# SGM2553/SGM2553D
# Precision Adjustable Current Limited Power Distribution Switches

## GENERAL DESCRIPTION

The SGM2553 and SGM2553D power distribution switches are intended for applications where precision current limiting is required or heavy capacitive loads and short circuits are encountered and provide up to 1.5A of continuous load current. These devices offer a programmable current limit threshold between 100mA and 1.7A via an external resistor. The power switch rise and fall times are controlled to minimize current surges during turn on/off. The SGM2553D has quick auto-discharge function in disable status.

SGM2553 and SGM2553D devices limit the output current to a safe level by using a constant-current mode when the output load exceeds the current limit threshold. An internal reverse-voltage comparator disables the power switch when the output voltage is driven higher than the input to protect devices on the input side of the switch. The $\overline{\text{FAULT}}$ output asserts low during over-current, thermal shutdown and reverse-voltage conditions.

SGM2553 and SGM2553D are available in the Green TDFN-2×2-6L and SOT-23-6 packages. They are rated over the -40℃ to +85℃ temperature range.

## FEATURES

- **Up to 1.5A Maximum Load Current**
- **Meets USB Current Limiting Requirements**
- **Adjustable Current Limit: 100mA to 1.7A**
- **Fast Over-Current Response: 2μs**
- **90mΩ High-side MOSFET**
- **No Reverse Leakage Current of High-side MOSFET**
- **Reverse Input-Output Voltage Protection**
- **Operating Range: 2.5V to 5.5V**
- **Built-In Soft-Start Function**
- **Quick Auto-Discharge in Disable Status (SGM2553D)**
- **Evaluated to IEC 60950-1, Ed 2, Am1, Annex CC, Test Program 1 with CB Report**
- **Available in the Green TDFN-2×2-6L and SOT-23-6 Packages**

## APPLICATIONS

USB Ports/Hubs
Digital TV
Set-Top Boxes
VOIP Phones

## TYPICAL APPLICATION

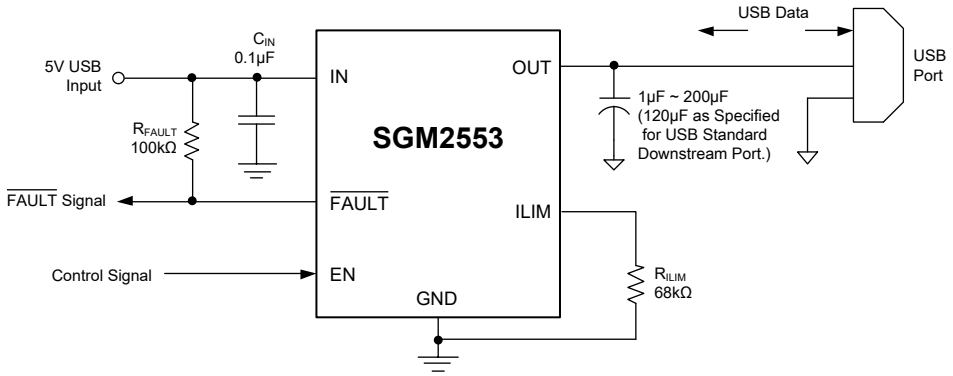



**Figure 1. Typical Application as USB Power Switch**

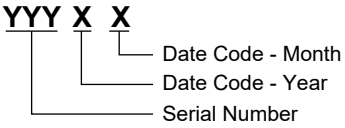
# PACKAGE/ORDERING INFORMATION

| MODEL | PACKAGE DESCRIPTION | SPECIFIED TEMPERATURE RANGE | ORDERING NUMBER | PACKAGE MARKING | PACKING OPTION |
|---|---|---|---|---|---|
| SGM2553 | SOT-23-6 | -40℃ to +85℃ | SGM2553YN6G/TR | SJ7XX | Tape and Reel, 3000 |
| | TDFN-2×2-6L | -40℃ to +85℃ | SGM2553YTDI6G/TR | 2553<br>XXXX | Tape and Reel, 3000 |
| SGM2553D | SOT-23-6 | -40℃ to +85℃ | SGM2553DYN6G/TR | SJ8XX | Tape and Reel, 3000 |
| | TDFN-2×2-6L | -40℃ to +85℃ | SGM2553DYTDI6G/TR | SJ4<br>XXXX | Tape and Reel, 3000 |

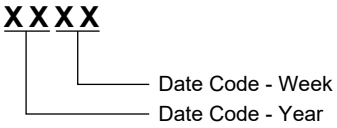
## MARKING INFORMATION

NOTE: XX = Date Code. XXXX = Date Code.

**SOT-23-6**




**TDFN-2×2-6L**




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, VOUT, EN, ILIM and $\overline{FAULT}$ to GND ..... -0.3V to 6V
Continuous Output Current..... Internally Limited
Continuous $\overline{FAULT}$ Sink Current ..... 25mA
ILIM Source Current ..... 1mA
Package Thermal Resistance
TDFN-2×2-6L, $\theta_{JA}$..... 160℃/W
SOT-23-6, $\theta_{JA}$ ..... 260℃/W
Junction Temperature .....+150℃
Storage Temperature Range.....-65℃ to +150℃
Lead Temperature (Soldering, 10s) .....+260℃
ESD Susceptibility
HBM.....2000V
MM.....200V

## RECOMMENDED OPERATING CONDITIONS

Input Voltage Range .....2.5V to 5.5V
Enable Voltage Range.....0V to 5.5V
Continuous Output Current Range .....0A to 1.5A
Current Limit Threshold Resistor Range..... 20kΩ to 387kΩ
Continuous $\overline{FAULT}$ Sink Current Range .....0mA to 10mA
Minimum Input Decoupling Capacitance ..... 0.1μF
Operating Temperature Range .....-40℃ to +85℃

## 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

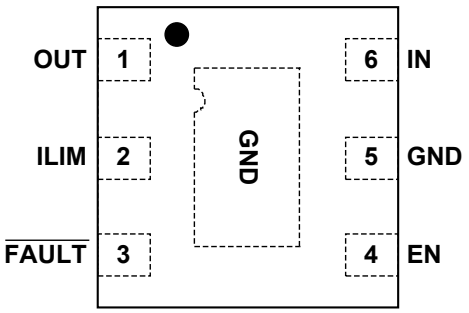
This integrated circuit can be damaged by ESD if you don't pay attention to ESD protection. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance 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.

