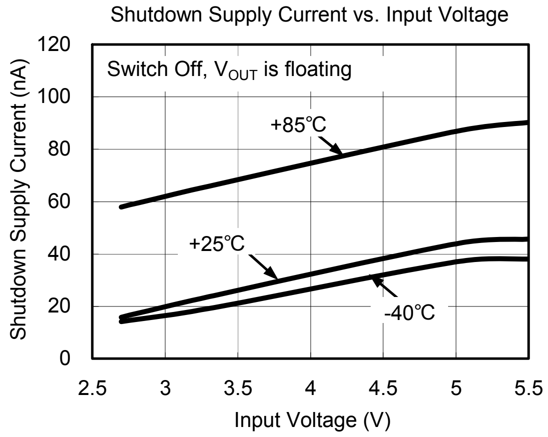


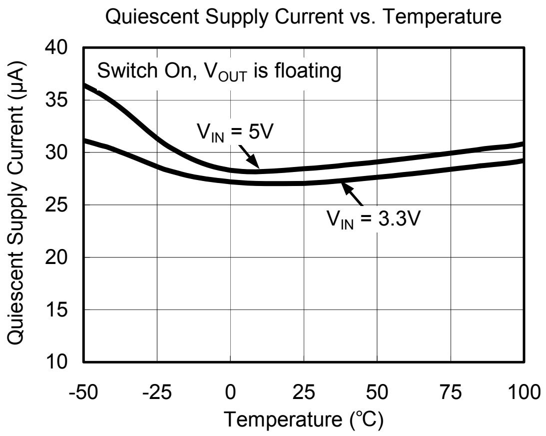


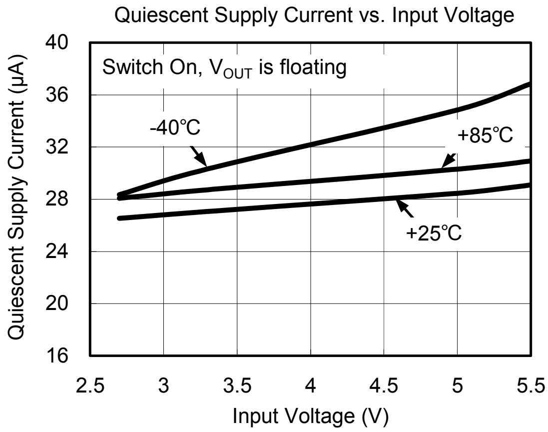
TYPICAL PERFORMANCE CHARACTERISTICS

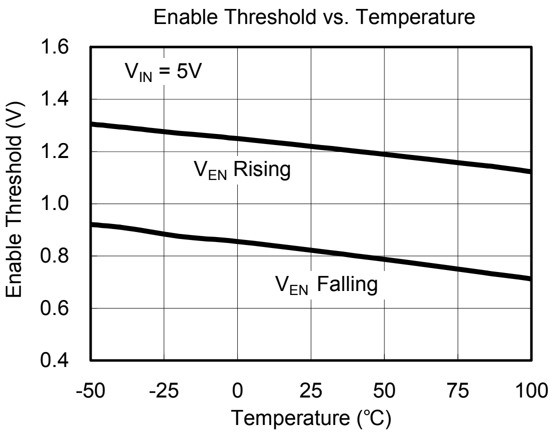
V_{IN} = 5V, T_A = 25℃, unless otherwise noted.

