

### GENERAL DESCRIPTION

The SGM2521/SGM2521A/SGM2522/SGM2522A are compact electronic fuses (eFuses), which can operate from 4.5V to 24V single supply. SGM2521/1A/2/2A are designed for a wide range of applications and can provide  $\pm 7\%$  current limit accuracy at  $T_A = +25^\circ\text{C}$ .

Internal protection functions are provided for over-current protection (OCP), over-voltage protection (OVP) and under-voltage lockout (UVLO). Fault conditions are indicated by the nFLT pin.

The threshold accuracy of UV and OV is 3%, which ensures close monitoring of bus voltage and reduces the demand of monitoring circuit.

The SGM2521/1A/2/2A are available in Green SOIC-8 and TDFN-2x3-8BL packages and operate over a temperature range of  $-40^\circ\text{C}$  to  $+85^\circ\text{C}$ .

### APPLICATIONS

- Hard Drives
- PCI-E SSD
- Motherboard Power Management
- White Goods, Appliances
- Set-Top Boxes and Gaming Consoles

### FEATURES

- Wide Input Voltage Range from 4.5V to 24V with Surge up to 30V
- On-Resistance:
  - 58m $\Omega$  (SOIC-8 Package)
  - 57m $\Omega$  (TDFN-2x3-8BL Package)
- Programmable Soft-Start Time
- Programmable Current Limit: 260mA to 2A
- $\pm 7\%$  Current Limit Accuracy at  $T_A = +25^\circ\text{C}$
- Protection Features
  - ◆ Short-Circuit Protection
  - ◆ Over-Voltage Protection
  - ◆ Under-Voltage Lockout
  - ◆ Fault Output for Short-Circuit, UVLO, Thermal Shutdown and OVP
- Enable Interface Pin
- Thermal Shutdown Protection
  - SGM2521/SGM2521A: Auto-Retry
  - SGM2522/SGM2522A: Latch-Off
- $-40^\circ\text{C}$  to  $+85^\circ\text{C}$  Operating Temperature Range
- Available in Green SOIC-8 and TDFN-2x3-8BL Packages

### TYPICAL APPLICATION

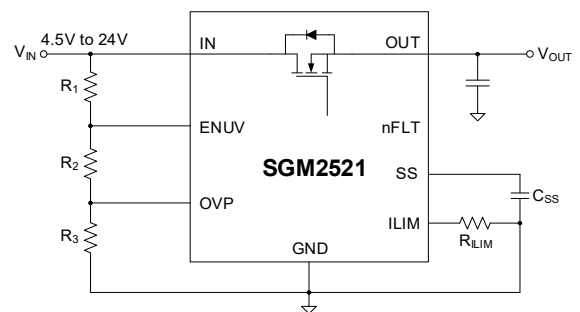


Figure 1. Typical Application Circuit

**PACKAGE/ORDERING INFORMATION**

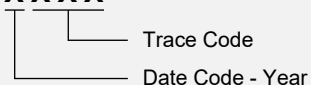
| MODEL    | PACKAGE DESCRIPTION | SPECIFIED TEMPERATURE RANGE | ORDERING NUMBER   | PACKAGE MARKING          | PACKING OPTION      |
|----------|---------------------|-----------------------------|-------------------|--------------------------|---------------------|
| SGM2521  | TDFN-2×3-8BL        | -40°C to +85°C              | SGM2521YTDC8G/TR  | 2521<br>XXXX             | Tape and Reel, 3000 |
|          | SOIC-8              | -40°C to +85°C              | SGM2521YS8G/TR    | SGM<br>2521YS8<br>XXXXX  | Tape and Reel, 4000 |
| SGM2521A | TDFN-2×3-8BL        | -40°C to +85°C              | SGM2521AYTDC8G/TR | ML6<br>XXXX              | Tape and Reel, 3000 |
|          | SOIC-8              | -40°C to +85°C              | SGM2521AYS8G/TR   | SGM<br>2521AYS8<br>XXXXX | Tape and Reel, 4000 |
| SGM2522  | TDFN-2×3-8BL        | -40°C to +85°C              | SGM2522YTDC8G/TR  | 2522<br>XXXX             | Tape and Reel, 3000 |
|          | SOIC-8              | -40°C to +85°C              | SGM2522YS8G/TR    | SGM<br>2522YS8<br>XXXXX  | Tape and Reel, 4000 |
| SGM2522A | TDFN-2×3-8BL        | -40°C to +85°C              | SGM2522AYTDC8G/TR | ML7<br>XXXX              | Tape and Reel, 3000 |
|          | SOIC-8              | -40°C to +85°C              | SGM2522AYS8G/TR   | SGM<br>2522AYS8<br>XXXXX | Tape and Reel, 4000 |

