SGM2593/SGM2593D
Power Distribution Switches

GENERAL DESCRIPTION

The SGM2593 and SGM2593D are single channel power distribution switches. The switch is controlled by the EN pin and operates from 2.5V to 6V supply voltage. It can be used in USB power distribution applications.

The device integrates programmable current limit to protect the upstream power supply from damage during over-current or short-circuit condition. It also has the function of over-temperature protection.

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 SGM2593 and SGM2593D are available in Green TDFN-2×2-6AL and SOT-23-6 packages.

FEATURES

- **High-side N-MOSFET**
- **On-Resistance:**
  - **TDFN-2×2-6AL: 60mΩ (TYP)**
  - **SOT-23-6: 65mΩ (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 (SGM2593D Only)**
- **1.2MΩ Pull-Down Resistor at EN Pin**
- **Available in Green TDFN-2×2-6AL and SOT-23-6 Packages**

APPLICATIONS

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

TYPICAL APPLICATION

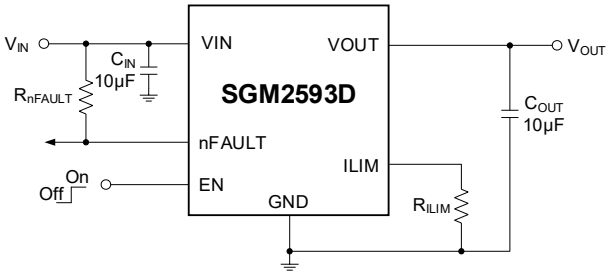


Figure 1. Typical Application Circuit

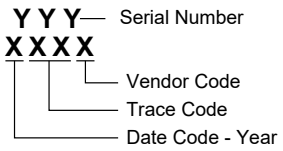
PACKAGE/ORDERING INFORMATION

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
	SOT-23-6	-40℃ to +125℃	SGM2593DXN6G/TR	082XX	Tape and Reel, 3000
SGM2593	TDFN-2×2-6AL	-40℃ to +125℃	SGM2593XTDI6G/TR	2593 XXXX	Tape and Reel, 3000
	SOT-23-6	-40℃ to +125℃	SGM2593XN6G/TR	081XX	Tape and Reel, 3000

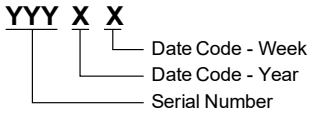
MARKING INFORMATION

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

TDFN-2×2-6AL



SOT-23-6



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
Package Thermal Resistance
TDFN-2×2-6AL, θ_{JA} ..... 83℃/W
SOT-23-6, θ_{JA} ..... 173℃/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

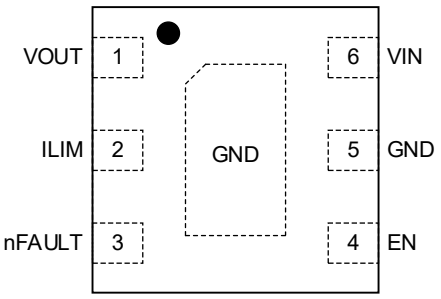
This integrated circuit can be damaged if ESD protections are not considered carefully. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance 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.

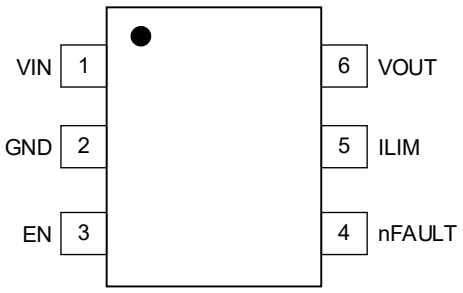
PIN CONFIGURATIONS

(TOP VIEW)



TDFN-2×2-6AL

(TOP VIEW)



SOT-23-6

PIN DESCRIPTION

PIN		NAME	FUNCTION
TDFN-2×2-6AL	SOT-23-6		
1	6	VOUT	Output Voltage.
2	5	ILIM	Current Limit Programming Pin. Connect a resistor R_{ILIM} from this pin to GND to set the overload current limit threshold: $I_{LIM}(mA) = \frac{6612V}{R_{ILIM}^{0.982}k\Omega}$ If the ILIM pin is connected to GND directly, the current limit function is not available.
3	4	nFAULT	Active-Low Open-Drain Output. It is asserted during over-current, over-temperature or reverse voltage condition.
4	3	EN	Chip Enable. Active-high for SGM2593D/SGM2593. It has integrated a 1.2MΩ pull-down resistor at this pin.
5	2	GND	Ground.
6	1	VIN	Power Input Voltage.
Exposed Pad	-	GND	Device Ground. The exposed pad must be connected to ground.