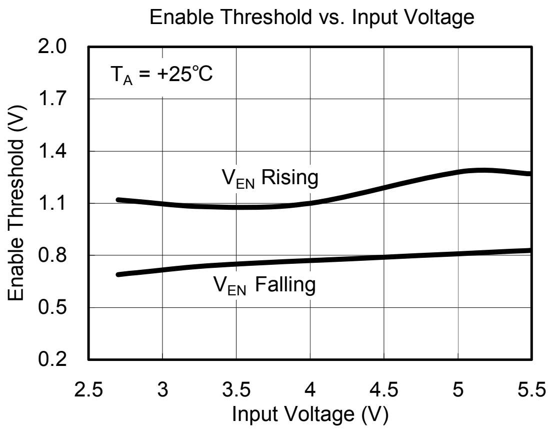






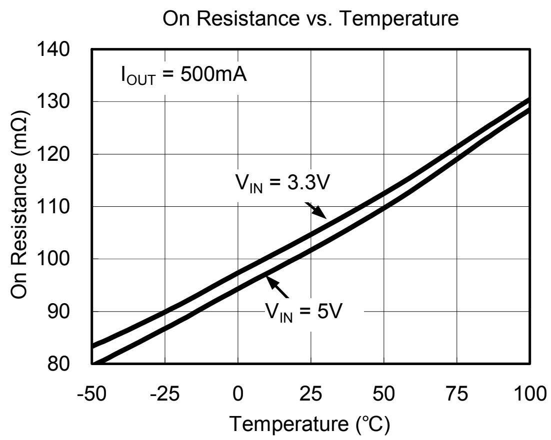


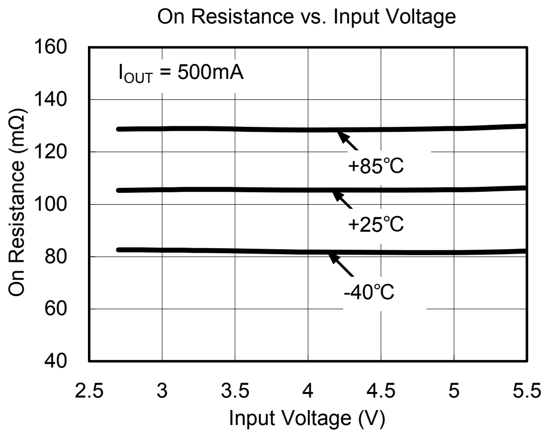


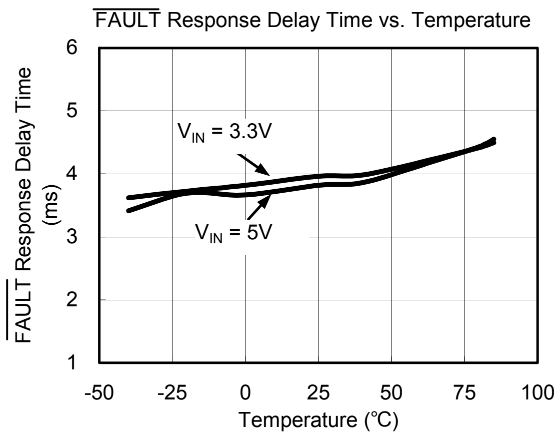


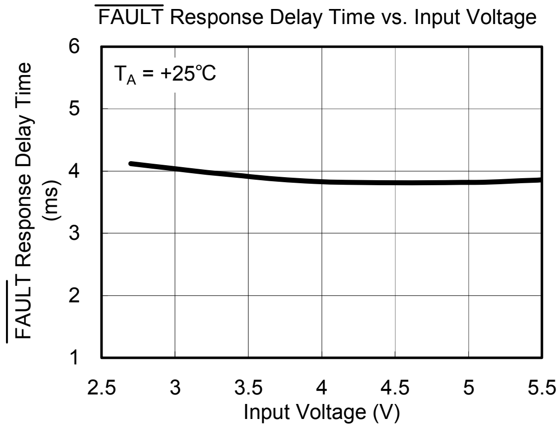
TYPICAL PERFORMANCE CHARACTERISTICS

V_{IN} = 5V, T_A = 25℃, unless otherwise noted.









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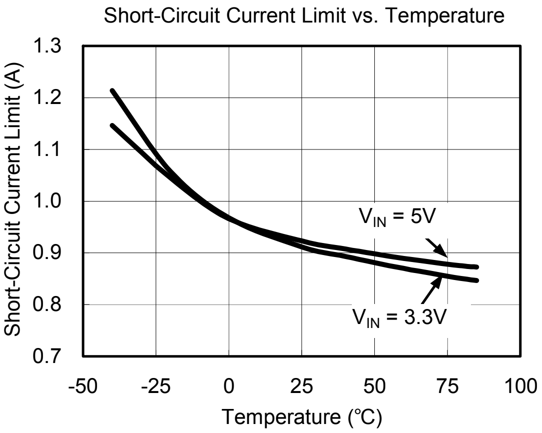
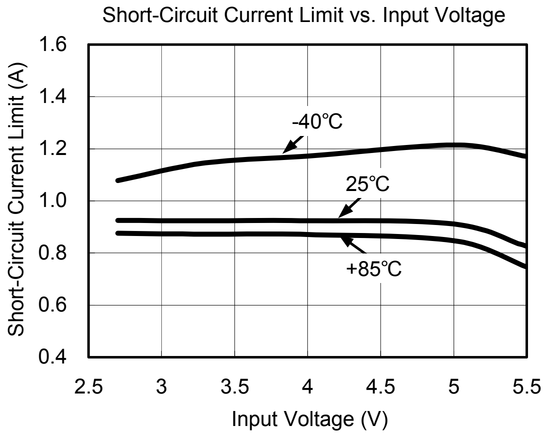
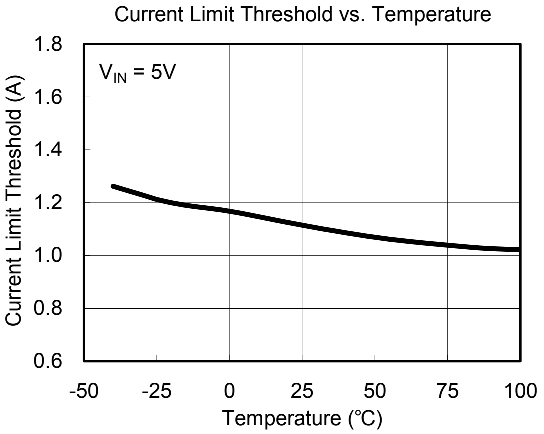
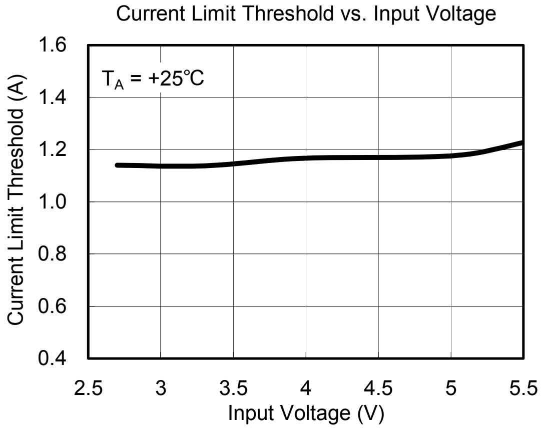
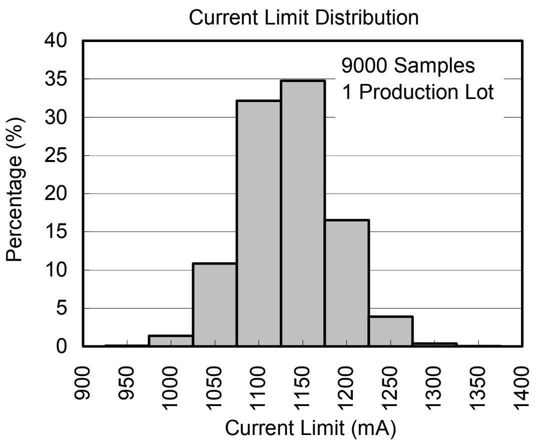
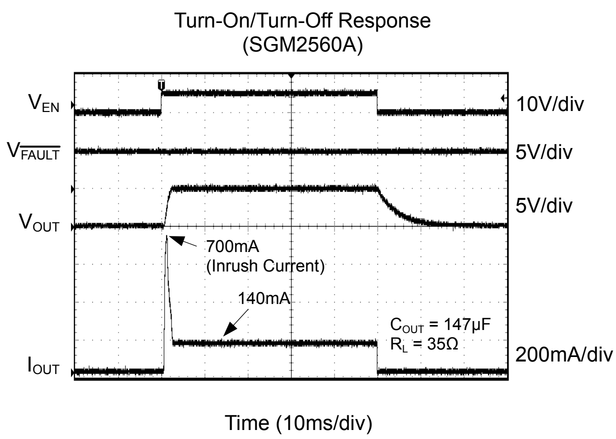








