SGM2593D
Power Distribution Switch

GENERAL DESCRIPTION

The SGM2593D is a single channel power distribution switch. The switch controlled by the EN pin operates from 2.5V to 6V supply voltage. It can be used in USB power distribution applications.

The SGM2593D integrates programmable current limit to protect the upstream power supply from damage during over-current or short-circuit condition.

The device has the function of over-temperature protection. When the junction temperature exceeds +151℃, the device will be turned off and the internal MOSFET will remain off until the temperature drops to +105℃. In current limit mode, the over-temperature protection will shut down the output if the maintaining time of over-current state is long enough to cause the junction temperature exceeds +128℃. The internal switch will not be turned on until the temperature drops below +105℃.

The device is designed with soft-start circuit to cope with inrush currents when large capacitive loads are connected. The nFAULT output will be asserted to low level during over-current, over-temperature or reverse voltage condition.

The SGM2593D further reduces the total solution size by integrating a 47Ω pull-down resistor for output discharge when the switch is shut down by EN.

The SGM2593D is available in a Green TDFN-2×2-6AL package.

FEATURES

- **High-side N-MOSFET**
- **On-Resistance: 60mΩ (TYP)**
- **Programmable Current Limit Range: 0.1A to 3A**
  1.5A at R_{ILIM} = 4.53kΩ
- **Input Voltage Range: 2.5V to 6V**
- **Quiescent Current: 27μA (TYP)**
- **Shutdown Current: 0.28μA (TYP)**
- **Soft-Start Function**
- **Over-Temperature Protection**
- **Under-Voltage Lockout Protection for VIN**
- **No Reversed Leakage Current (Reverse Blocking)**
- **Fault Flag (nFAULT Pin)**
- **Quick Output Discharge**
- **1.2MΩ Pull-Down Resistor at EN Pin**
- **Available in a Green TDFN-2×2-6AL Package**

APPLICATIONS

General Purpose Power Switching
USB Bus/Self-Powered Hub
USB Peripheral
ACPI Power Distribution
Smart Phone
LCD TV

TYPICAL APPLICATION

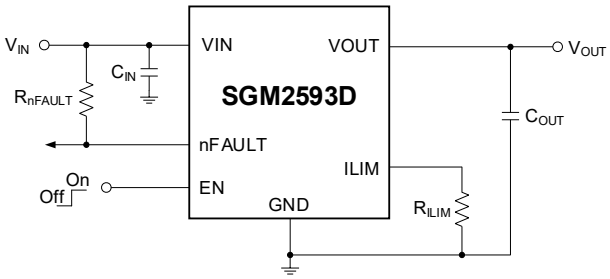


Figure 1. Typical Application Circuit

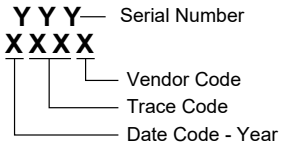
PACKAGE/ORDERING INFORMATION

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM2593D	TDFN-2×2-6AL	-40℃ to +125℃	SGM2593DXTDI6G/TR	05O XXXX	Tape and Reel, 3000

MARKING INFORMATION

NOTE: XXXX = Date Code, Trace Code and Vendor Code.

TDFN-2×2-6AL



Green (RoHS & HSF): SG Micro Corp defines "Green" to mean Pb-Free (RoHS compatible) and free of halogen substances. If you have additional comments or questions, please contact your SGMICRO representative directly.

ABSOLUTE MAXIMUM RATINGS

VIN 6.5V
All Other Pins 6V
nFAULT Current 25mA
Package Thermal Resistance
TDFN-2×2-6AL, θ_{JA} ..... 83℃/W
Junction Temperature ..... +150℃
Storage Temperature Range ..... -65℃ to +150℃
Lead Temperature (Soldering, 10s) ..... +260℃
ESD Susceptibility
HBM 2000V
CDM 1000V

RECOMMENDED OPERATING CONDITIONS

Input Voltage Range ..... 2.5V to 6V
EN Voltage Range ..... -0.3V to 5.5V
All Other Pins ..... 0V to 5.5V
Operating Junction Temperature Range ..... -40℃ to +125℃

OVERSTRESS CAUTION

Stresses beyond those listed in Absolute Maximum Ratings may cause permanent damage to the device. Exposure to absolute maximum rating conditions for extended periods may affect reliability. Functional operation of the device at any conditions beyond those indicated in the Recommended Operating Conditions section is not implied.

ESD SENSITIVITY CAUTION

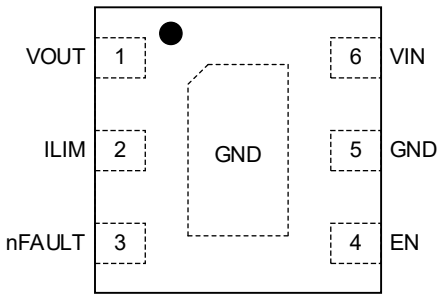
This integrated circuit can be damaged if ESD protections are not considered carefully. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because even small parametric changes could cause the device not to meet the published specifications.