## DISCLAIMER

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

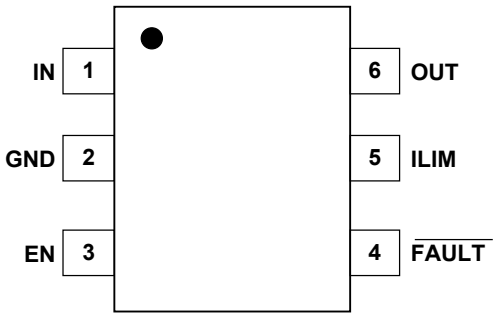
## PIN CONFIGURATIONS

(TOP VIEW)




TDFN-2×2-6L

(TOP VIEW)




SOT-23-6

## PIN DESCRIPTION

| PIN | | NAME | FUNCTION |
|---|---|---|---|
| TDFN-2×2-6L | SOT-23-6 | | |
| 1 | 6 | OUT | Power Switch Output. |
| 2 | 5 | ILIM | ILIM Pin. External resistor used to set current limit threshold; recommended 20kΩ ≤ $R_{ILIM}$ ≤ 387kΩ. $I_{LIM} = \frac{39}{R_{ILIM} + 3}$ (A) where $R_{ILIM}$ is in kΩ. |
| 3 | 4 | $\overline{FAULT}$ | Active-Low Open-Drain Output. Asserted during over-current, over-temperature, or reverse-voltage conditions. |
| 4 | 3 | EN | Enable Input. Logic high turns on power switch. |
| 5 | 2 | GND | Ground. Connect externally to exposed pad. |
| 6 | 1 | IN | Input Voltage. Connect a 0.1μF or greater ceramic capacitor from IN to GND as close to the IC as possible. |
| Exposed Pad | — | GND | Internally connected to GND; used to heat-sink the part to the circuit board traces. Connect exposed pad to GND pin externally. |

## ELECTRICAL CHARACTERISTICS

($V_{IN}$ = 5V, $R_{FAULT}$ = 10kΩ, $T_A$ = +25℃, unless otherwise noted.)

| PARAMETER | SYMBOL | CONDITIONS | | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|---|---|
| **POWER SWITCH** | | | | | | | |
| High-side MOSFET On Resistance | $R_{DS(ON)}$ | | | | 90 | 130 | mΩ |
| Output Rise Time | $t_R$ | $V_{IN}$ = 5.5V | $C_L$ = 1μF, $R_L$ = 100Ω, Figure 2 | | 1.8 | 3.5 | ms |
| | | $V_{IN}$ = 2.5V | | | 1.1 | 2.5 | |
| Output Fall Time | $t_F$ | $V_{IN}$ = 5.5V | | | 0.3 | 0.4 | |
| | | $V_{IN}$ = 2.5V | | | 0.3 | 0.4 | |
| **ENABLE INPUT** | | | | | | | |
| Logic High of Enable Pin | $V_{IH}$ | | | 1.4 | | | V |
| Logic Low of Enable Pin | $V_{IL}$ | | | | | 0.3 | V |
| Input Current | $I_{EN}$ | $V_{EN}$ = 5.5V | | | 0.01 | 1 | μA |
| Turn-On Time | $t_{ON}$ | $C_L$ = 1μF, $R_L$ = 100Ω, Figure 2 | | | 3 | 5 | ms |
| Turn-Off Time | $t_{OFF}$ | | | | 1.6 | 2.5 | ms |
| **CURRENT LIMIT** | | | | | | | |
| Current Limit Threshold (Maximum DC output current $I_{OUT}$ delivered to load), OUT connected to GND through 4Ω. | $I_{LIM}$ | $V_{IN}$ = 3V, $R_{ILIM}$ = 68kΩ | | 460 | 545 | 610 | mA |
| Response Time to Short Circuit | $t_{IOS}$ | Figure 3 | | | 2 | | μs |
| **REVERSE-VOLTAGE PROTECTION** | | | | | | | |
| Reverse-Voltage Comparator Trip Point ($V_{OUT}$ - $V_{IN}$) | | | | 115 | 160 | 205 | mV |
| Time from Reverse-Voltage Condition to MOSFET Turn-Off | | | | 3.5 | 5.5 | 7.5 | ms |
| **SUPPLY CURRENT** | | | | | | | |
| Supply Current, Low-Level Output | $I_{IN(OFF)}$ | $V_{IN}$ = 5.5V, No load on OUT, $V_{EN}$ = 0V | | | 0.1 | 2.5 | μA |
| Supply Current, High-Level Output | $I_{IN(ON)}$ | $R_{ILIM}$ = 36kΩ | $V_{IN}$ = 5.5V, No load on OUT | | 71 | 105 | μA |
| | | $R_{ILIM}$ = 68kΩ | | | 62 | 95 | |
| Reverse Leakage Current | $I_{REV}$ | $V_{OUT}$ = 5.5V, $V_{IN}$ = 0V | | | 0.01 | 1 | μA |
| **UNDER-VOLTAGE LOCKOUT** | | | | | | | |
| Under-Voltage Lockout Threshold | $V_{UVLO}$ | $V_{IN}$ Rising | | | 2.36 | 2.47 | V |
| Under-Voltage Lockout Threshold Hysteresis | | | | | 140 | | mV |
| **QUICK DISCHARGE RESISTOR (SGM2553D ONLY)** | | | | | | | |
| Discharge Resistor | $R_{Discharge}$ | | | | 45 | | Ω |
| **$\overline{\text{FAULT}}$ FLAG** | | | | | | | |
| $\overline{\text{FAULT}}$ Output Low Voltage | | $I_{FAULT}$ = 1mA | | | 95 | 150 | mV |
| Off-State Leakage | | $V_{FAULT}$ = 5.5V | | | 0.02 | 1 | μA |
| $\overline{\text{FAULT}}$ Deglitch | | $\overline{\text{FAULT}}$ assertion or de-assertion due to over-current condition. | | 6.5 | 10 | 14 | ms |
| | | $\overline{\text{FAULT}}$ assertion or de-assertion due to reverse-voltage condition. | | 3.5 | 5.5 | 7.5 | |
| **THERMAL SHUTDOWN** | | | | | | | |
| Thermal Shutdown Threshold | | | | | 140 | | ℃ |
| Thermal Shutdown Threshold in Current Limit | | | | | 115 | | ℃ |
| Thermal Shutdown Hysteresis | | | | | 10 | | ℃ |