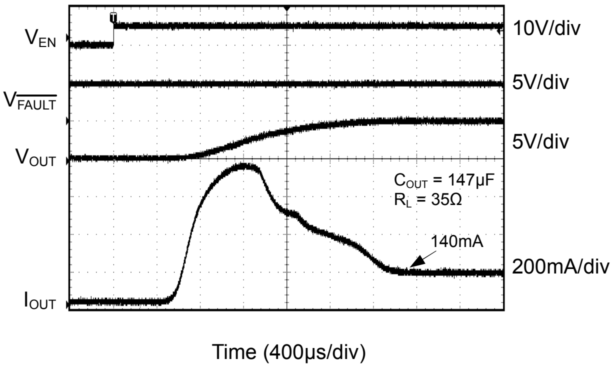




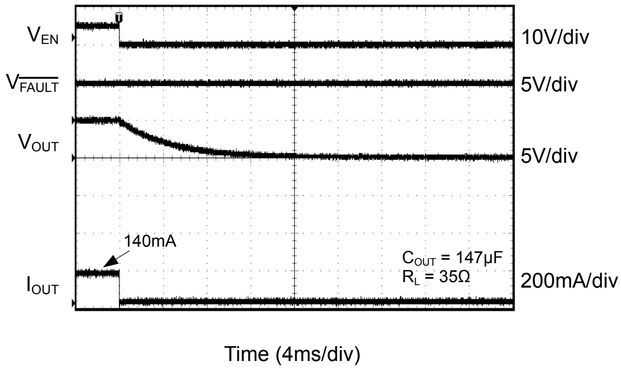
TYPICAL PERFORMANCE CHARACTERISTICS

V_{IN} = 5V, T_A = 25℃, unless otherwise noted.

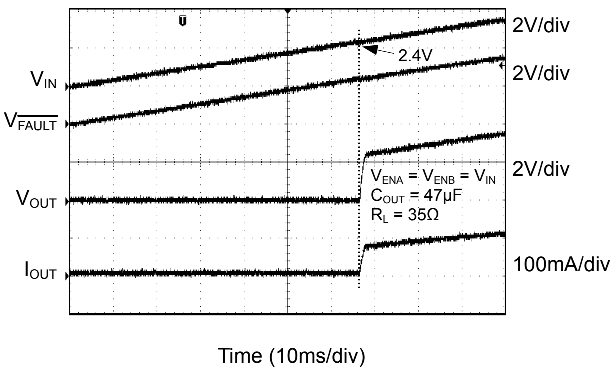
Turn-On Response (SGM2560A)



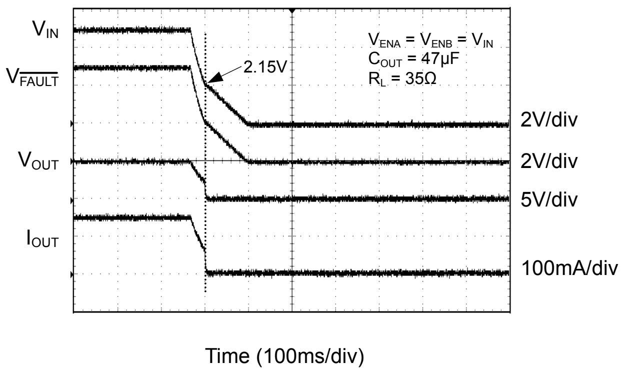
Turn-Off Response (SGM2560A)



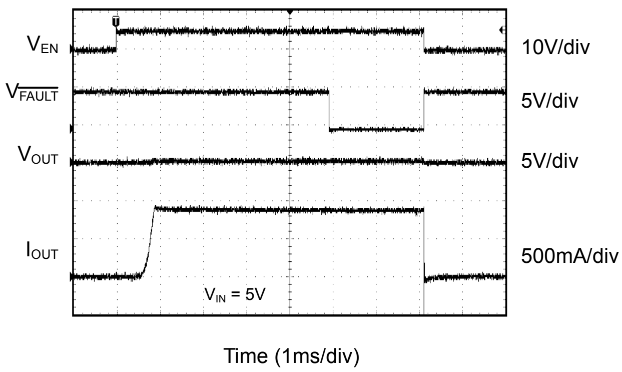
UVLO at V_{IN} Rising (SGM2560A)



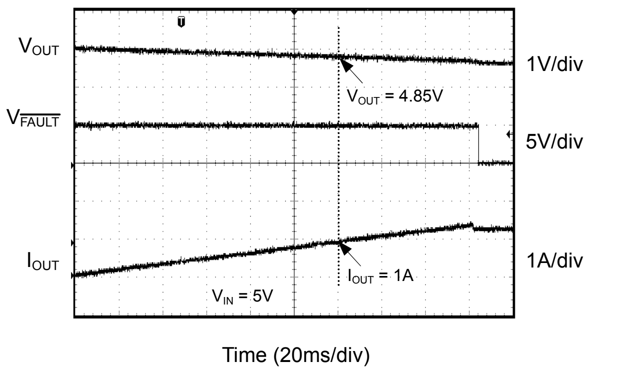
UVLO at V_{IN} Falling (SGM2560A)