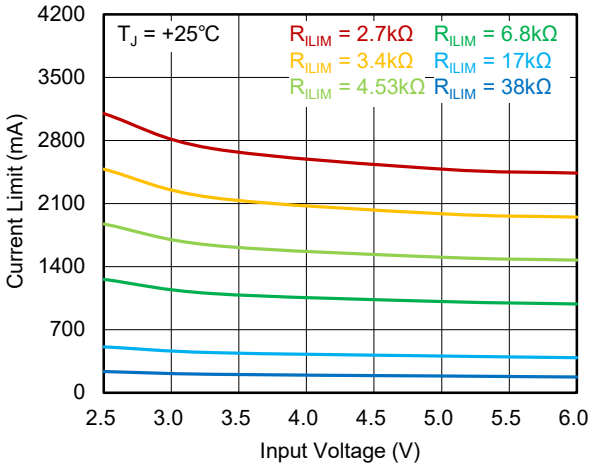
ELECTRICAL CHARACTERISTICS

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

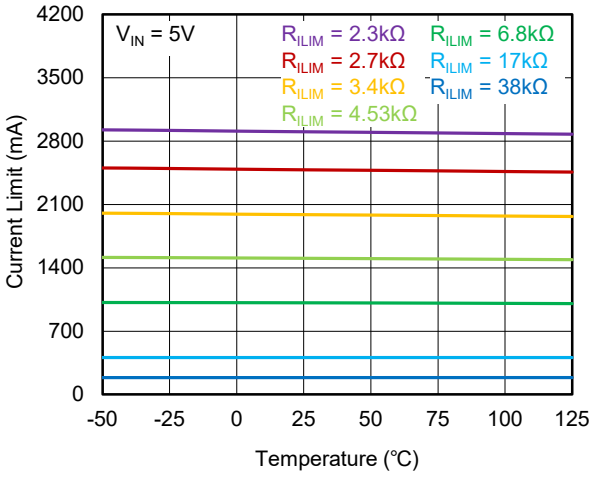
PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Input Voltage Range	V_{IN}			2.5		6	V
Under-Voltage Lockout Threshold	V_{UVLO}	V_{IN} rising			2.23	2.4	V
	V_{UVLO_HYS}	V_{IN} falling			100		mV
Quiescent Current	I_Q	Switch on, V_{OUT} = Open			27	60	μA
Shutdown Current	I_{SD}	Switch off, V_{OUT} = Open			0.28	5	μA
Output Leakage Current	$I_{LEAKAGE}$	Switch off, V_{OUT} = 6V, V_{IN} = 0V, T_J = -40℃ to +85℃			0.21	1.5	μA
		Switch off, V_{OUT} = 6V, V_{IN} = 0V, T_J = -40℃ to +125℃			0.21	6	
Enable Input Threshold	V_{IH}			1.2			V
	V_{IL}	T_J = -40℃ to +85℃				0.4	
		T_J = -40℃ to +125℃				0.3	
Pull-Down Resistor at EN Pin	R_{PULL_DOWN}				1.2		MΩ
On-Resistance	R_{DSON}	I_{OUT} = 200mA	TDFN-2×2-6AL		60	100	mΩ
			SOT-23-6, T_J = -40℃ to +85℃		65	98	
			SOT-23-6, T_J = -40℃ to +125℃		65	125	mΩ
Output Turn-On Delay Time	t_{ON}	R_L = 100Ω, C_{OUT} = 0.1μF			1.1		ms
Output Turn-Off Delay Time	t_{OFF}	R_L = 100Ω, C_{OUT} = 0.1μF	SGM2593		32		μs
			SGM2593D		27		
Output Turn-On Rise Time	t_R	R_L = 100Ω, C_{OUT} = 0.1μF			1.3		ms
Output Turn-Off Fall Time	t_F	R_L = 100Ω, C_{OUT} = 0.1μF	SGM2593		27		μs
			SGM2593D		13		
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}				4		ms
Current Limit Threshold	I_{LIM}	R_{ILIM} = 68kΩ, T_J = -40℃ to +125℃		55	105	135	mA
		R_{ILIM} = 68kΩ, T_J = +25℃		60	105	130	
		R_{ILIM} = 38kΩ, T_J = -40℃ to +125℃		125	185	245	
		R_{ILIM} = 38kΩ, T_J = +25℃		130	185	240	
		R_{ILIM} = 17kΩ, T_J = -40℃ to +125℃		345	410	467	
		R_{ILIM} = 17kΩ, T_J = +25℃		350	410	465	
		R_{ILIM} = 6.8kΩ, T_J = -40℃ to +125℃		915	1010	1088	
		R_{ILIM} = 6.8kΩ, T_J = +25℃		935	1010	1080	
		R_{ILIM} = 4.53kΩ, T_J = -40℃ to +125℃		1375	1500	1609	
		R_{ILIM} = 4.53kΩ, T_J = +25℃		1405	1500	1595	
		R_{ILIM} = 3.4kΩ, T_J = -40℃ to +125℃		1805	1980	2134	
		R_{ILIM} = 3.4kΩ, T_J = +25℃		1850	1980	2110	
		R_{ILIM} = 2.7kΩ, T_J = -40℃ to +125℃		2260	2480	2671	
		R_{ILIM} = 2.7kΩ, T_J = +25℃		2315	2480	2650	
		R_{ILIM} = 2.3kΩ, T_J = -40℃ to +125℃		2645	2890	3116	
		R_{ILIM} = 2.3kΩ, T_J = +25℃		2700	2890	3090	
Reverse Protection Threshold	V_{REV}	V_{OUT}-V_{IN} rising		7	23	39	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			1		nA
VOUT Shutdown Discharge Resistance (SGM2593D Only)	R_{DIS}	Switch off, sink 2mA into OUT			47		Ω
Thermal Shutdown Temperature	T_{SD}	T_J increasing, no load			156		℃
Thermal Shutdown Hysteresis	T_{HYS}				55		℃