DISCLAIMER

SG Micro Corp reserves the right to make any change in circuit design, or specifications without prior notice.

PIN CONFIGURATION

SGM2593D (TOP VIEW)



TDFN-2×2-6AL

PIN DESCRIPTION

PIN	NAME	FUNCTION
1	VOUT	Output Voltage.
2	ILIM	Current Limit Programming Pin. Connect a resistor R_{ILIM} from this pin to GND to set the overload current limit threshold: $I_{LIM} = \frac{6612}{R_{ILIM}^{0.982}}$ (A) If the ILIM pin is connected to GND directly, the current limit function is not available.
3	nFAULT	Active-Low Open-Drain Output. It is asserted during over-current, over-temperature or reverse voltage condition.
4	EN	Chip Enable. Active-high for SGM2593D. It has integrated a 1.2MΩ pull-down resistor at this pin.
5	GND	Ground.
6	VIN	Power Input Voltage.
Exposed Pad	GND	Device Ground. The exposed pad must be connected to ground.

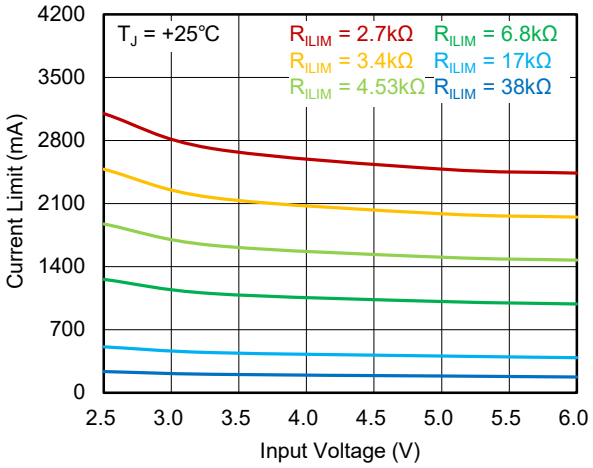
ELECTRICAL CHARACTERISTICS

(T_J = -40℃ to +125℃, typical values are at T_J = +25℃, V_{IN} = 5V, unless otherwise noted.)

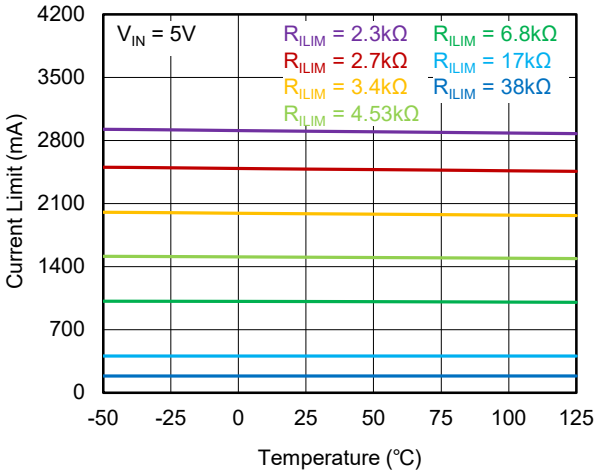
PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Input Voltage Range	V_{IN}		2.5		6	V
Under-Voltage Lockout Threshold	V_{UVLO}	V_{IN} rising		2.23	2.4	V
	V_{UVLO_HYS}	V_{IN} falling		96		mV
Quiescent Current	I_Q	Switch on, V_{OUT} = Open		27	55	μA
Shutdown Current	I_{SD}	Switch off, V_{OUT} = Open		0.28	1.6	μA
Output Leakage Current	$I_{LEAKAGE}$	Switch off, V_{OUT} = 6V, V_{IN} = 0V, T_J = -40℃ to +125℃		0.21	10	μA
		Switch off, V_{OUT} = 6V, V_{IN} = 0V, T_J = -40℃ to +85℃		0.21	1.5	
Enable Input Threshold	V_{IH}		1.2			V
	V_{IL}				0.4	
Pull-Down Resistor at EN Pin	R_{PULL_DOWN}			1.2		MΩ
On-Resistance	R_{DSON}	I_{OUT} = 200mA		60	100	mΩ
Output Turn-On Delay Time	t_{ON}	R_L = 100Ω, C_{OUT} = 0.1μF		1.13		ms
Output Turn-Off Delay Time	t_{OFF}	R_L = 100Ω, C_{OUT} = 0.1μF		37		μs
Output Turn-On Rise Time	t_R	R_L = 100Ω, C_{OUT} = 0.1μF		1.4		ms
Output Turn-Off Fall Time	t_F	R_L = 100Ω, C_{OUT} = 0.1μF		25		μs
Over-Current nFAULT Response Delay Time	t_D	Force the chip into current limit mode		14		ms
Reverse nFAULT Response Delay Time	t_{D_REV}			3		ms
Current Limit Threshold	I_{LIM}	R_{ILIM} = 38kΩ, T_J = -40℃ to +125℃	125	185	245	mA
		R_{ILIM} = 38kΩ, T_J = +25℃	135	185	235	
		R_{ILIM} = 17kΩ, T_J = -40℃ to +125℃	345	410	470	
		R_{ILIM} = 17kΩ, T_J = +25℃	356	410	460	
		R_{ILIM} = 6.8kΩ, T_J = -40℃ to +125℃	915	1010	1095	
		R_{ILIM} = 6.8kΩ, T_J = +25℃	940	1010	1074	
		R_{ILIM} = 4.53kΩ, T_J = -40℃ to +125℃	1375	1500	1615	
		R_{ILIM} = 4.53kΩ, T_J = +25℃	1412	1500	1588	
		R_{ILIM} = 3.4kΩ, T_J = -40℃ to +125℃	1806	1980	2140	
		R_{ILIM} = 3.4kΩ, T_J = +25℃	1857	1980	2104	
		R_{ILIM} = 2.7kΩ, T_J = -40℃ to +125℃	2262	2480	2680	
		R_{ILIM} = 2.7kΩ, T_J = +25℃	2325	2480	2637	
		R_{ILIM} = 2.3kΩ, T_J = -40℃ to +125℃	2645	2890	3125	
		R_{ILIM} = 2.3kΩ, T_J = +25℃	2712	2890	3077	
Reverse Protection Threshold	V_{REV}	V_{OUT}-V_{IN} rising		23		mV
Reverse Protection Threshold Hysteresis	V_{REV_HYS}			15		mV
nFAULT Output Resistance	R_{nFAULT}	nFAULT is low and I_{SINK} = 10mA		20		Ω
nFAULT Leakage Current	I_{nFAULT}	nFAULT is high		0.8		nA
VOUT Shutdown Discharge Resistance	R_{DIS}	Switch off, sink 2mA into OUT		47		Ω
Thermal Shutdown Temperature	T_{SD}	T_J increasing		151		℃
		T_J increasing, only in the current limit mode.		128		
Thermal Shutdown Hysteresis	T_{HYS}			46		℃
		Only in the current limit mode.		23		