Enabled Into Short-Circuit (SGM2560A)



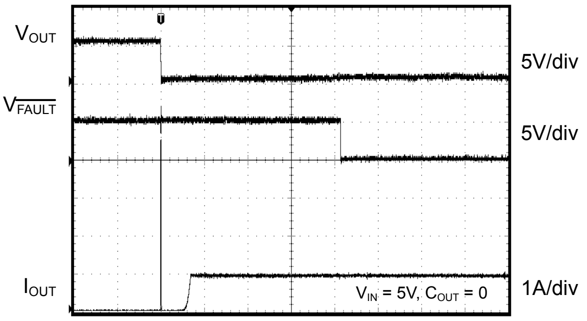
Ramped Load Response



TYPICAL PERFORMANCE CHARACTERISTICS

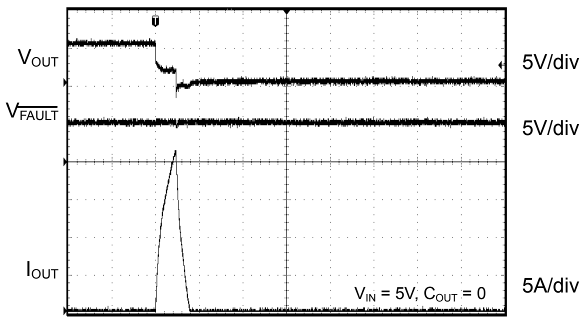
V_{IN} = 5V, T_A = 25℃, unless otherwise noted.

Short-Circuit Response



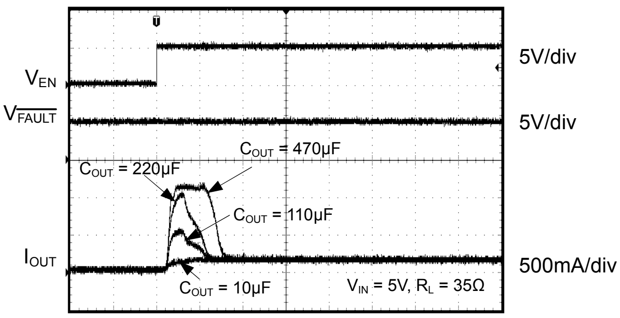
Time (1ms/div)

Short-Circuit Response



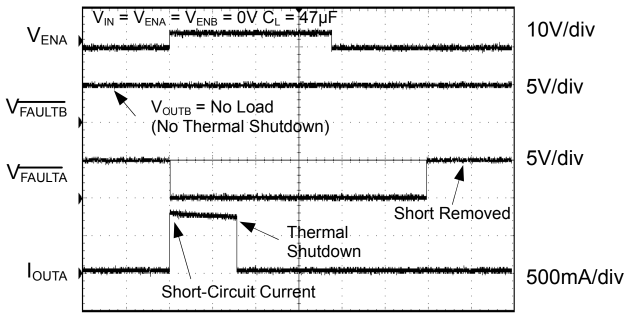
Time (20μs/div)

Inrush Current Response (SGM2560A)



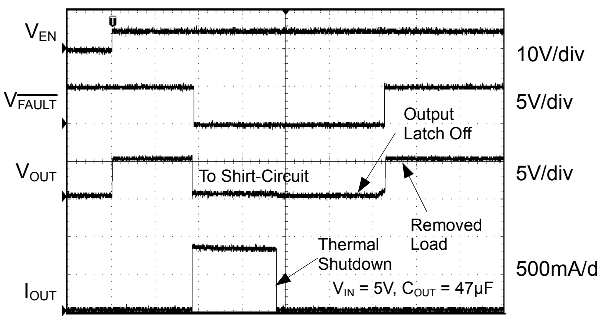
Time (2ms/div)

Independent Thermal Shutdown (SGM2560A Channel A)



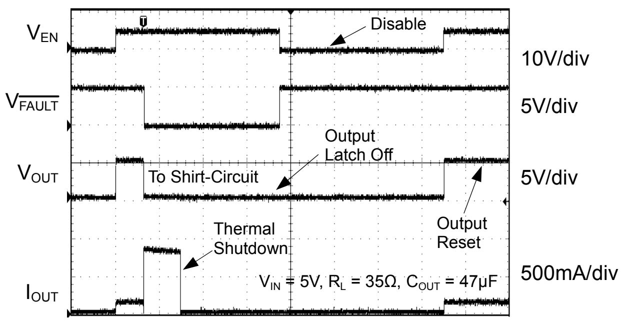
Time (400ms/div)

Thermal Shutdown (SGM2560A) (Output Reset by Removing Load)



Time (100ms/div)

Thermal Shutdown (SGM2560A) (Output Reset by Toggling Enable)



Time (200ms/div)

FUNCTIONAL DESCRIPTION

The SGM2560 is a high-side dual channel N-MOSFET switch.

Input and Output

IN is the power supply connection to the logic circuitry and the drain of the output MOSFET. OUT is the source of the output MOSFET. In a typical circuit, current flows from IN to OUT toward the load. The output MOSFET and driver circuitry are also designed to allow the MOSFET source to be externally forced to a higher voltage than the drain ($V_{OUT} > V_{IN}$) when the switch is disabled. In this situation, the SGM2560 prevents undesirable current flow from OUT to IN.