## PARAMETER MEASUREMENT INFORMATION

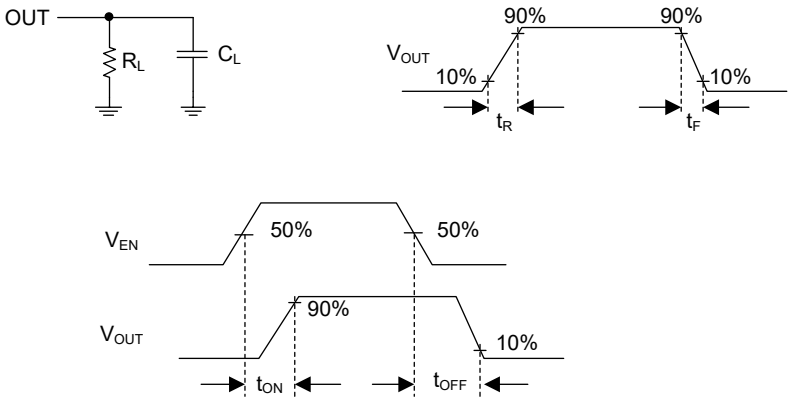



**Figure 2. Test Circuit and Voltage Waveforms**

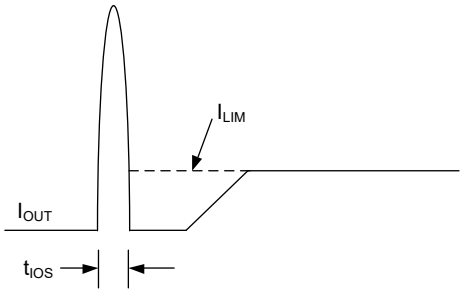



**Figure 3. Response Time to Short Circuit Waveform**

## TYPICAL APPLICATION CIRCUIT

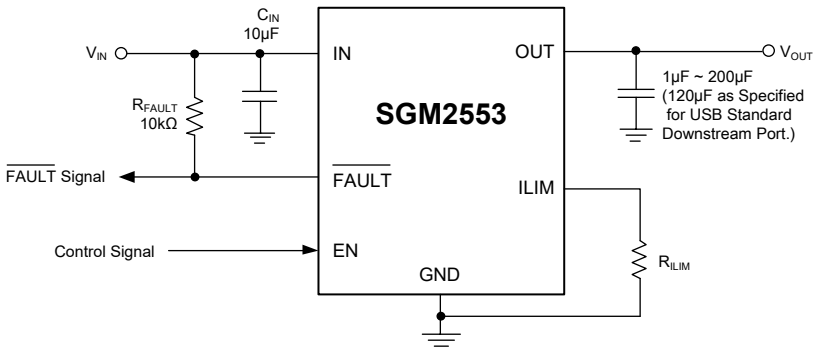
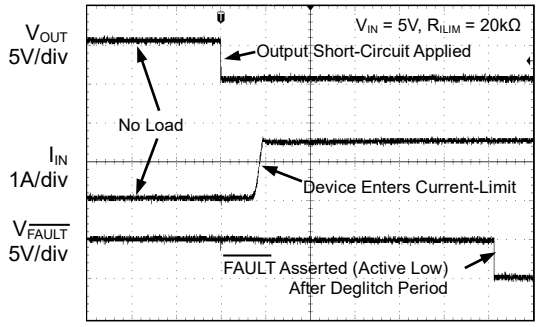



**Figure 4. Typical Characteristics Reference Schematic**

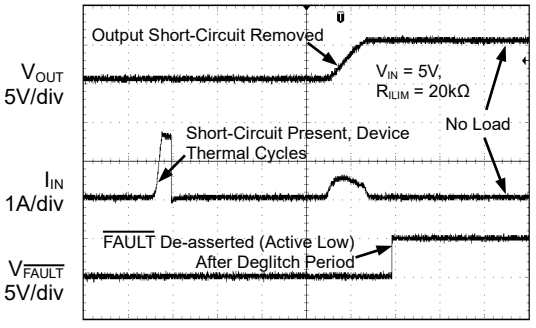
## TYPICAL PERFORMANCE CHARACTERISTICS

No-Load to Short-Circuit Transient Response



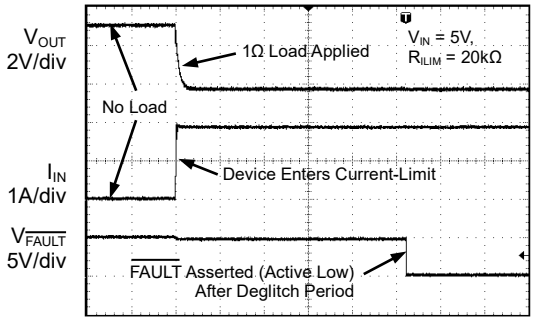

Time (2ms/div)