TYPICAL PERFORMANCE CHARACTERISTICS

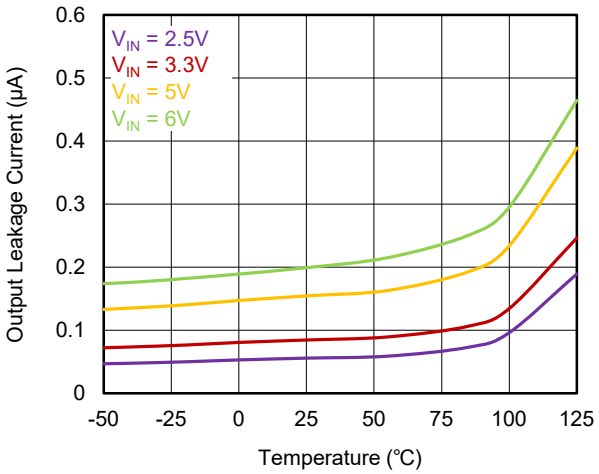
Current Limit vs. Input Voltage



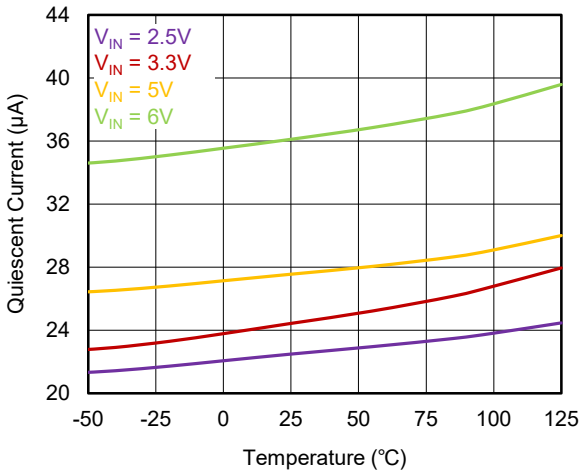
Current Limit vs. Temperature



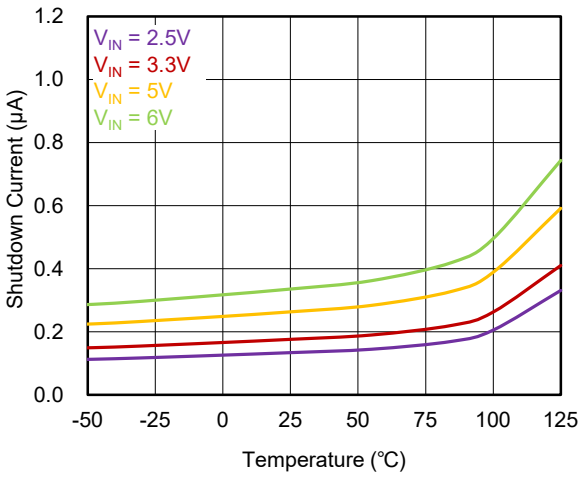
Output Leakage Current vs. Temperature



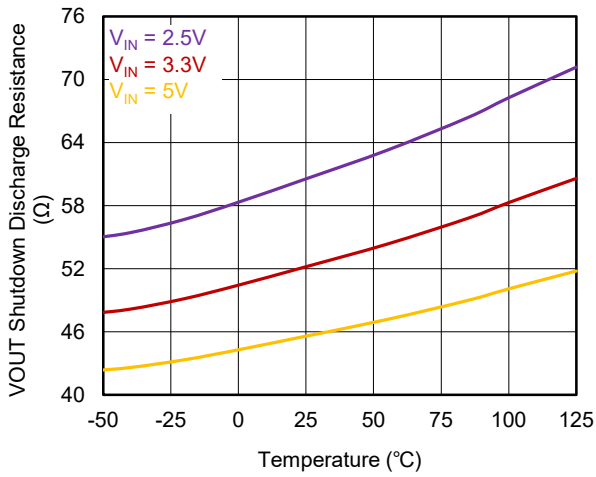
Quiescent Current vs. Temperature



Shutdown Current vs. Temperature

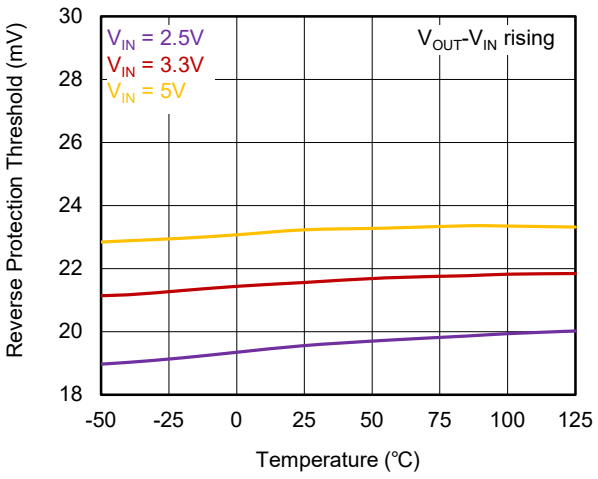


VOUT Shutdown Discharge Resistance vs. Temperature

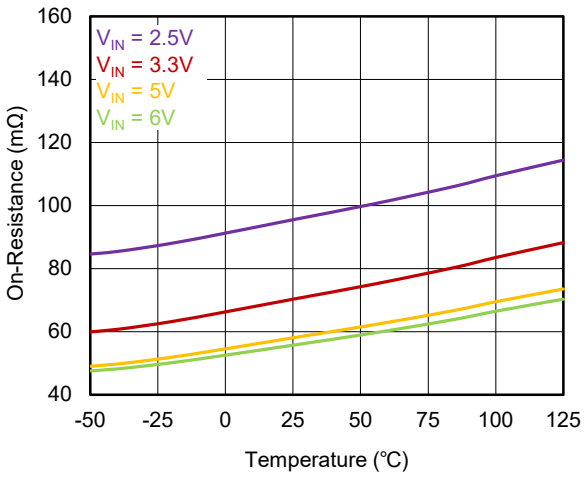


TYPICAL PERFORMANCE CHARACTERISTICS (continued)

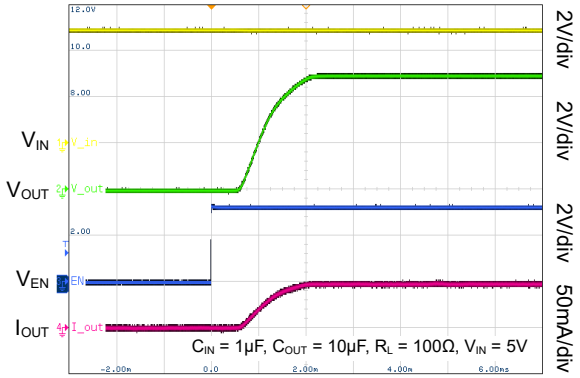
Reverse Protection Threshold vs. Temperature