Thermal Shutdown

Thermal shutdown is employed to protect the device from damage should the die temperature exceed safe margins due mainly to short circuit faults. Each channel employs its own thermal sensor. Thermal shutdown shuts off the output MOSFET and asserts the $\overline{FAULT}$ output if the die temperature reaches 140°C and the overheated channel is in current limit. The other channel is not affected. If however, the die temperature exceeds 160°C, both channels will be shut off.

Upon determining a thermal shutdown condition, the SGM2560 will latch the output off. In this case, a pull-up current source is activated. This allows the output latch to automatically reset when the load (such as a USB device) is removed. The output can also be reset by toggling EN. Refer to Figure 3 and Figure 4 for timing details.

Depending on PCB layout, package, ambient temperature, etc., it may take several hundred milliseconds from the incidence of the fault to the output MOSFET being shut off. This time will be shortest in the case of a dead short on the output.

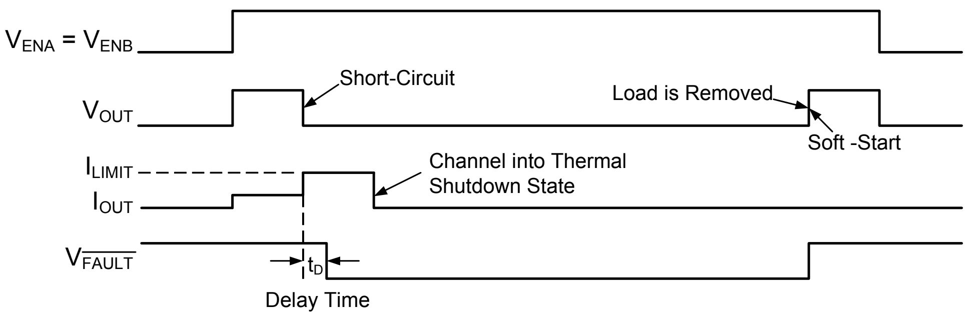


Figure 3. SGM2560A Fault Timing: Output Reset by Removing Load

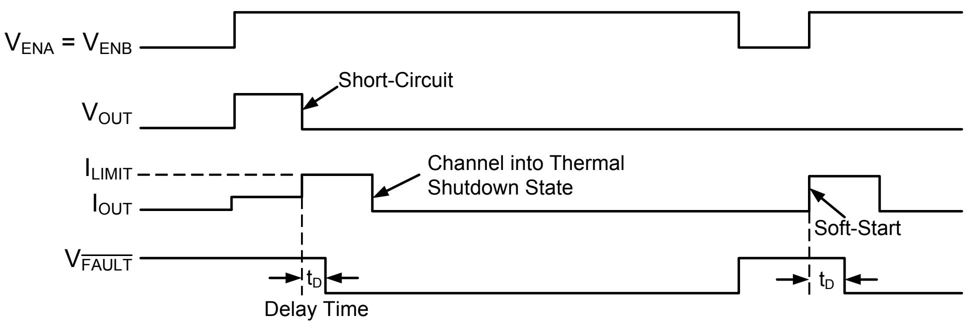


Figure 4. SGM2560A Fault Timing: Output Reset by Toggling EN

FUNCTIONAL DESCRIPTION

$\overline{\text{FAULT}}$ Flag

The $\overline{\text{FAULT}}$ signal is an N-Channel open-drain MOSFET output. $\overline{\text{FAULT}}$ is asserted (active-low) when either an over-current or thermal shutdown condition occurs. In the case of an over-current condition, $\overline{\text{FAULT}}$ will be asserted only after the $\overline{\text{FAULT}}$ response delay time, t_D, has elapsed. This ensures that $\overline{\text{FAULT}}$ is asserted only upon valid over-current conditions and that erroneous error reporting is eliminated.

For example, false over-current conditions can occur during hot-plug events when a highly capacitive load is connected and causes a high transient inrush current that exceeds the current limit threshold for up to 1ms. The $\overline{\text{FAULT}}$ response delay time t_D is typically 4ms.

Soft-Start

In order to eliminate the upstream voltage droop caused by the large inrush current during hot-plug events, the “soft-start” feature effectively isolates power supplies from such highly capacitive loads.

Power Dissipation

The device’s junction temperature depends on several factors such as the load, PCB layout, ambient temperature, and package type. Equations that can be used to calculate power dissipation of each channel and junction temperature are found below:

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

Total power dissipation of the device will be the summation of P_D for both channels. To relate this to junction temperature, the following equation can be used:

$$T_J = P_D \times \theta_{JA} + T_A$$

where:
T_J = junction temperature
T_A = ambient temperature
θ_{JA} = the thermal resistance of the package

Under-Voltage Lockout

UVLO prevents the MOSFET switch from turning on until input voltage exceeds 2.4V (TYP). If input voltage drops below 2.15V (TYP), UVLO shuts off the MOSFET switch. Under-voltage detection functions only when the switch is enabled.

Reverse-Voltage Protection

The reverse-voltage protection feature turns off the N-MOSFET switch whenever the output voltage exceeds the input voltage by 50mV (TYP). The SGM2560 keeps the N-MOSFET turned off until the output voltage is higher than the input voltage by 25mV (TYP) or the chip enable is toggled.

Current Sensing and Limiting

The current limit threshold is preset internally. The preset level prevents damage to the device and external load but still allows a minimum current of 500mA to be delivered to the load. The current limit circuit senses a portion of the output MOSFET switch current. The current-sense resistor shown in the block diagram is virtual and has no voltage drop. The reaction to an over-current condition varies with three scenarios:

Switch Enabled into Short-Circuit

If a switch is enabled into a heavy load or short-circuit, the switch immediately enters into a constant-current mode, reducing the output voltage. The $\overline{\text{FAULT}}$ signal is asserted indicating an over-current condition.