TYPICAL PERFORMANCE CHARACTERISTICS

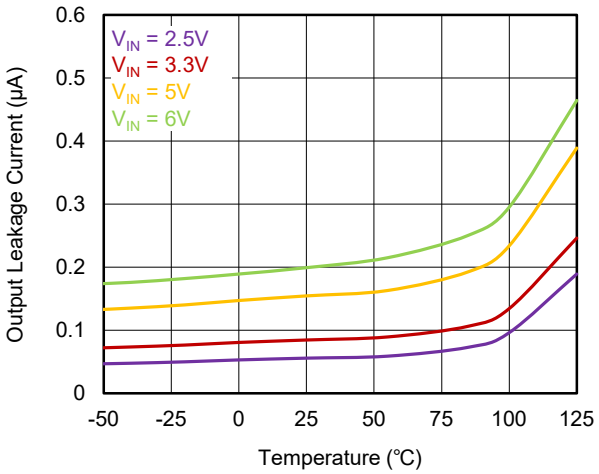
Current Limit vs. Input Voltage



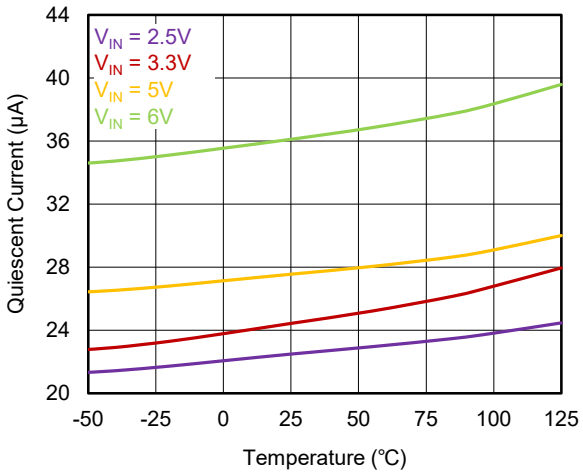
Current Limit vs. Temperature



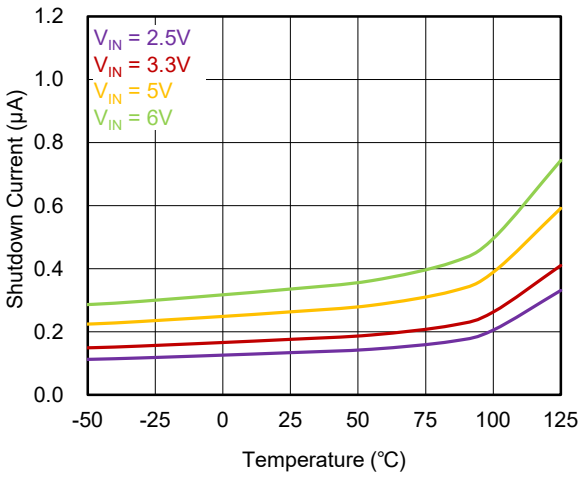
Output Leakage Current vs. Temperature



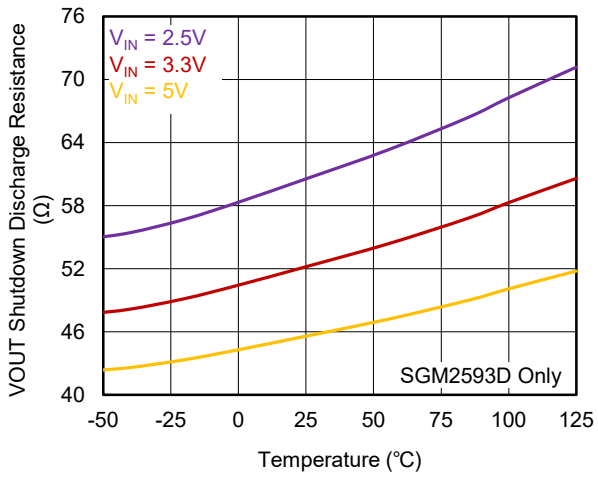
Quiescent Current vs. Temperature



Shutdown Current vs. Temperature

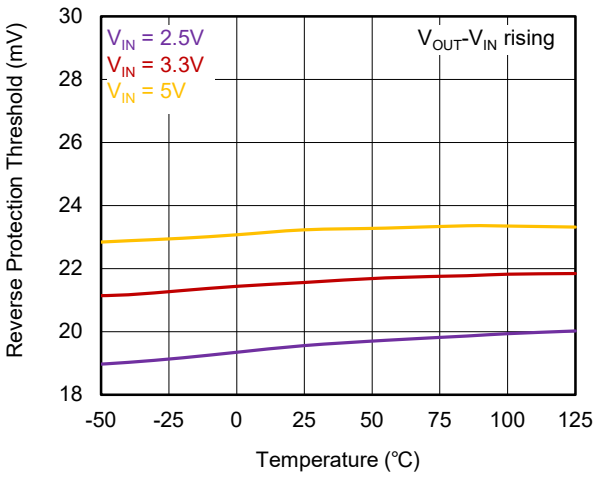


VOUT Shutdown Discharge Resistance vs. Temperature