On-Resistance vs. Temperature

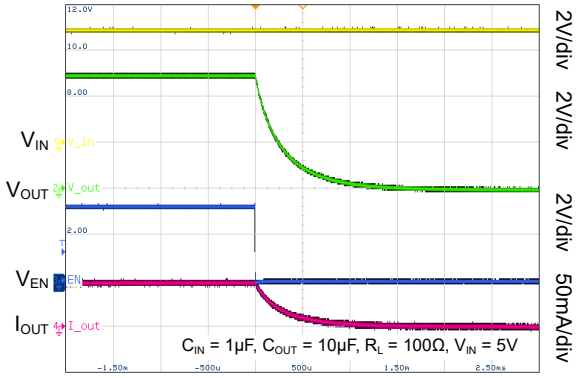


Turn-On Delay and Rise Time



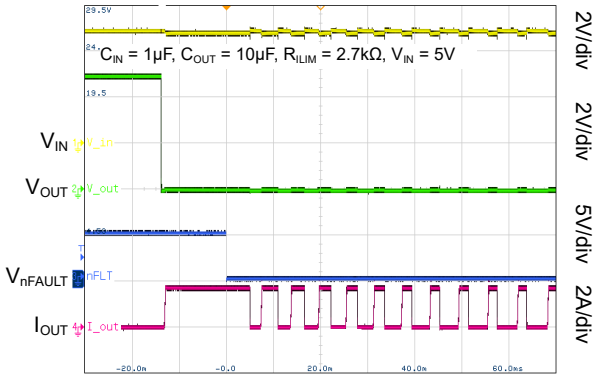
Time (1ms/div)

Turn-Off Delay and Fall Time



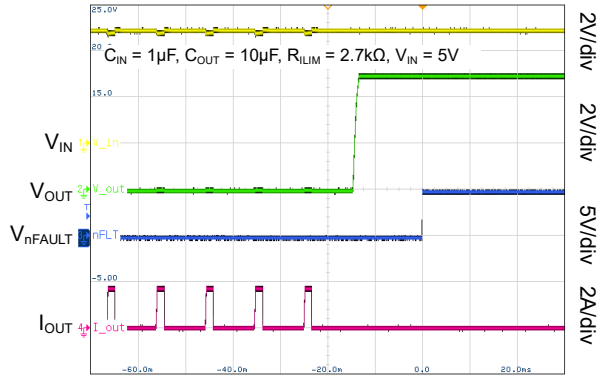
Time (500μs/div)

No Load to Output Short Transient Response



Time (10ms/div)

Output Short to No Load Recovery Response



Time (10ms/div)