Short-Circuit to No-Load Recovery Response



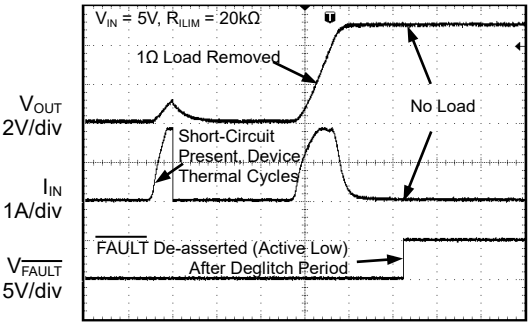

Time (2ms/div)

No-Load to 1Ω Transient Response



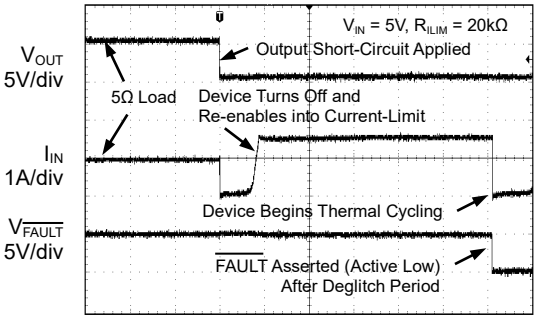

Time (2ms/div)

1Ω to No-Load Transient Response



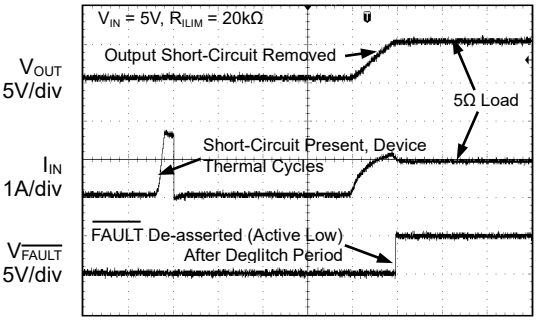

Time (2ms/div)

Full-Load to Short-Circuit Transient Response




Time (2ms/div)

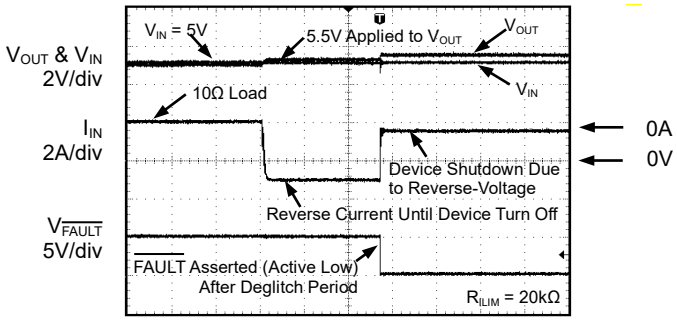
Short-Circuit to Full-Load Recovery Response




Time (2ms/div)

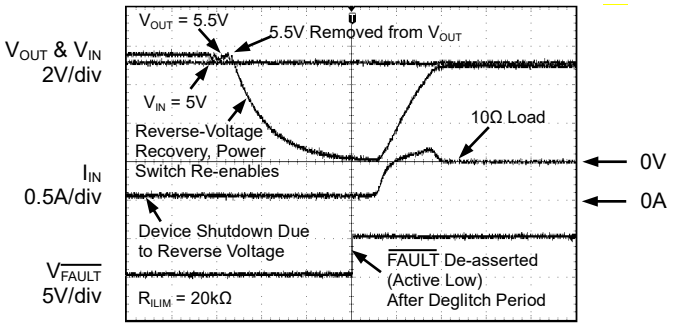
## TYPICAL PERFORMANCE CHARACTERISTICS (continued)

Reverse-Voltage Protection Response



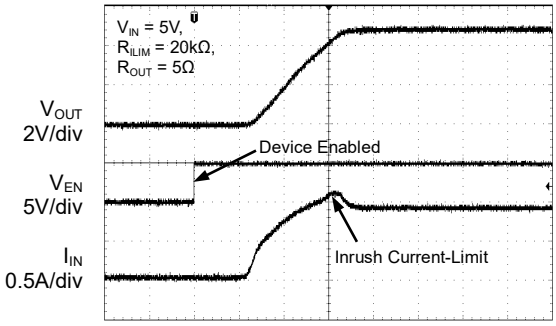

Time (2ms/div)

Reverse-Voltage Protection Recovery



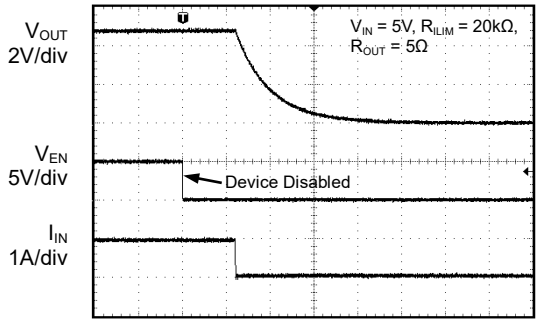

Time (2ms/div)