**MARKING INFORMATION**

**SGM2521: TDFN-2×3-8BL**

(1) XXXX = Date Code and Trace Code.

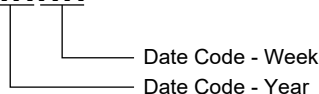
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**SGM2521A/SGM2522/SGM2522A: TDFN-2×3-8BL**

(2) XXXX = Date Code.

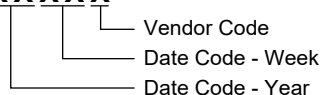
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**SOIC-8**

(3) XXXXX = Date Code and Vendor Code.

**XXXXX**



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**

|   |                 |
|---|-----------------|
| IN, OUT, ENUV, nFLT, OVP to GND.....    | -0.3V to 30V    |
| SS, ILIM to GND .....                   | -0.3V to 6V     |
| Package Thermal Resistance              |                 |
| SOIC-8, $\theta_{JA}$ .....             | 107.8°C/W       |
| TDFN-2x3-8BL, $\theta_{JA}$ .....       | 87.4°C/W        |
| Junction Temperature .....              | +150°C          |
| Storage Temperature Range.....          | -65°C to +150°C |
| Lead Temperature (Soldering, 10s) ..... | +260°C          |
| ESD Susceptibility                      |                 |
| HBM.....                                | 4000V           |
| CDM .....                               | 1000V           |

**RECOMMENDED OPERATING CONDITIONS**

|   |                 |
|---|-----------------|
| Supply Input Voltage.....                 | 4.5V to 24V     |
| Operating Ambient Temperature Range.....  | -40°C to +85°C  |
| Operating Junction Temperature Range..... | -40°C to +125°C |

**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.

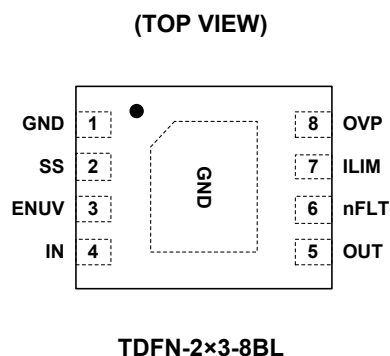
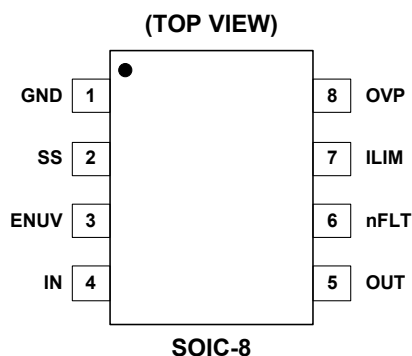
**ESD SENSITIVITY CAUTION**