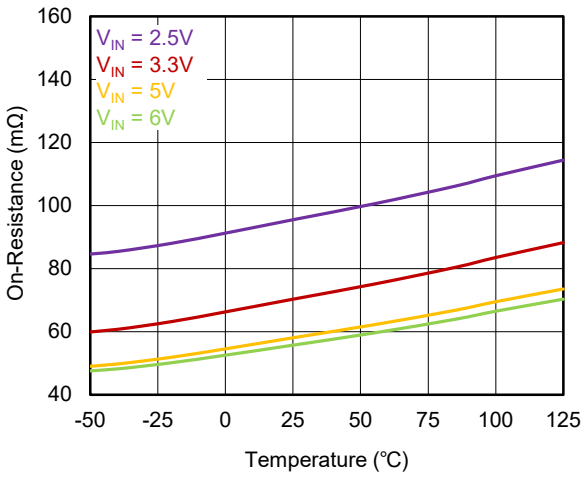


TYPICAL PERFORMANCE CHARACTERISTICS (continued)

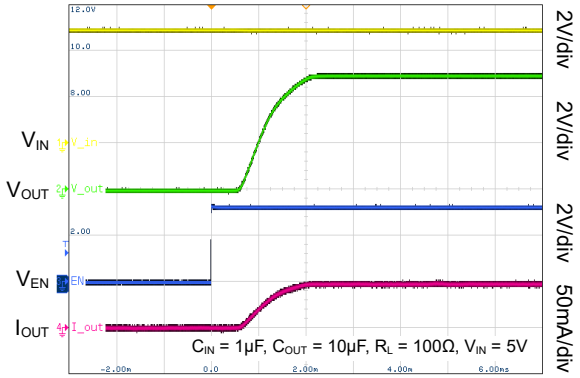
Reverse Protection Threshold vs. Temperature



On-Resistance vs. Temperature

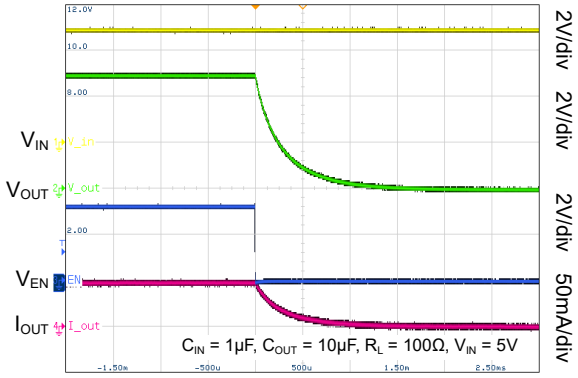


Turn-On Delay and Rise Time



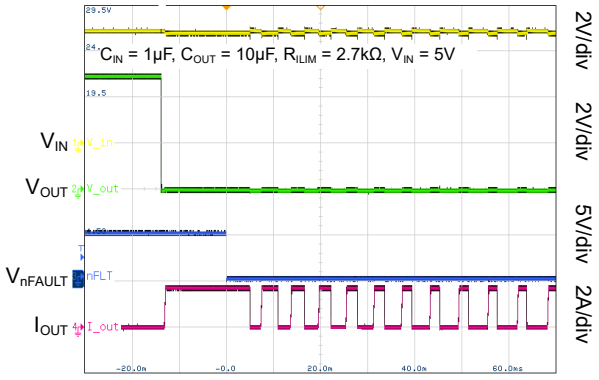
Time (1ms/div)

Turn-Off Delay and Fall Time



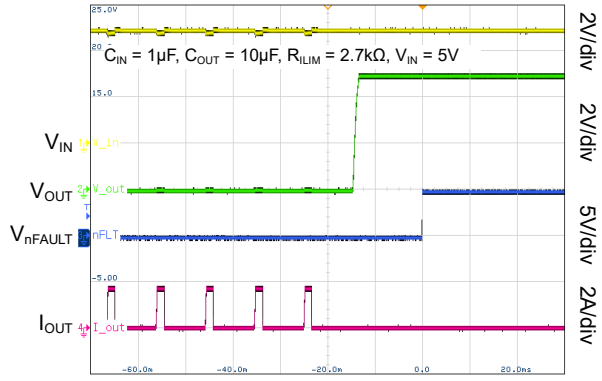
Time (500μs/div)