Turn-On Delay and Rise Time



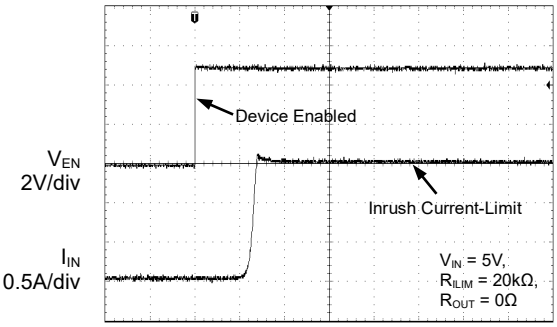

Time (1ms/div)

Turn-Off Delay and Fall Time




Time (1ms/div)

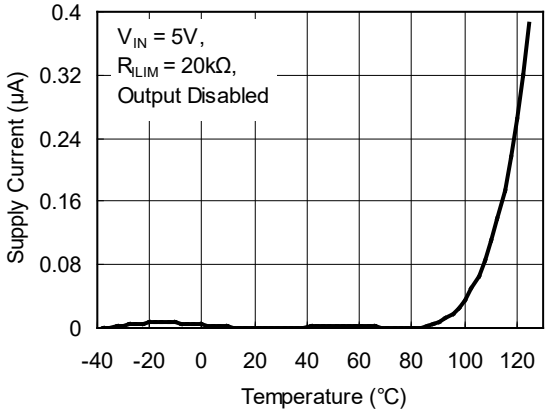
Device Enabled into Short-Circuit



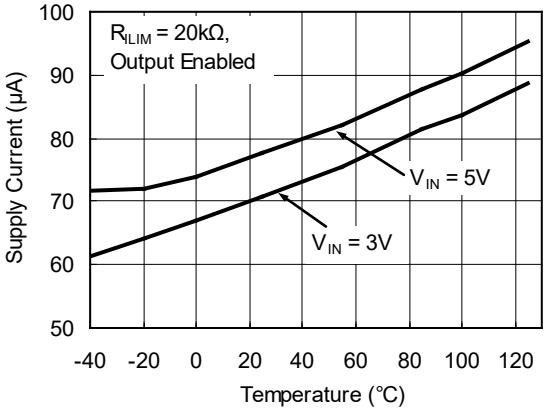

Time (1ms/div)