FUNCTIONAL BLOCK DIAGRAM

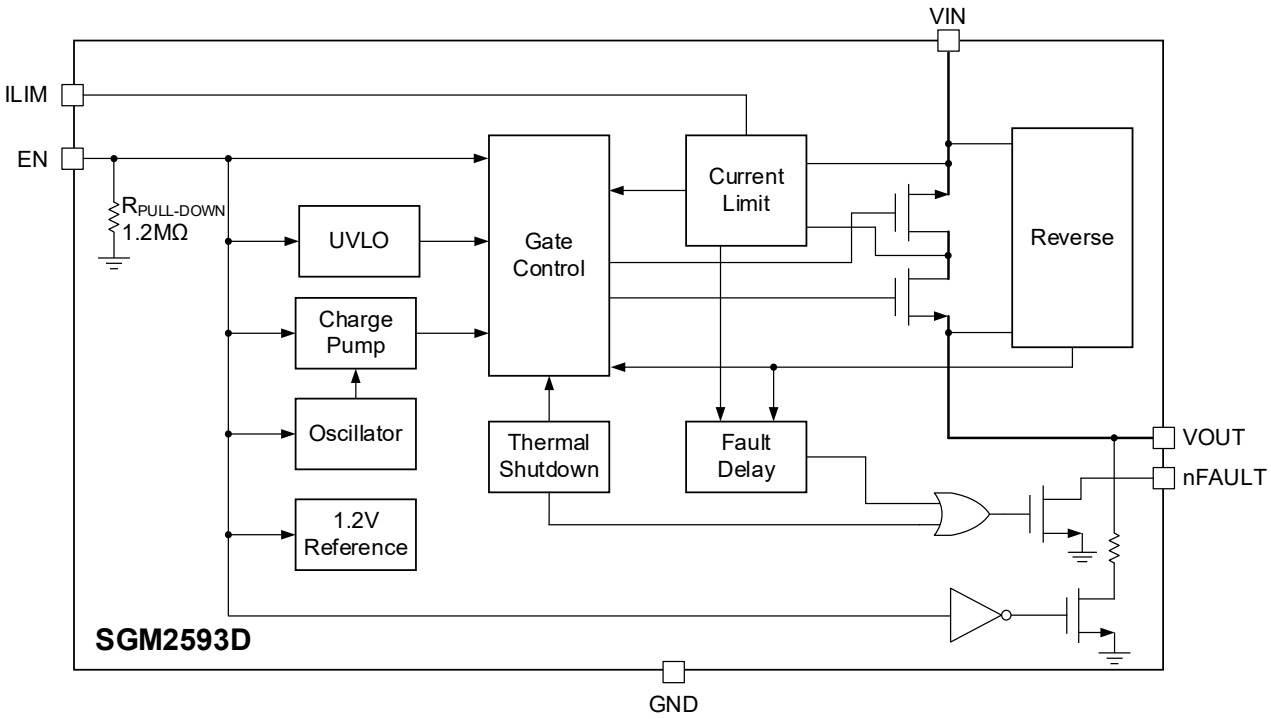


Figure 2. SGM2593D Block Diagram

TIMING DIAGRAMS

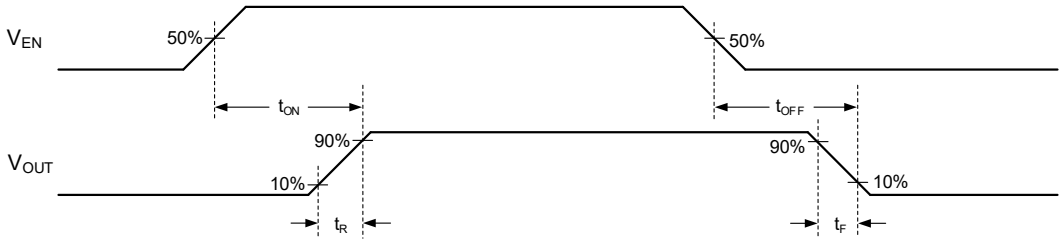


Figure 3. Switch Turn-On and Turn-Off Times

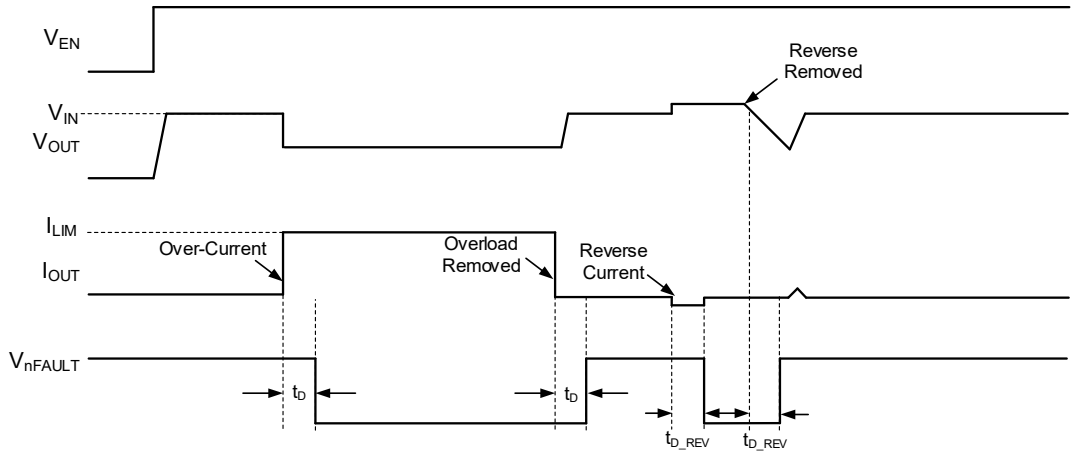


Figure 4. SGM2593D Fault Timing: Output Reset by Toggling EN

DETAILED DESCRIPTION

Input and Output

VIN should be connected to the power source that is the power supply of the internal logic circuitry and loads. Normally, load current flows from VIN to VOUT. The output MOSFET and driver circuit are designed to allow the voltage of VOUT is higher than VIN, when the device is turned off.

Thermal Shutdown (TSD)

In current limit mode, the internal switch will be shut down if the junction temperature exceeds +128℃ to protect the device from the damage caused by excessive power dissipation. The switch will be turned on again once the junction temperature falls below +105℃.

If there's no over-current condition, the thermal shutdown threshold is +151℃ with 46℃ hysteresis.

Soft-Start

The soft-start feature is used to limit inrush current during start-up or hot-plug events so that the device can cope with inrush current when connected to large capacitive loads.

Under-Voltage Lockout (UVLO)

If the voltage on VIN pin falls below its under-voltage lockout threshold, the device will be disabled. The device resumes operation when the power supply goes back above UVLO threshold.

Current Limit and Short-Circuit Protection