Short-Circuit Applied to Enabled Output

When a heavy load or short-circuit is applied to an enabled switch, a large transient current may flow until the current limit circuitry responds. Once this occurs, the device limits current to less than the short-circuit current limit specification.

Current Limit Response-Ramped Load

The SGM2560 current limit profile exhibits a small foldback effect of about 200mA. Once this current limit threshold is exceeded the device switches into a constant-current mode. It is important to note that the device will supply current up to the current limit threshold.

APPLICATION INFORMATION

Supply Filtering

A 0.1μF to 1μF bypass capacitor positioned close to V_{IN} and GND of 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.

Printed Circuit Board Hot-Plug

The SGM2560 is ideal inrush current limiter for hot-plug applications. Due to their integrated charge pumps, the SGM2560 present a high impedance when off and slowly become a low impedance as their integrated charge pumps turn on. This "soft-start" feature effectively isolates power supplies from highly capacitive loads by reducing inrush current. Figure 5 shows how the SGM2560 may be used in a card hot-plug application.

In cases of extremely large capacitive loads (> 400μF), the length of the transient due to inrush current may exceed the delay provided by the integrated filter. Since this inrush current exceeds the current limit delay specification, $\overline{FAULT}$ will be asserted during this time. To prevent the logic controller from responding to $\overline{FAULT}$ being asserted, an external RC filter, as shown in Figure 6, can be used to filter out transient $\overline{FAULT}$ assertion. The value of the RC time constant should be selected to match the length of the transient, less than $t_{D(MIN)}$ of the SGM2560.

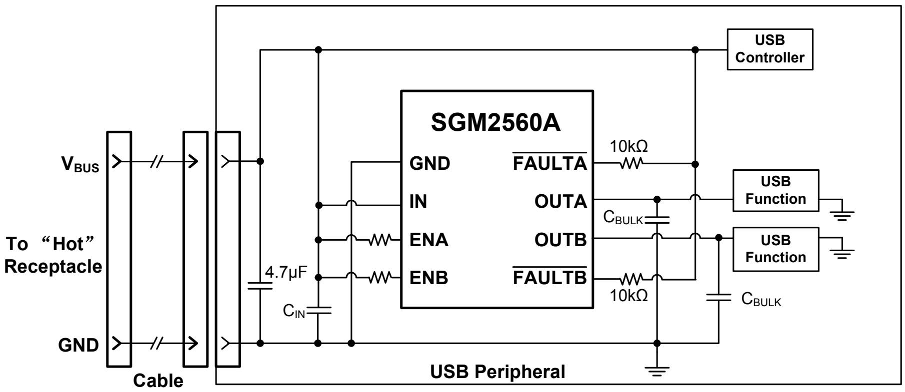


Figure 5. Hot-Plug Application

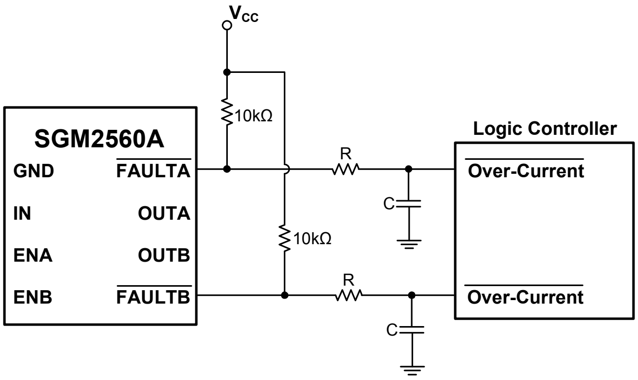


Figure 6. Transient Filter

APPLICATION INFORMATION

Universal Serial Bus (USB) Power Distribution

The SGM2560 is ideally suited for USB power distribution applications. The USB specification defines power distribution for USB host systems such as PCs and USB hubs. Hubs can either be self-powered or bus-powered (that is, powered from the bus). Figure 7 shows a typical USB host application that may be suited for mobile PC applications employing USB. The requirement for USB host systems is that the port must supply a minimum of 500mA at an output voltage of 5V ± 5%. In addition, the output power delivered must be limited to below 25VA. Upon an over-current condition, the host must also be notified. To support hot-plug events, the hub must have a minimum of 120μF of bulk capacitance, preferably low ESR electrolytic or tantulum.

For bus-powered hubs, USB requires that each downstream port be switched on or off under control by the host. Up to four downstream ports each capable of supplying 100mA at 4.4V minimum are allowed. In addition, to reduce voltage droop on the upstream V_{BUS}, soft-start is necessary. Although the hub can consume up to 500mA from the upstream bus, the hub must consume only 100mA max at start-up, until it enumerates with the host prior to requesting more power. The same requirements apply for bus-powered peripherals that have no downstream ports. Figure 8 shows a bus-powered hub.