## TYPICAL PERFORMANCE CHARACTERISTICS (continued)

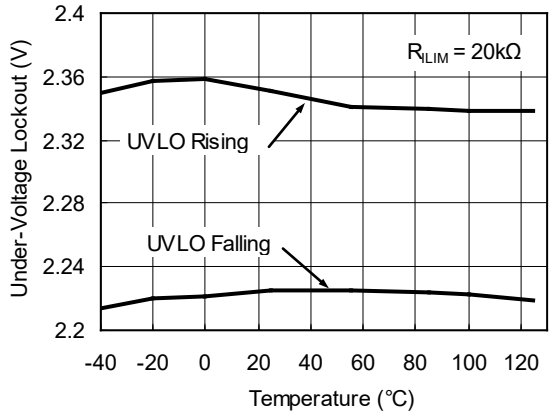
Supply Current vs. Temperature



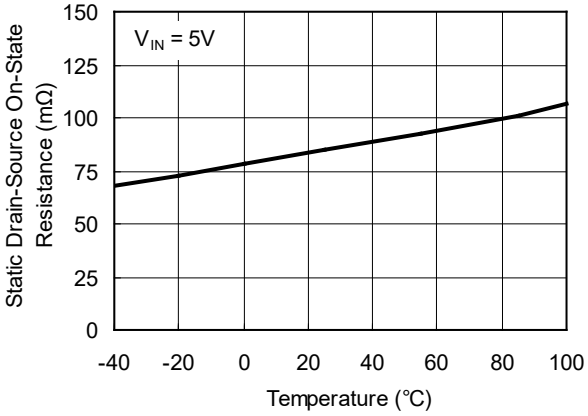

Supply Current vs. Temperature



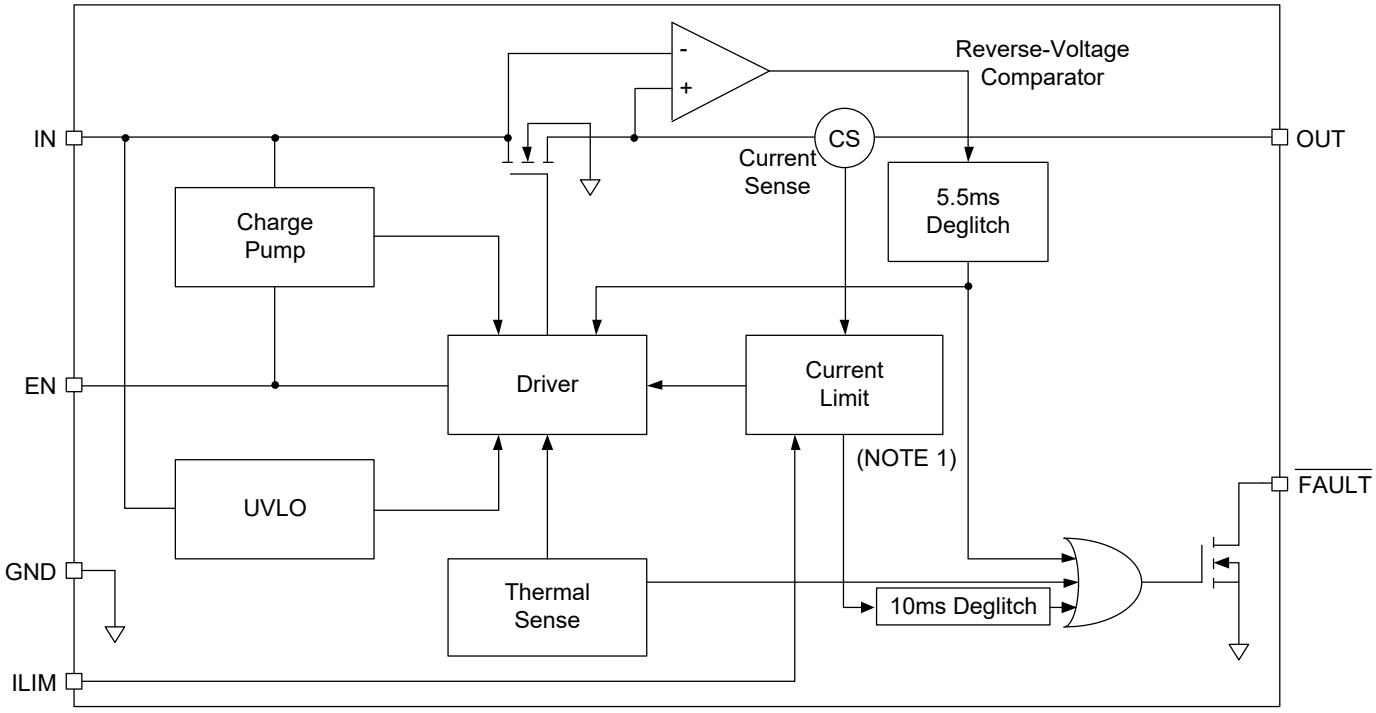

Under-Voltage Lockout vs. Temperature




MOSFET $R_{DS(ON)}$ vs. Temperature



## FUNCTIONAL BLOCK DIAGRAM




NOTE 1: SGM2553 and SGM2553D parts enter constant-current mode during current limit condition.

# DETAILED DESCRIPTION

## Overview

The SGM2553 and SGM2553D are current limited, power distribution switches using N-Channel MOSFETs for applications where short circuits or heavy capacitive loads will be encountered and provide up to 1.5A of continuous load current. These devices allow the user to program the current limit threshold between 100mA and 1.7A via an external resistor. Additional device shutdown features include over-temperature protection and reverse-voltage protection. The device incorporates an internal charge pump and gate drive circuitry necessary to drive the N-Channel MOSFET. The charge pump supplies power to the driver circuit and provides the necessary voltage to pull the gate of the MOSFET above the source. The charge pump operates from input voltages as low as 2.5V and requires little supply current. The driver controls the gate voltage of the power switch. The driver incorporates circuitry that controls the rise and fall times of the output voltage to limit large current and voltage surges and provides built-in soft-start functionality. The SGM2553 and SGM2553D enter constant-current mode when the load exceeds the current limit threshold.

## Over-Current Conditions

The SGM2553 and SGM2553D respond to over-current conditions by limiting output current to the $I_{LIM}$ levels. When an over-current condition is detected, the device maintains a constant output current and reduces the output voltage accordingly. Two possible overload conditions can occur.

The first condition is when a short circuit or partial short circuit is present when the device is powered-up or enabled. The output voltage is held near zero potential with respect to ground and the SGM2553/SGM2553D ramp the output current to $I_{LIM}$. The SGM2553 and SGM2553D devices will limit the current to $I_{LIM}$ until the overload condition is removed or the device begins to thermal cycle.

The second condition is when a short circuit, partial short circuit, or transient overload occurs while the device is enabled and powered on. The device responds to the over-current condition within time $t_{IOS}$ (see Figure 3). The current-sense amplifier is overdriven during this time and momentarily disables the internal current limit MOSFET. The current-sense amplifier recovers and limits the output current to $I_{LIM}$. Similar to the previous case, the SGM2553 and SGM2553D will limit the current to $I_{LIM}$ until the overload condition is removed or the device begins to thermal cycle.

The SGM2553 and SGM2553D thermal cycles if an overload condition is present long enough to activate thermal limiting in any of the above cases. The device turns off when the junction temperature exceeds 115℃ while in current limit. The device remains off until the junction temperature cools 10℃ and then restarts. The SGM2553 and SGM2553D cycles on/off until the overload are removed.

## Reverse-Voltage Protection

The reverse-voltage protection feature turns off the N-Channel MOSFET whenever the output voltage exceeds the input voltage by 160mV for 5.5ms. This prevents damage to devices on the input side of the SGM2553/SGM2553D by preventing significant current from sinking into the input capacitance. The SGM2553/SGM2553D devices allow the N-Channel MOSFET to turn on once the output voltage goes below the input voltage for the same 5.5ms deglitch time. The reverse-voltage comparator also asserts the $\overline{FAULT}$ output (active low) after 5.5ms.

## $\overline{FAULT}$ Response

The $\overline{FAULT}$ open-drain output is asserted (active low) during an over-current, over-temperature or reverse-voltage condition. The SGM2553 and SGM2553D assert the $\overline{FAULT}$ signal until the fault condition is removed and the device resumes normal operation. The $\overline{FAULT}$ signal is de-asserted once device power is cycled or the enable is toggled and the device resumes normal operation. The SGM2553 and SGM2553D are designed to eliminate false $\overline{FAULT}$ reporting by using an internal delay deglitch circuit for over-current (10ms) and reverse-voltage (5.5ms) conditions without the need for external circuitry. This ensures that $\overline{FAULT}$ is not accidentally asserted due to normal operation such as starting into a heavy capacitive load. The deglitch circuitry delays entering and leaving fault conditions. Over-temperature condition is not deglitched and assert the $\overline{FAULT}$ signal immediately.

## DETAILED DESCRIPTION (continued)

### Under-Voltage Lockout (UVLO)

The under-voltage lockout (UVLO) circuit disables the power switch until the input voltage reaches the UVLO turn-on threshold. Built-in hysteresis prevents unwanted on/off cycling due to input voltage drop from large current surges.