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**



| PIN | NAME | FUNCTION  |
|-----|------|---|
| 1   | GND  | Ground.   |
| 2   | SS   | Soft-Start Pin. The capacitor between SS and GND pins will set the slew rate according to the application requirements.   |
| 3   | ENUV | Enable Input or Under-Voltage Lockout. The UVLO threshold is programmed by an external resistor divider. If under-voltage occurs, the internal FET will be disconnected and an error will be reported at the nFLT pin. Pull this pin to GND to reset the latch (thermal fault) of the SGM2522/SGM2522A. |
| 4   | IN   | Input Supply Voltage.   |
| 5   | OUT  | Output of the Device.   |
| 6   | nFLT | Fault Event Indicator. This pin is an open-drain output, and when a fault (under-voltage, over-voltage, short-circuit or thermal shutdown) occurs, it will be low. A fast-trip does not trigger fault.  |
| 7   | ILIM | Current Limit Programming Pin. Connect a resistor $R_{ILIM}$ from this pin to GND to set the overload and short-circuit current limit. Do not float this pin.   |
| 8   | OVP  | Over-Voltage Protection Pin. If over-voltage occurs, the internal FET will be disconnected and an error will be reported at the nFLT pin.   |

**ELECTRICAL CHARACTERISTICS**

(T<sub>J</sub> = -40°C to +85°C, V<sub>IN</sub> = 4.5V to 24V, V<sub>ENUV</sub> = 2V, V<sub>OVP</sub> = 0V, R<sub>ILIM</sub> = 95.3kΩ, C<sub>SS</sub> = open, nFLT = open, unless otherwise noted.)

| PARAMETER                                      | SYMBOL                 | CONDITIONS   | MIN   | TYP   | MAX   | UNITS |   |
|--|------------------------|--|---|-------|-------|-------|---|
| <b>Input Supply (IN)</b>                       |                        |  |   |       |       |       |   |
| Input Voltage Range                            | V <sub>IN</sub>        |  | 4.5   |       | 24    | V     |   |
| UVLO Threshold Voltage                         | V <sub>UVR</sub>       | Rising   | 4.19  | 4.27  | 4.36  | V     |   |
| UVLO Hysteresis                                | V <sub>UVHYS</sub>     |  | 190   | 230   | 270   | mV    |   |
| Supply Quiescent Current                       | I <sub>Q_ON</sub>      | V <sub>ENUV</sub> = 2V, V <sub>IN</sub> = 12V          | 0.12  | 0.17  | 0.23  | mA    |   |
| Supply Disabled Current                        | I <sub>Q_OFF</sub>     | V <sub>ENUV</sub> = 0V, V <sub>IN</sub> = 12V          | 0.1   | 0.8   | 1.4   | μA    |   |
| <b>Over-Voltage Protection (OVP)</b>           |                        |  |   |       |       |       |   |
| Over-Voltage Threshold Voltage                 | V <sub>OVP</sub>       | Rising   | 1.35  | 1.39  | 1.42  | V     |   |
|  | V <sub>OVPF</sub>      | Falling  | 1.30  | 1.33  | 1.37  | V     |   |
| OVP Input Leakage Current                      | I <sub>OVP</sub>       | 0V ≤ V <sub>OVP</sub> ≤ 18V                            | -100  | 0     | 100   | nA    |   |
| <b>Enable and Under-Voltage Lockout (ENUV)</b> |                        |  |   |       |       |       |   |
| ENUV Threshold Voltage                         | V <sub>ENR</sub>       | Rising   | 1.34  | 1.38  | 1.43  | V     |   |
|  | V <sub>ENF</sub>       | Falling  | 1.27  | 1.33  | 1.39  | V     |   |