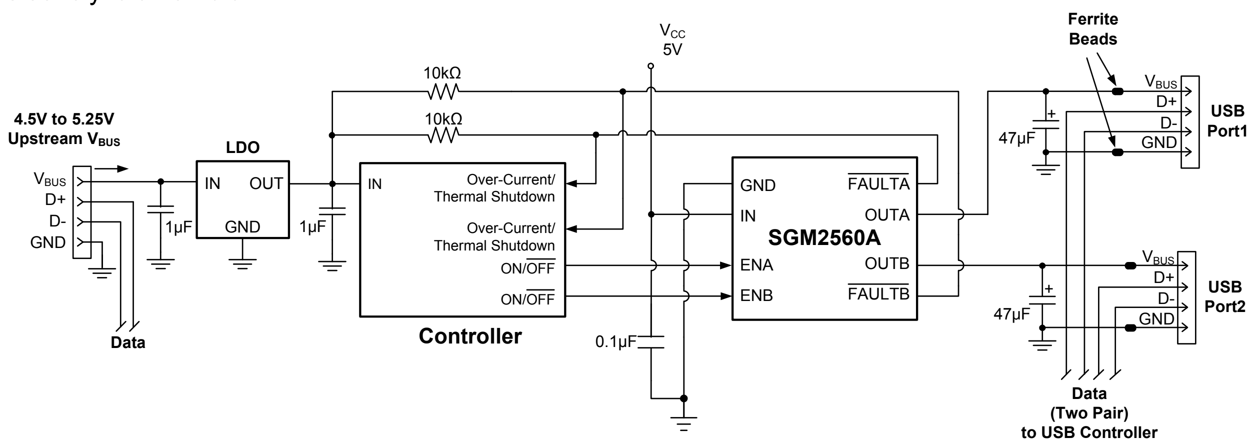


Figure 7. USB Two-Port Host Application

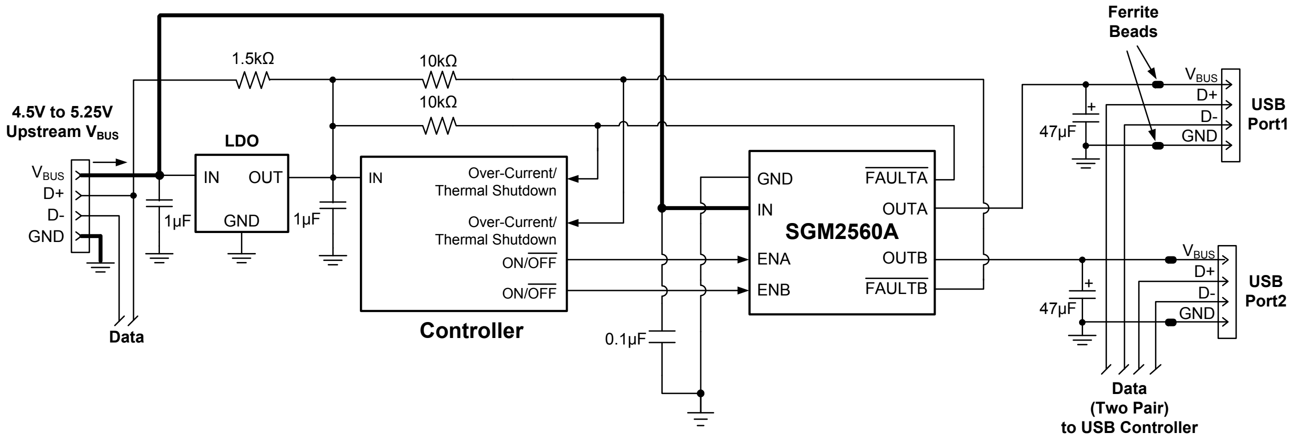
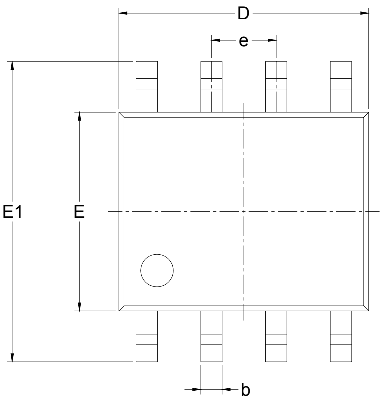
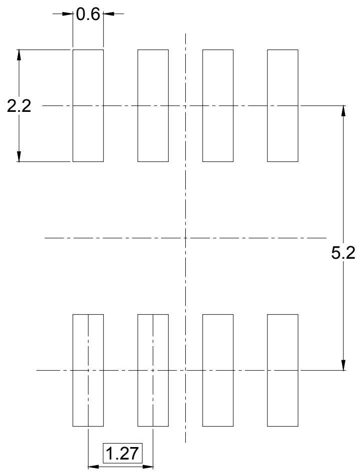


Figure 8. USB Two-Port Bus-Powered Hub

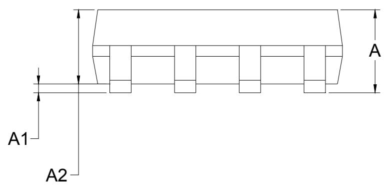
PACKAGE OUTLINE DIMENSIONS

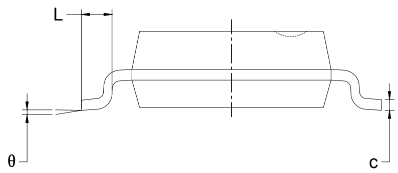
SOIC-8





RECOMMENDED LAND PATTERN (Unit: mm)

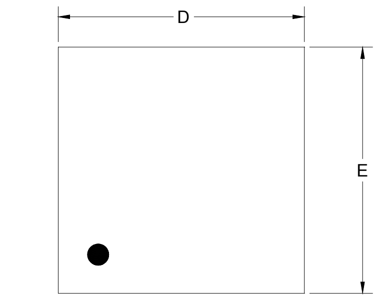




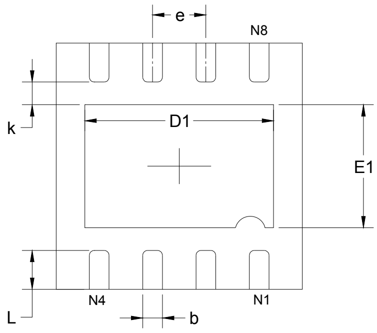
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.006	0.010
D	4.700	5.100	0.185	0.200
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.27 BSC		0.050 BSC	
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°