### Enable

The logic enable controls the power switch, bias for the charge pump, driver, and other circuits to reduce the supply current. The supply current is reduced to less than 1μA when a logic low is present on EN pin. A logic high input on EN enables the driver, control circuits, and power switch. The enable input is compatible with both TTL and CMOS logic levels.

### Thermal Sense

The SGM2553 and SGM2553D have self-protection feature using two independent thermal sensing circuits that monitor the operating temperature of the power switch and disable operation if the temperature exceeds recommended operating conditions. The SGM2553 and SGM2553D devices operate in constant-current mode during an over-current condition, which increases the voltage drop across power switch. The power dissipation in the package is proportional to the voltage drop across the power switch, which increases the junction temperature during an over-current condition. The first thermal sensor turns off the power switch when the die temperature exceeds 115℃ and the part is in current limit. Hysteresis is built into the thermal sensor, and the switch turns on after the device has cooled approximately 10℃.

The SGM2553 and SGM2553D also have a second ambient thermal sensor. The ambient thermal sensor turns off the power switch when the die temperature exceeds 140℃ regardless of whether the power switch is in current limit and will turn on the power switch after the device has cooled approximately 10℃. It continues to cycle off and on until the fault is removed.

The open-drain fault reporting output $\overline{\text{FAULT}}$ is asserted (active low) immediately during an over-temperature shutdown condition.

## REVISION HISTORY

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

**JUNE 2018 – REV.A.2 to REV.A.3**

| | |
|---|---|
| Update Recommended Operating Conditions | 2 |

**DECEMBER 2017 – REV.A.1 to REV.A.2**

| | |
|---|---|
| Update Feature section | 1 |

**APRIL 2015 – REV.A to REV.A.1**

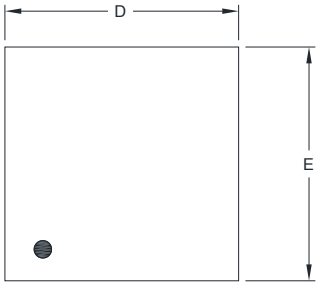
| | |
|---|---|
| Change the $C_{OUT}$ of Figure 1&4 | 1, 5 |

**Changes from Original (FEBRUARY 2015) to REV.A**

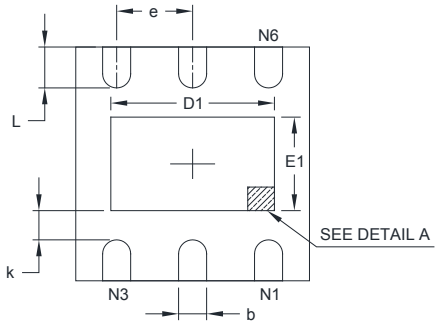
| | |
|---|---|
| Changed from product preview to production data | All |

# PACKAGE OUTLINE DIMENSIONS

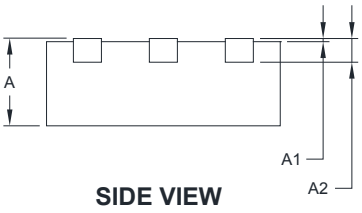
## TDFN-2×2-6L



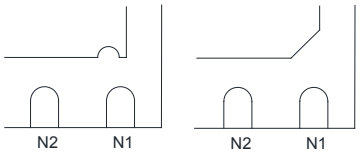

TOP VIEW




BOTTOM VIEW



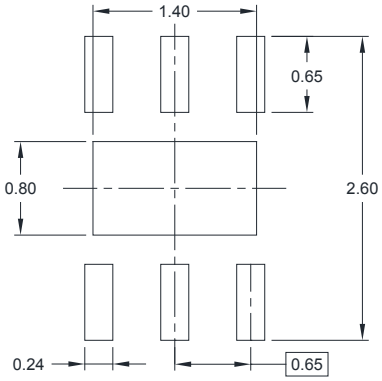

SIDE VIEW




DETAIL A

Pin #1 ID and Tie Bar Mark Options

NOTE: The configuration of the Pin #1 identifier is optional, but must be located within the zone indicated.

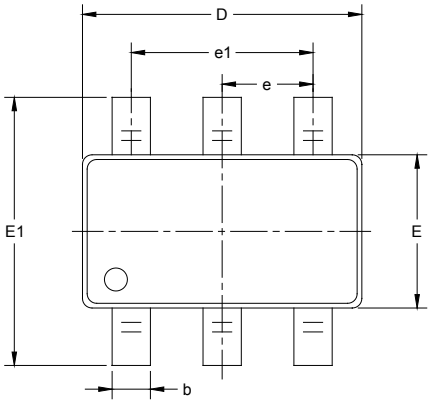


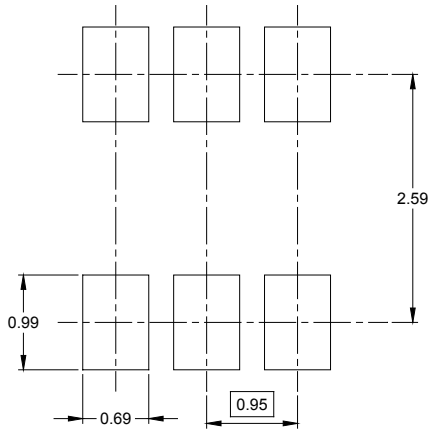

**RECOMMENDED LAND PATTERN** (Unit: mm)

| 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 | 1.100 | 1.450 | 0.043 | 0.057 |
| E | 1.900 | 2.100 | 0.075 | 0.083 |
| E1 | 0.600 | 0.850 | 0.024 | 0.034 |
| k | 0.200 MIN | | 0.008 MIN | |
| b | 0.180 | 0.300 | 0.007 | 0.012 |
| e | 0.650 TYP | | 0.026 TYP | |
| L | 0.250 | 0.450 | 0.010 | 0.018 |