The current limit protection circuit is designed to protect the upstream power supply by limiting the output current to the current limit threshold set by the R_{ILIM} from ILIM to GND.

The current limit threshold is 40% discount of I_{LIM} in short-circuit state and the nFAULT pin will be asserted after the device enters short-circuit state for t_D (14ms).

If the short-circuit state persists, the device will cycle on and off under thermal protection as a result of power dissipation.

Fault Flag (nFAULT)

The SGM2593D is designed to achieve delayed response via the internal delay "deglitch" circuit for over-current (t_D = 14ms, TYP) and reverse voltage (3ms, TYP) conditions. The nFAULT pin indicates the device enters and leaves the following fault state: over-current, reverse voltage after the delay time (t_D). But nFAULT will be asserted to low level as soon as the over-temperature condition occurs.

The nFAULT is the structure of N-MOSFET open-drain that outputs low level when an over-current, over-temperature or reverse voltage condition occurs. Figure 4 depicts the typical timing.

When an over-current occurs, nFAULT will not be asserted until the over-current persists for a delay time (t_D). This ensures that nFAULT will not be asserted due to disturbances such as current jitter, thus avoids false fault reports.

Reverse Voltage Protection

When the output voltage exceeds the input voltage by 23mV (TYP), the device turns off the internal N-MOSFET to avoid the reverse current from the output to input. Its hysteresis voltage is 15mV (TYP).