No Load to Output Short Transient Response



Time (10ms/div)

Output Short to No Load Recovery Response



Time (10ms/div)

FUNCTIONAL BLOCK DIAGRAMS

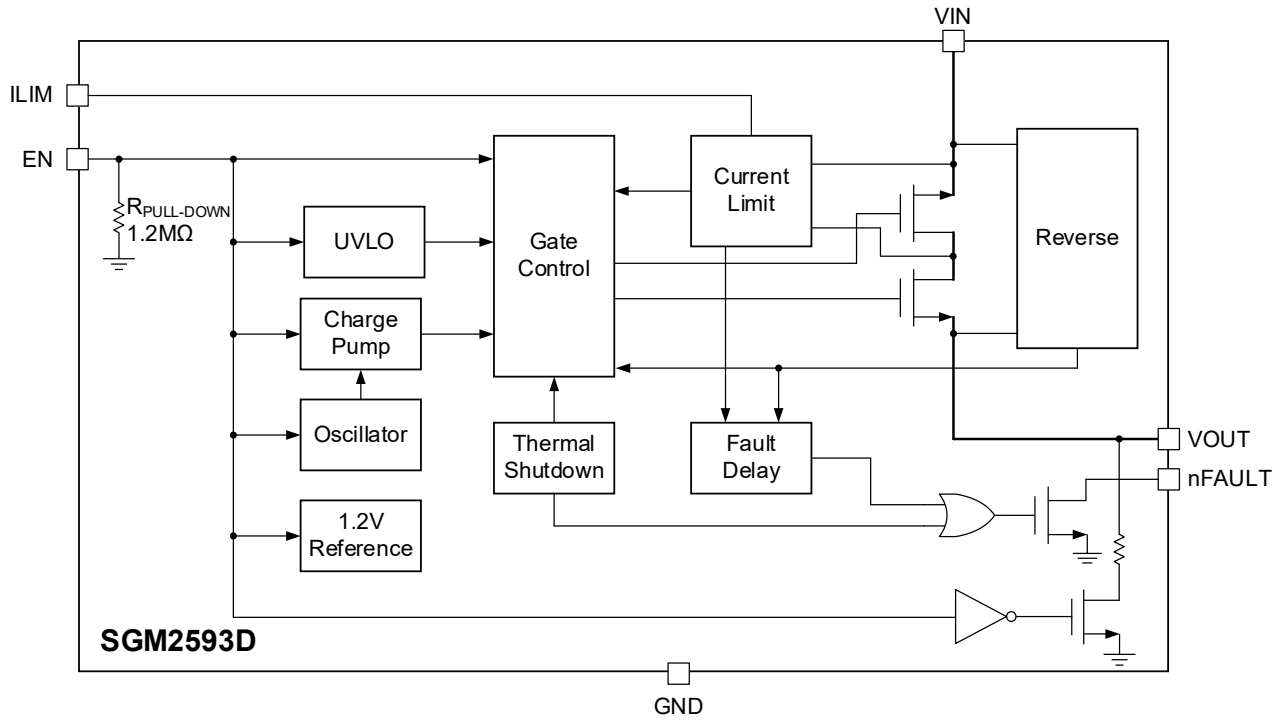


Figure 2. SGM2593D Block Diagram

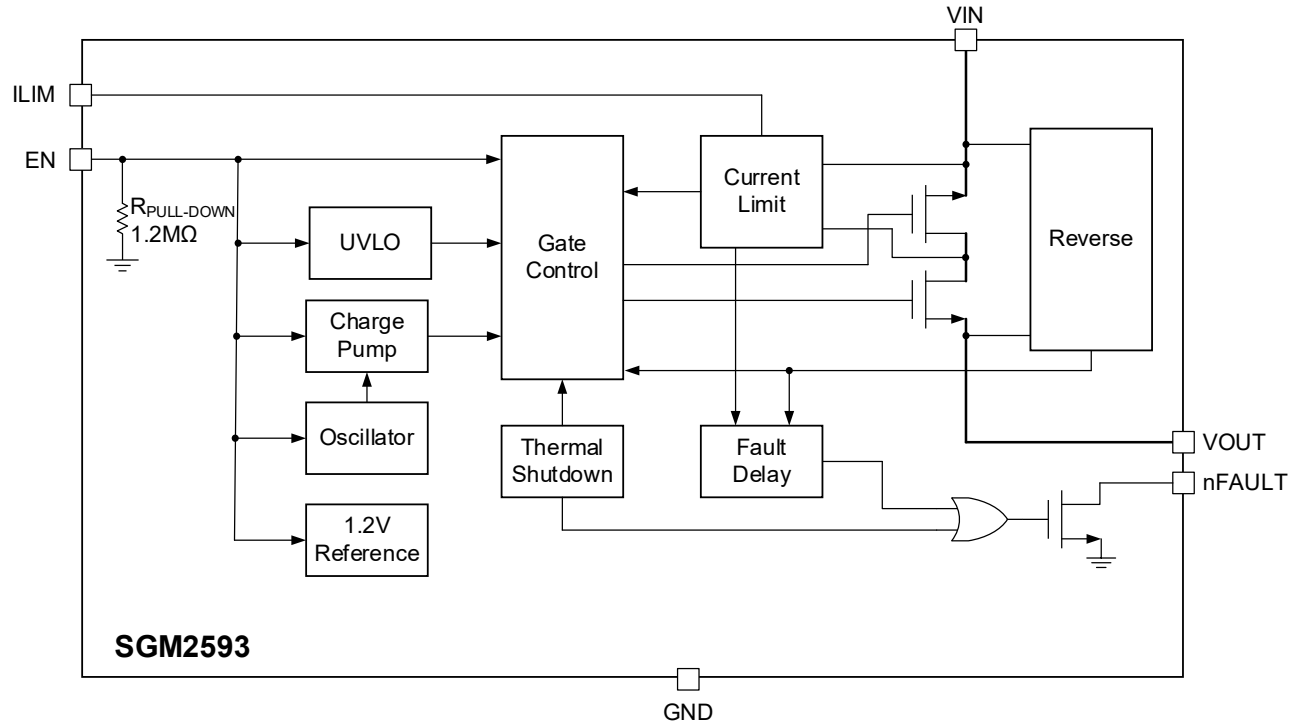


Figure 3. SGM2593 Block Diagram

TIMING DIAGRAMS

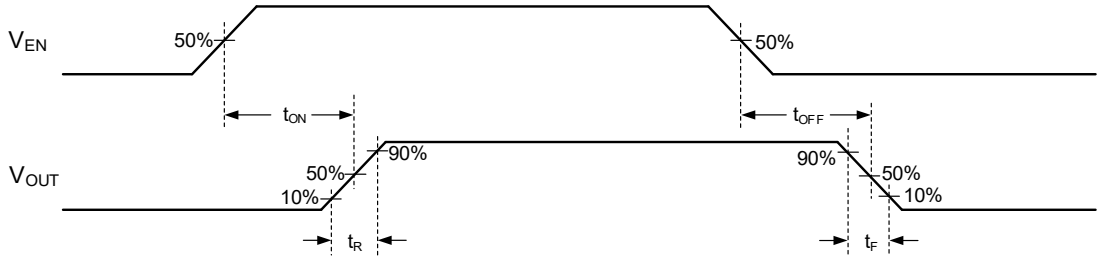


Figure 4. Switch Turn-On and Turn-Off Times

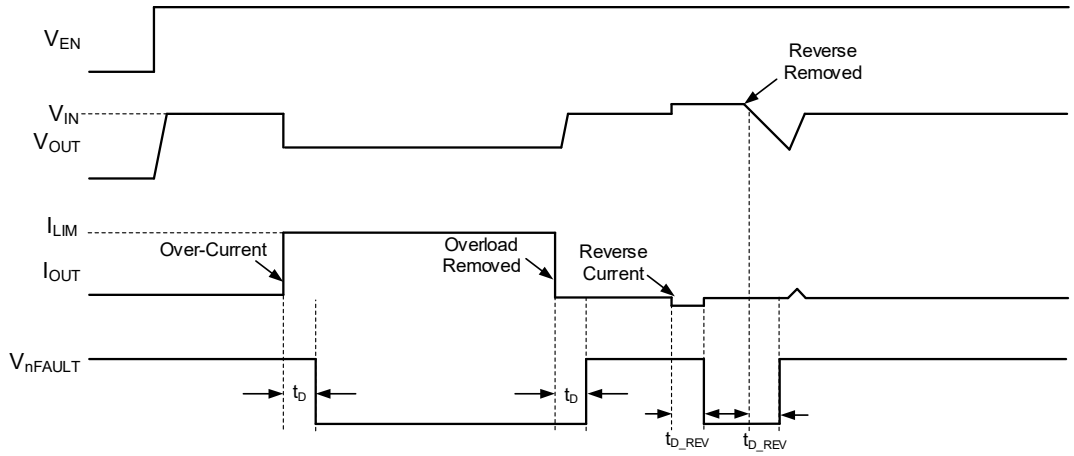


Figure 5. SGM2593D Fault Timing: Output Reset by Toggling EN

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)

The thermal shutdown threshold is +156℃ with 55℃ 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 device is designed to achieve delayed response via the internal delay "deglitch" circuit for over-current (t_D = 14ms, TYP) and reverse voltage (4ms, 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 5 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.