| ENUV Threshold Voltage to Reset Thermal Fault  | V <sub>ENF_RST</sub>   | Falling  |   |       | 0.53  | V     |   |
| EN Input Leakage Current                       | I <sub>EN</sub>        | 0 ≤ V <sub>ENUV</sub> ≤ 18V                            | -100  | 0     | 100   | nA    |   |
| <b>Soft-Start: Output Ramp Control (SS)</b>    |                        |  |   |       |       |       |   |
| SS Charging Current                            | I <sub>SS</sub>        | V <sub>SS</sub> = 0V                                   | 0.72  | 1.03  | 1.33  | μA    |   |
| SS Discharging Resistance                      | R <sub>SS</sub>        | V <sub>ENUV</sub> = 0V, I <sub>SS</sub> = 10mA sinking | 47  | 67    | 89    | Ω     |   |
| SS Maximum Capacitor Voltage                   | V <sub>SSMAX</sub>     |  |   | 5.3   |       | V     |   |
| SS to OUT Gain                                 | GAIN <sub>SS</sub>     | ΔV <sub>OUT</sub> /ΔV <sub>SS</sub>                    | 4.82  | 4.95  | 5.10  | V/V   |   |
| <b>Current Limit Programming (ILIM)</b>        |                        |  |   |       |       |       |   |
| ILIM Pin Bias Current                          | I <sub>ILIM</sub>      |  | 8.8   | 10    | 11.4  | μA    |   |
| Current Limit                                  | I <sub>LIMIT</sub>     | SGM2521/2  | R <sub>ILIM</sub> = 35.7kΩ                                | 0.224 | 0.353 | 0.467 | A |
|  |                        |  | R <sub>ILIM</sub> = 45.3kΩ                                | 0.315 | 0.455 | 0.575 |   |
|  |                        |  | R <sub>ILIM</sub> = 95.3kΩ, T <sub>A</sub> = +25°C        | 0.930 | 1.000 | 1.070 |   |
|  |                        |  | R <sub>ILIM</sub> = 95.3kΩ                                | 0.884 | 1.000 | 1.114 |   |
|  |                        |  | R <sub>ILIM</sub> = 150kΩ                                 | 1.339 | 1.608 | 1.917 |   |
|  |                        |  | R <sub>ILIM</sub> = Short, shorted resistor current limit | 0.105 | 0.216 | 0.325 |   |
|  |                        | SGM2521A/2A  | R <sub>ILIM</sub> = 27kΩ, T <sub>A</sub> = +25°C          | 0.266 | 0.285 | 0.304 |   |
|  |                        |  | R <sub>ILIM</sub> = 27kΩ                                  | 0.253 | 0.285 | 0.316 |   |
|  |                        |  | R <sub>ILIM</sub> = 35.7kΩ                                | 0.281 | 0.372 | 0.454 |   |
|  |                        |  | R <sub>ILIM</sub> = 45.3kΩ                                | 0.353 | 0.466 | 0.570 |   |
|  |                        |  | R <sub>ILIM</sub> = 95.3kΩ                                | 0.704 | 0.943 | 1.172 |   |
|  |                        |  | R <sub>ILIM</sub> = 150kΩ                                 | 0.977 | 1.454 | 1.919 |   |
|  |                        |  | R <sub>ILIM</sub> = Short, shorted resistor current limit | 0.154 | 0.240 | 0.322 |   |
|  |                        |  |   |       |       |       |   |
| Fast-Trip Comparator Threshold                 | I <sub>FAST-TRIP</sub> | R <sub>ILIM</sub> in kΩ                                | 1.8 × I <sub>LIMIT</sub>                                  |       |       | A     |   |
| ILIM Open Resistor Detect Threshold            | V <sub>ILIM_OPEN</sub> | V <sub>ILIM</sub> rising, R <sub>ILIM</sub> = Open     | 2.9   | 3.0   | 3.1   | V     |   |