Output Discharge

The SGM2593D integrates the output discharge feature. When the EN pin is pulled low (below V_{IL}), a discharge resistance with a typical value of 47Ω is connected between the VOUT and GND. This resistance pulls down the output and prevents it from floating when the device is disabled.

APPLICATION INFORMATION

Current Limit Programming

An external resistor (R_{ILIM}) placed between the ILIM pin and GND sets the switch current limit threshold (I_{LIM}). The ILIM pin voltage is regulated by an internal control loop. The current limit threshold is proportional to the current pulled from the ILIM pin by the resistor. Use short trace routes for the R_{ILIM} on the PCB to minimize the impact of parasitics and noise on the accuracy of the current limit setting.

$$I_{LIM} = \frac{6612}{R_{ILIM}^{0.982}} \quad (1)$$

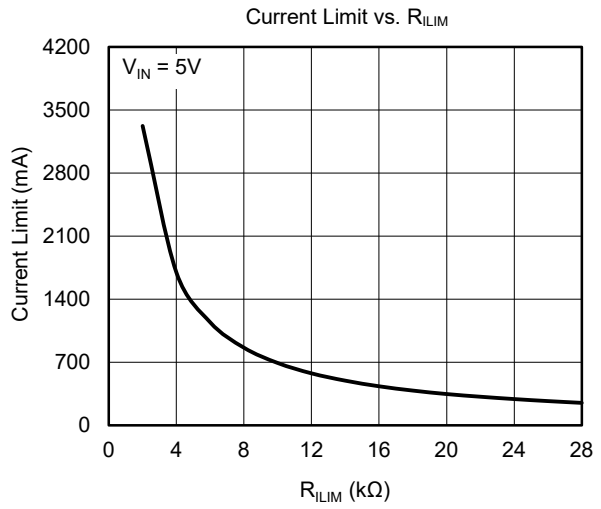


Figure 5. Current Limit Threshold (I_{LIM}) vs. Current Limit Programming Resistor (R_{ILIM})

Power Dissipation

Assuming a given ambient temperature and an output current, the maximum allowable power dissipation is calculated by:

$$P_{D(MAX)} = \frac{T_{J(MAX)} - T_A}{\theta_{JA}} \quad (2)$$

where:

- $P_{D(MAX)}$ is the maximum power dissipation.
- $T_{J(MAX)}$ is the maximum operating junction temperature.
- T_A is the operating ambient temperature.
- θ_{JA} is junction to air thermal impedance.

Please note that the thermal vias are placed under the exposed pad of the device, thus allowing for thermal dissipation away from the device.

Supply Filter Capacitor

It is recommended to use a 1μF capacitor between VIN and GND close to the device pins. It can limit the voltage drop of the input supply. Larger C_{IN} can reduce voltage dip in high current applications. Without an input capacitor, short-circuit at the output will cause the input voltage to ring, which may destroy the chip's internal circuitry when the input transient voltage exceeds the absolute maximum supply voltage (6.5V).

Output Filter Capacitor

To reduce EMI, improve the transient performance, and minimize negative effects of resistance and inductance between the bypass capacitor and the downstream connector, a low-ESR 10μF ceramic capacitor between VOUT and GND standard bypass methods are recommended. If the output port is connected to the load through a long cable, the parasitic inductance of the cable may cause voltage to ring, whose negative ringing may damage the chip, so an anti-parallel Schottky diode such as BAT54 is recommended to connect in parallel with the output.

PCB Layout Guidelines

A reasonable PCB layout is critical to the stable performance of the SGM2593D. For best results, follow the guidelines below.

- Keep the power traces as short and wide as possible, and use at least 2 ounces of copper.
- Placing a ground plane under all circuits to reduce resistance and inductance will improve DC and transient performances.
- Ensure that the input decoupling capacitors on VIN have a minimal trace length to VIN and GND.
- Place the output capacitors as close to the SGM2593D as possible to minimize the affect of PCB parasitic inductance.

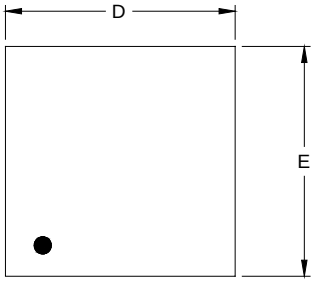
REVISION HISTORY

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

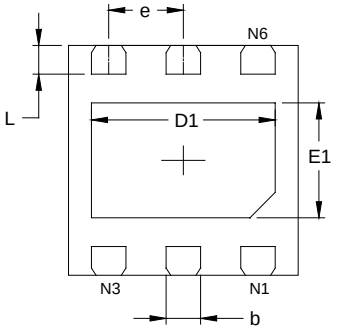
Changes from Original (MARCH 2023) to REV.A	Page
Changed from product preview to production data	All