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

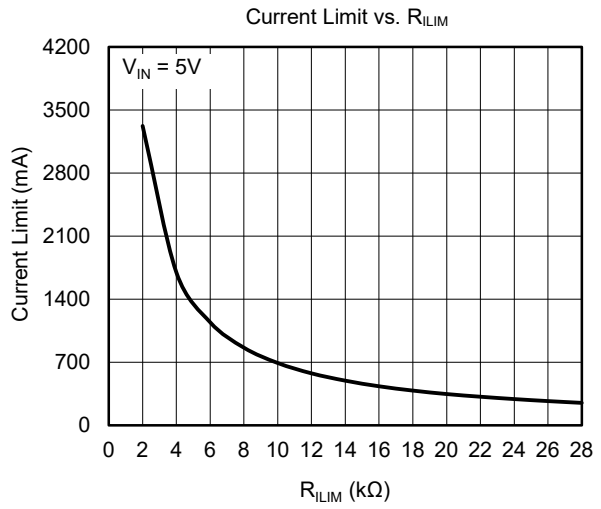


Figure 6. Current Limit Threshold (I_{LIM}) vs. Current Limit Programming Resistor (R_{ILIM})

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 10μF 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 device. 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 device as possible to minimize the effect of PCB parasitic inductance.

REVISION HISTORY

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

FEBRUARY 2024 – REV.A.2 to REV.A.3	Page
Updated the current limit equation	3, 10

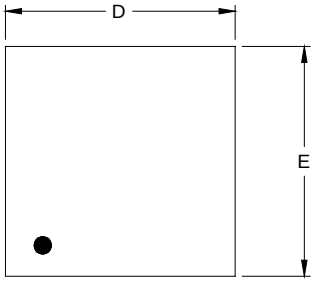
NOVEMBER 2023 – REV.A.1 to REV.A.2	Page
Added SGM2593 Model	All
Added SGM2593D SOT-23-6 Package	All
Updated Electrical Characteristics section	4

APRIL 2023 – REV.A to REV.A.1	Page
Updated Supply Filter Capacitor section	10

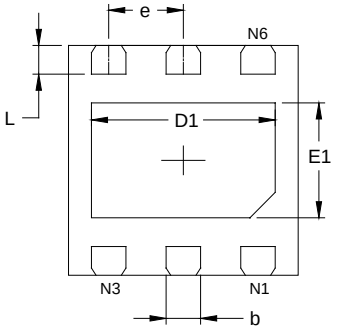
Changes from Original (MARCH 2023) to REV.A	Page
Changed from product preview to production data	All

PACKAGE OUTLINE DIMENSIONS

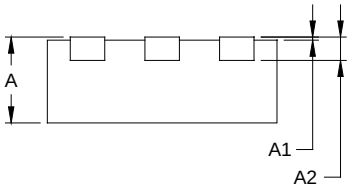
TDFN-2×2-6AL



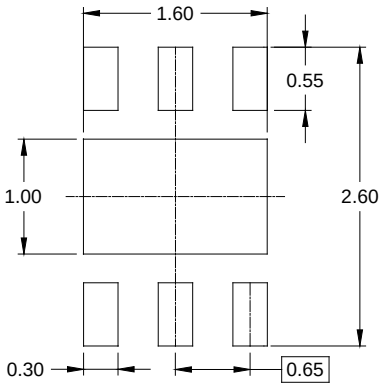
TOP VIEW



BOTTOM VIEW



SIDE VIEW



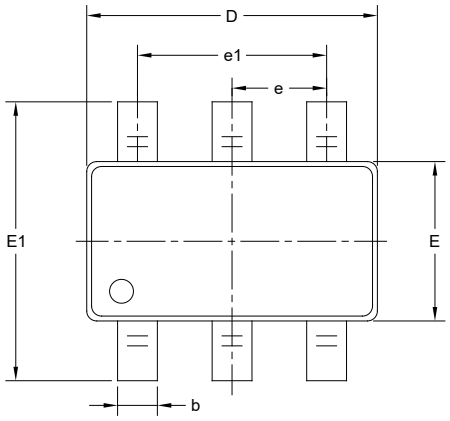
RECOMMENDED LAND PATTERN (Unit: mm)

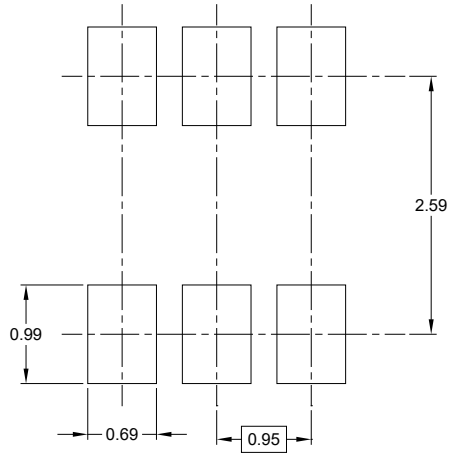
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.700	0.800	0.028	0.031
A1	0.000	0.050	0.000	0.002
A2	0.203 REF		0.008 REF	
D	1.900	2.100	0.075	0.083
D1	1.500	1.700	0.059	0.067
E	1.900	2.100	0.075	0.083
E1	0.900	1.100	0.035	0.043
b	0.250	0.350	0.010	0.014
e	0.650 BSC		0.026 BSC	
L	0.174	0.326	0.007	0.013

NOTE: This drawing is subject to change without notice.