**ELECTRICAL CHARACTERISTICS (continued)**

( $T_J = -40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$ ,  $V_{IN} = 4.5\text{V}$  to  $24\text{V}$ ,  $V_{ENUV} = 2\text{V}$ ,  $V_{OVP} = 0\text{V}$ ,  $R_{ILIM} = 95.3\text{k}\Omega$ ,  $C_{SS} = \text{open}$ ,  $nFLT = \text{open}$ , unless otherwise noted.)

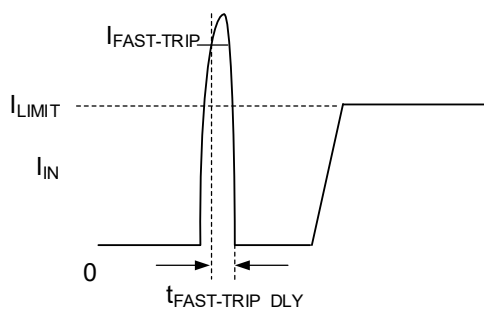
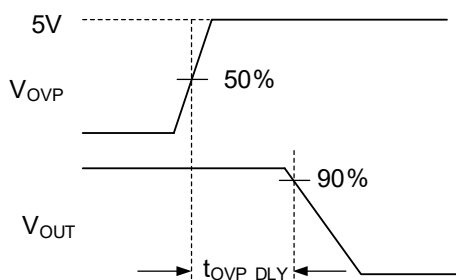
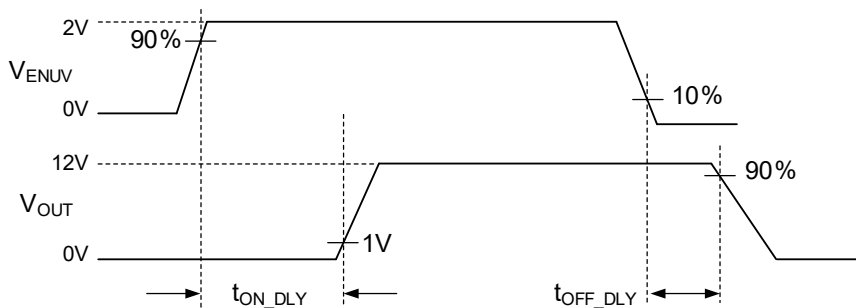
| PARAMETER                            | SYMBOL          | CONDITIONS  | MIN  | TYP | MAX | UNITS              |
|--------------------------------------|-----------------|---|------|-----|-----|--------------------|
| <b>On-Resistance (IN - OUT)</b>      |                 |   |      |     |     |                    |
| FET On-Resistance                    | $R_{DSON}$      | SOIC-8  | 34   | 58  | 81  | m $\Omega$         |
|                                      |                 | TDFN-2x3-8BL  | 35   | 57  | 81  |                    |
| <b>Pass FET Output (OUT)</b>         |                 |   |      |     |     |                    |
| OUT Bias Current in Off-State        | $I_{LKG\_OUT}$  | $V_{ENUV} = 0\text{V}$ , $V_{OUT} = 0\text{V}$ (Sourcing)                     | -0.5 | 0.1 | 0.5 | $\mu\text{A}$      |
|                                      | $I_{SINK\_OUT}$ | $V_{ENUV} = 0\text{V}$ , $V_{OUT} = 300\text{mV}$ (Sinking)                   | -0.5 | 0.2 | 0.5 |                    |
| <b>Fault Flag (nFLT): Active-Low</b> |                 |   |      |     |     |                    |
| nFLT Pull-Down Resistance            | $R_{nFLT}$      | Device in fault condition, $V_{ENUV} = 0\text{V}$ , $I_{nFLT} = 100\text{mA}$ | 24   | 31  | 41  | $\Omega$           |
| nFLT Input Leakage Current           | $I_{nFLT}$      | Device not in fault condition, $V_{nFLT} = 0\text{V}$ , $18\text{V}$          | -0.5 | 0.0 | 0.5 | $\mu\text{A}$      |
| <b>Thermal Shutdown (TSD)</b>        |                 |   |      |     |     |                    |
| Thermal Shutdown Threshold           | $T_{SD}$        | Rising  |      | 150 |     | $^{\circ}\text{C}$ |
| Thermal Shutdown Hysteresis          | $T_{HYS}$       |   |      | 20  |     | $^{\circ}\text{C}$ |

**TIMING REQUIREMENTS**

( $T_J = +25^\circ\text{C}$ ,  $V_{IN} = 12\text{V}$ ,  $V_{ENUV} = 2\text{V}$ ,  $V_{OVP} = 0\text{V}$ ,  $R_{ILIM} = 95.3\text{k}\Omega$ ,  $C_{SS} = \text{open}$ ,  $n\text{FLT} = \text{open}$ , unless otherwise noted.)