PACKAGE OUTLINE DIMENSIONS

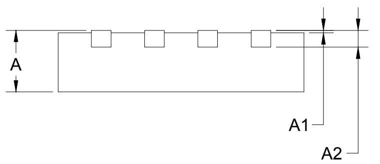
TDFN-3×3-8L



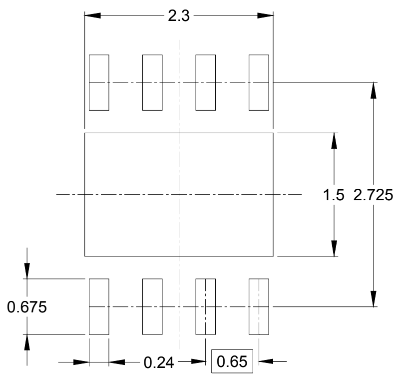
TOP VIEW



BOTTOM VIEW



SIDE VIEW

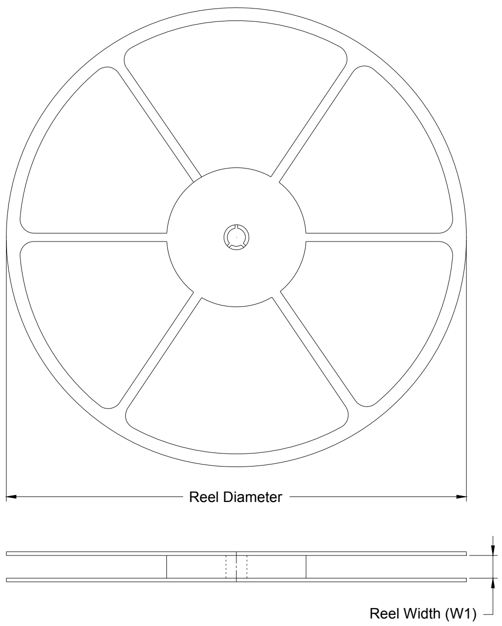


RECOMMENDED LAND PATTERN (Unit: mm)

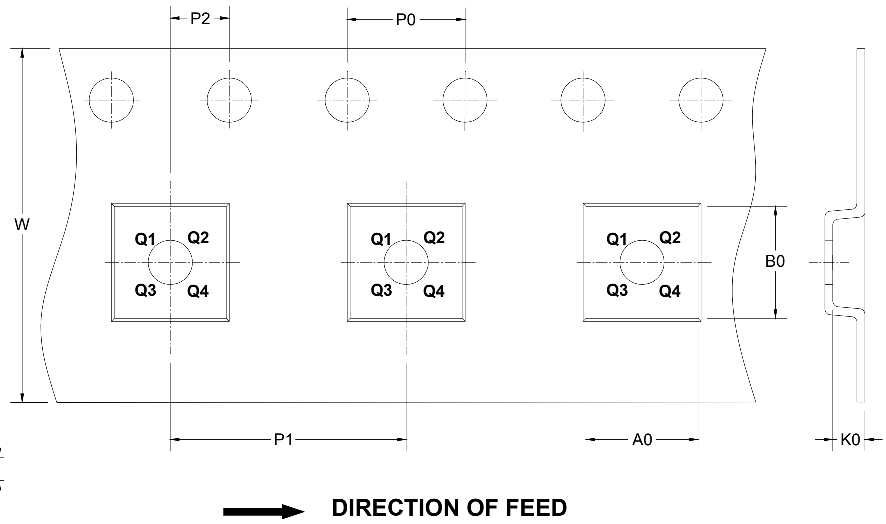
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	**MAX**	**MIN**	**MAX**
A	0.700	0.800	0.028	0.031
A1	0.000	0.050	0.000	0.002
A2	0.203 REF		0.008 REF	
D	2.900	3.100	0.114	0.122
D1	2.200	2.400	0.087	0.094
E	2.900	3.100	0.114	0.122
E1	1.400	1.600	0.055	0.063
k	0.200 MIN		0.008 MIN	
b	0.180	0.300	0.007	0.012
e	0.650 TYP		0.026 TYP	
L	0.375	0.575	0.015	0.023

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS

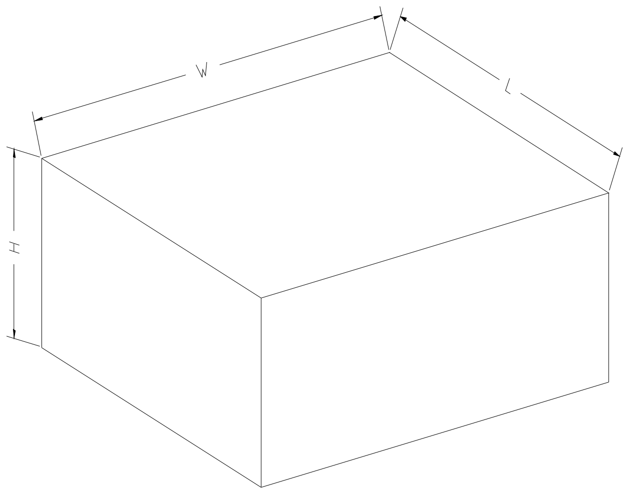


NOTE: The picture is only for reference. Please make the object as the standard.

KEY PARAMETER LIST OF TAPE AND REEL

Package Type	Reel Diameter	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	P1 (mm)	P2 (mm)	W (mm)	Pin1 Quadrant
SOIC-8	13″	12.4	6.4	5.4	2.1	4.0	8.0	2.0	12.0	Q1
TDFN-3×3-8L	13″	12.4	3.35	3.35	1.13	4.00	8.00	2.00	12.00	Q1

CARTON BOX DIMENSIONS



NOTE: The picture is only for reference. Please make the object as the standard.

KEY PARAMETER LIST OF CARTON BOX

Reel Type	Length (mm)	Width (mm)	Height (mm)	Pizza/Carton
13″	386	280	370	5