PACKAGE OUTLINE DIMENSIONS

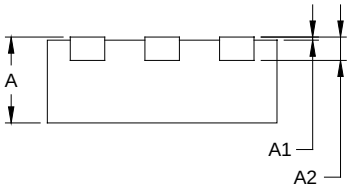
TDFN-2×2-6AL



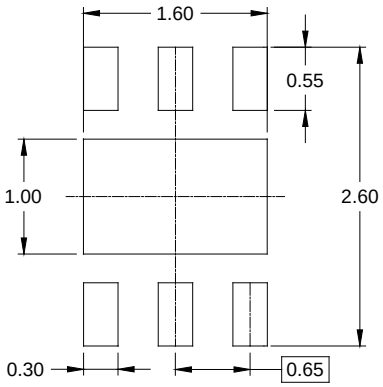
TOP VIEW



BOTTOM VIEW



SIDE VIEW



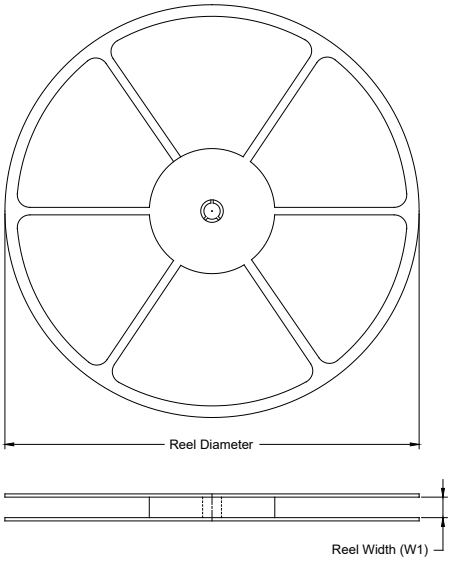
RECOMMENDED LAND PATTERN (Unit: mm)

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	1.900	2.100	0.075	0.083
D1	1.500	1.700	0.059	0.067
E	1.900	2.100	0.075	0.083
E1	0.900	1.100	0.035	0.043
b	0.250	0.350	0.010	0.014
e	0.650 BSC		0.026 BSC	
L	0.174	0.326	0.007	0.013

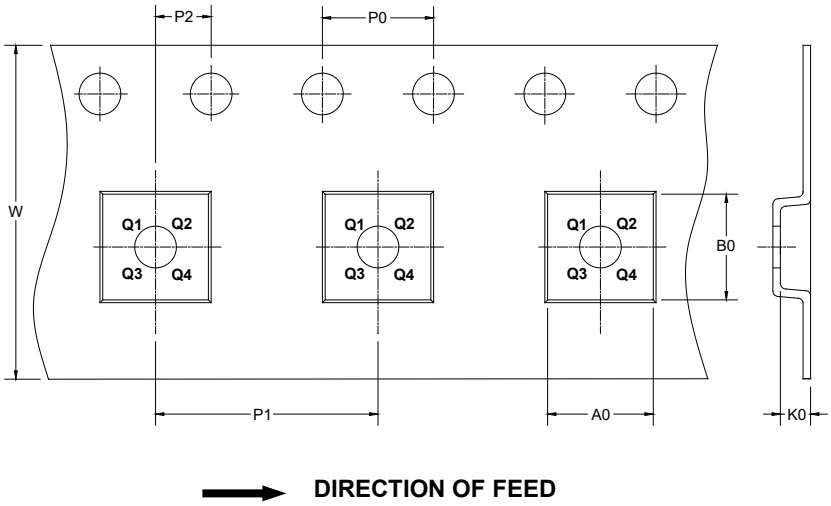
NOTE: This drawing is subject to change without notice.

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



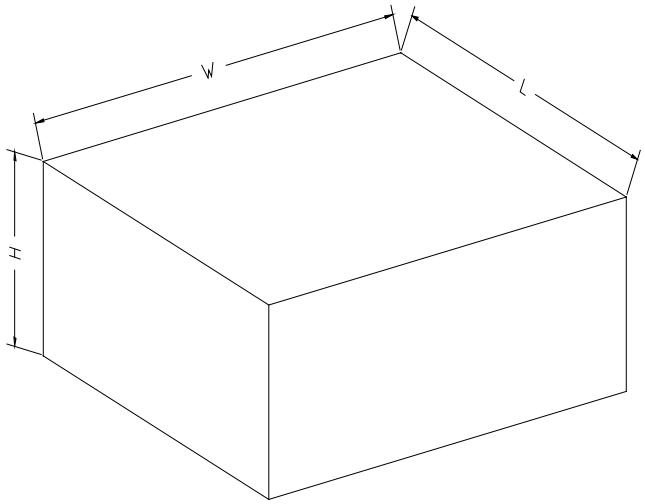
NOTE: The picture is only for reference. Please make the object as the standard.

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
TDFN-2×2-6AL	7″	9.5	2.30	2.30	1.10	4.0	4.0	2.0	8.0	Q2

DD0001

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
7″ (Option)	368	227	224	8
7″	442	410	224	18

DD0002