| PARAMETER   | SYMBOL                      | CONDITIONS   | MIN  | TYP  | MAX  | UNITS         |
|---|-----------------------------|--|------|------|------|---------------|
| <b>Enable and Under-Voltage Lockout (ENUV)</b>  |                             |  |      |      |      |               |
| Turn-On Delay   | $t_{\text{ON\_DLY}}$        | ENUV $\uparrow$ to $V_{\text{OUT}} = 1\text{V}$ , $C_{\text{SS}} = \text{open}$  |      | 96   |      | $\mu\text{s}$ |
| Turn-Off Delay  | $t_{\text{OFF\_DLY}}$       | ENUV $\downarrow$ to $V_{\text{OUT}}\downarrow$  |      | 8    |      | $\mu\text{s}$ |
| <b>Over-Voltage Protection (OVP)</b>  |                             |  |      |      |      |               |
| OVP Disable Delay   | $t_{\text{OVP\_DLY}}$       | OVP $\uparrow$ to $V_{\text{OUT}}\downarrow$   |      | 8    |      | $\mu\text{s}$ |
| <b>Soft-Start: Output Ramp Control (SS)</b>   |                             |  |      |      |      |               |
| Output Ramp Time  | $t_{\text{SS}}$             | ENUV $\uparrow$ to $V_{\text{OUT}} = 11\text{V}$ , with $C_{\text{SS}} = \text{open}$ , $C_{\text{OUT}} = 2.2\mu\text{F}$  | 0.17 | 0.27 | 0.38 | ms            |
|   |                             | ENUV $\uparrow$ to $V_{\text{OUT}} = 11\text{V}$ , with $C_{\text{SS}} = 1.2\text{nF}$ , $C_{\text{OUT}} = 2.2\mu\text{F}$ | 1.7  | 2.9  | 3.8  |               |
| <b>Current Limit Programming (ILIM)</b>   |                             |  |      |      |      |               |
| Fast-Trip Comparator Delay  | $t_{\text{FAST-TRIP\_DLY}}$ | $I_{\text{OUT}} > I_{\text{FAST-TRIP}}$  |      | 3    |      | $\mu\text{s}$ |
| <b>Thermal Shutdown (TSD)</b>   |                             |  |      |      |      |               |
| Retry Delay after Thermal Shutdown Recovery, $T_J < [T_{\text{SD}} - 20^\circ\text{C}]$ | $t_{\text{SD\_DLY}}$        | SGM2521/SGM2521A only, $V_{\text{IN}} = 12\text{V}$  |      | 130  |      | ms            |
|   |                             | SGM2521/SGM2521A only, $V_{\text{IN}} = 4.5\text{V}$   |      | 130  |      | ms            |