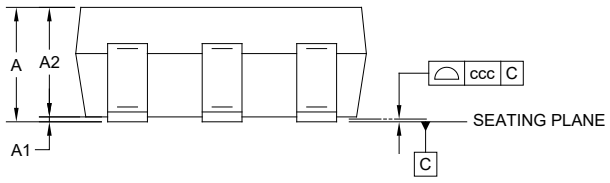
PACKAGE OUTLINE DIMENSIONS

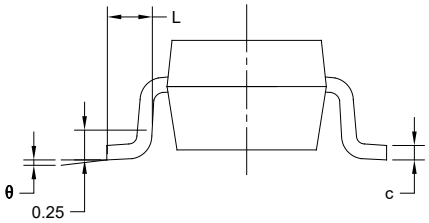
SOT-23-6





RECOMMENDED LAND PATTERN (Unit: mm)



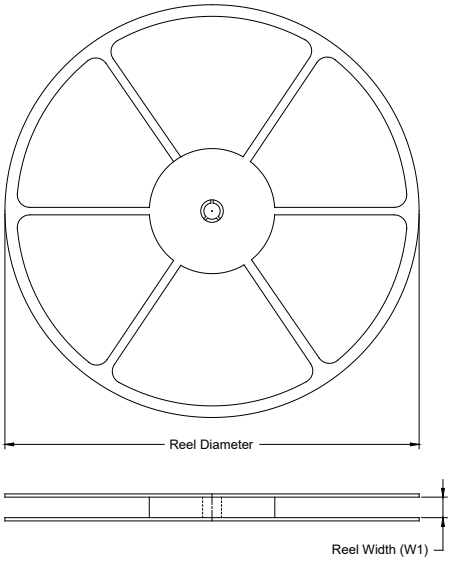


Symbol	Dimensions In Millimeters		
	MIN	MOD	MAX
A	-	-	1.450
A1	0.000	-	0.150
A2	0.900	-	1.300
b	0.300	-	0.500
c	0.080	-	0.220
D	2.750	-	3.050
E	1.450	-	1.750
E1	2.600	-	3.000
e	0.950 BSC		
e1	1.900 BSC		
L	0.300	-	0.600
θ	0°	-	8°
ccc	0.100		

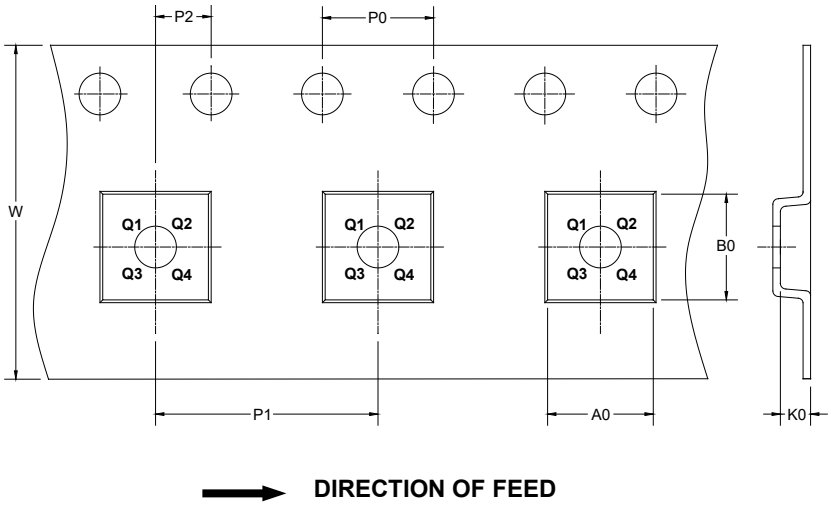
NOTES:
1. This drawing is subject to change without notice.
2. The dimensions do not include mold flashes, protrusions or gate burrs.
3. Reference JEDEC MO-178.

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



DIRECTION OF FEED

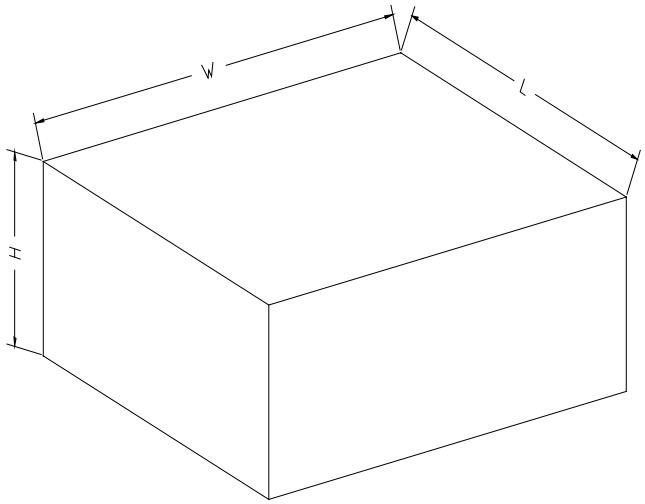
NOTE: The picture is only for reference. Please make the object as the standard.

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
SOT-23-6	7"	9.5	3.23	3.17	1.37	4.0	4.0	2.0	8.0	Q3

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