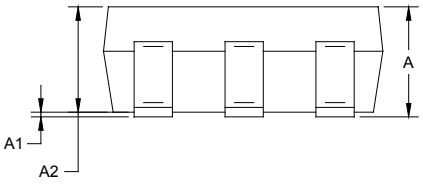
# PACKAGE OUTLINE DIMENSIONS

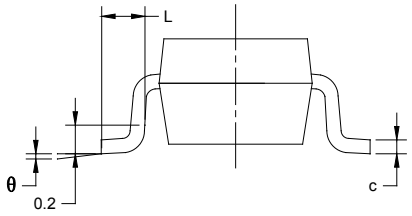
## SOT-23-6




**RECOMMENDED LAND PATTERN** (Unit: mm)

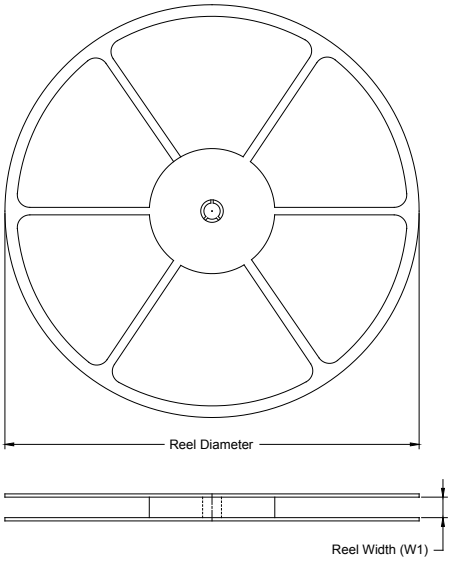


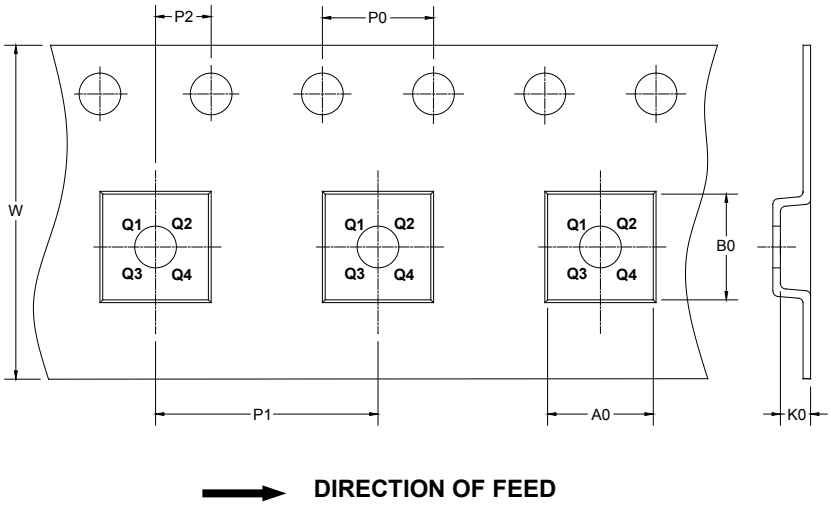

| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|---|---|---|---|---|
| | MIN | MAX | MIN | MAX |
| A | 1.050 | 1.250 | 0.041 | 0.049 |
| A1 | 0.000 | 0.100 | 0.000 | 0.004 |
| A2 | 1.050 | 1.150 | 0.041 | 0.045 |
| b | 0.300 | 0.500 | 0.012 | 0.020 |
| c | 0.100 | 0.200 | 0.004 | 0.008 |
| D | 2.820 | 3.020 | 0.111 | 0.119 |
| E | 1.500 | 1.700 | 0.059 | 0.067 |
| E1 | 2.650 | 2.950 | 0.104 | 0.116 |
| e | 0.950 BSC | | 0.037 BSC | |
| e1 | 1.900 BSC | | 0.075 BSC | |
| L | 0.300 | 0.600 | 0.012 | 0.024 |
| θ | 0° | 8° | 0° | 8° |

# TAPE AND REEL INFORMATION

### REEL DIMENSIONS




### TAPE DIMENSIONS



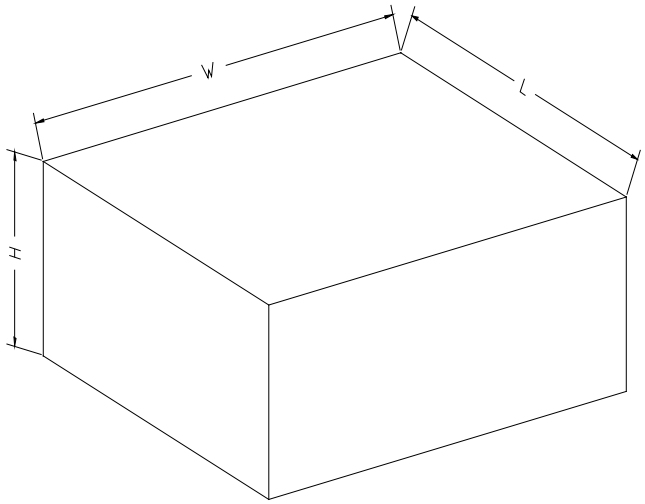

NOTE: The picture is only for reference. Please make the object as the standard.

## 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 |
|---|---|---|---|---|---|---|---|---|---|---|
| SOT-23-6 | 7″ | 9.5 | 3.17 | 3.23 | 1.37 | 4.0 | 4.0 | 2.0 | 8.0 | Q3 |
| TDFN-2×2-6L | 7″ | 9.5 | 2.30 | 2.30 | 1.10 | 4.0 | 4.0 | 2.0 | 8.0 | Q1 |

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