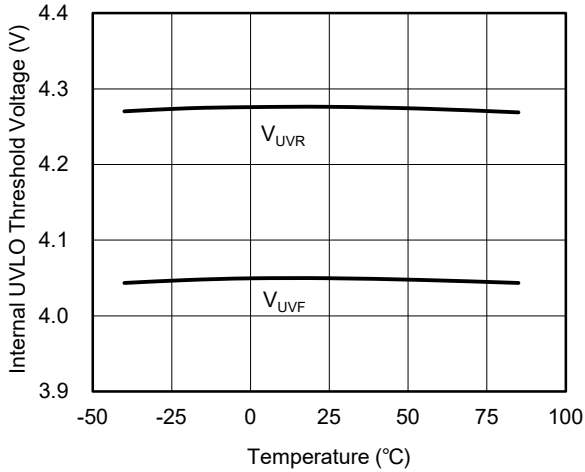
**PARAMETRIC MEASUREMENT INFORMATION**



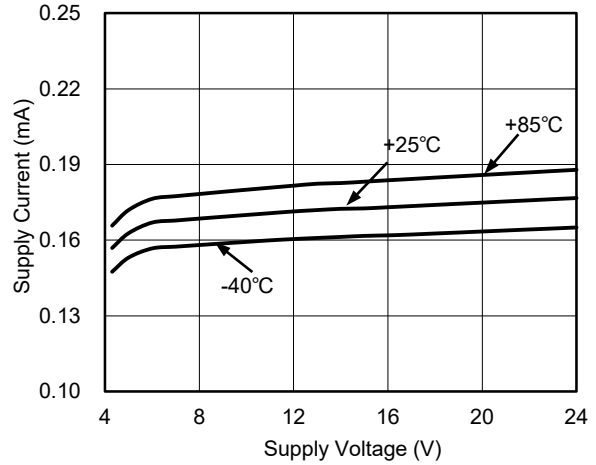
**TYPICAL PERFORMANCE CHARACTERISTICS**

$T_J = +25^\circ\text{C}$ ,  $V_{IN} = 4.5\text{V to } 24\text{V}$ ,  $V_{ENUV} = 2\text{V}$ ,  $V_{OVP} = 0\text{V}$ ,  $R_{ILIM} = 95.3\text{k}\Omega$ ,  $C_{SS} = \text{open}$ ,  $nFLT = \text{open}$ , unless otherwise noted.

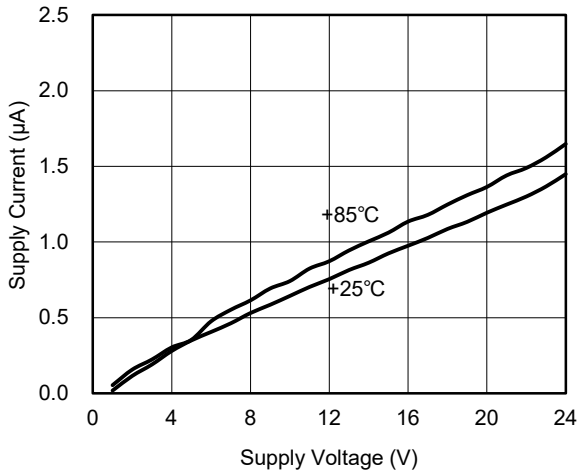
UVLO Threshold Voltage vs. Temperature



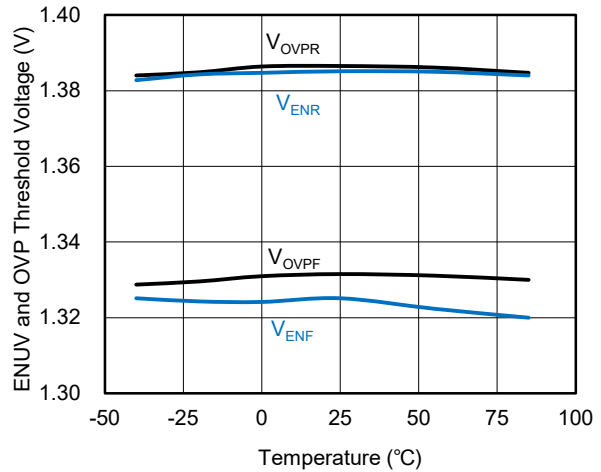
Input Supply Current vs. Supply Voltage during Normal Operation



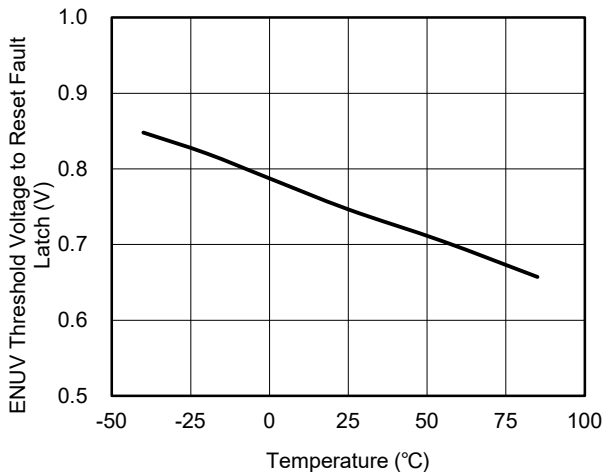
Input Supply Current vs. Supply Voltage at Shutdown



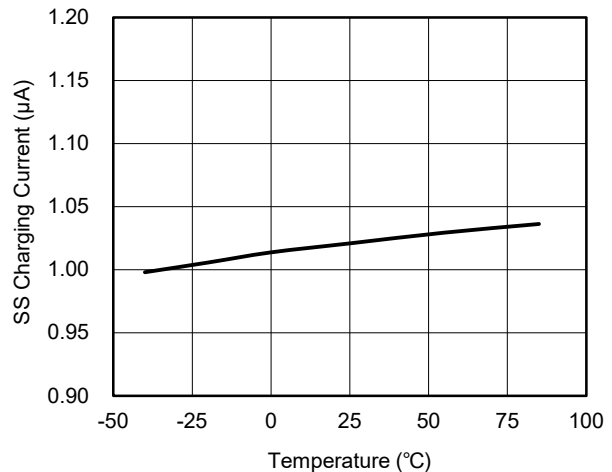
ENUV and OVP Threshold Voltage vs. Temperature



ENUV Threshold Voltage to Reset Fault Latch vs. Temperature



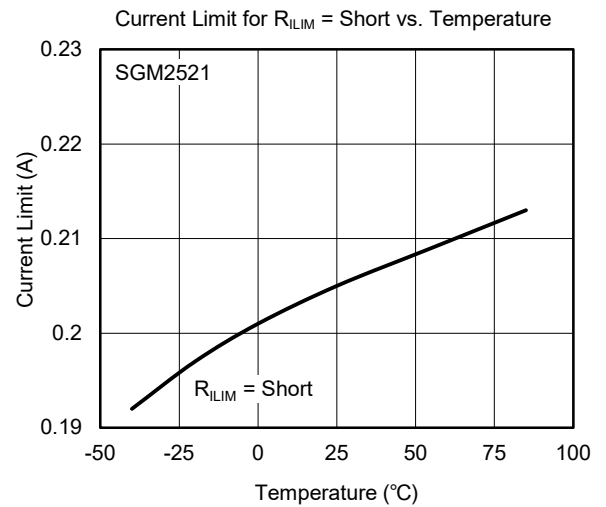
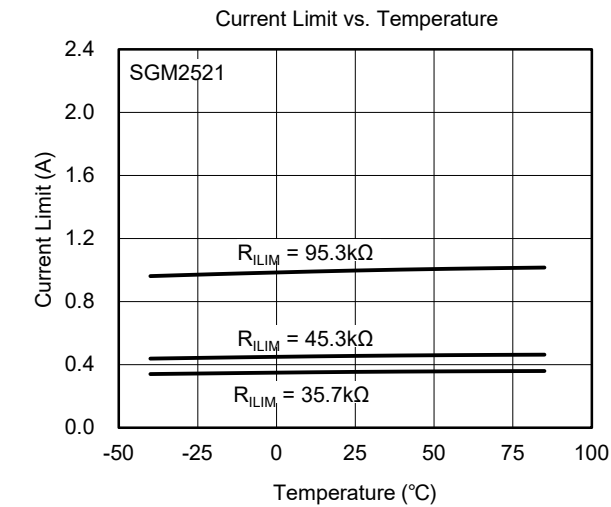
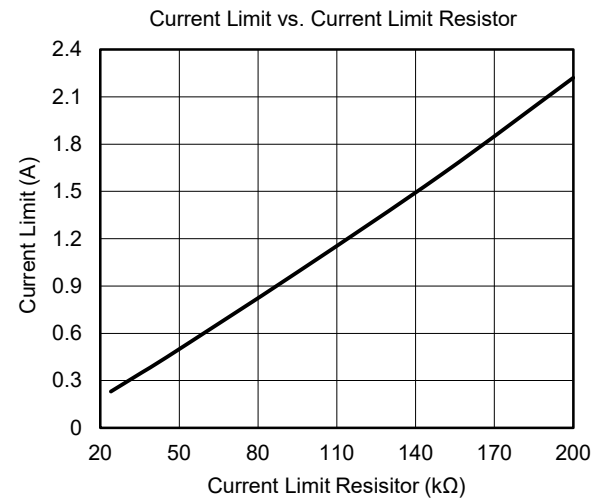
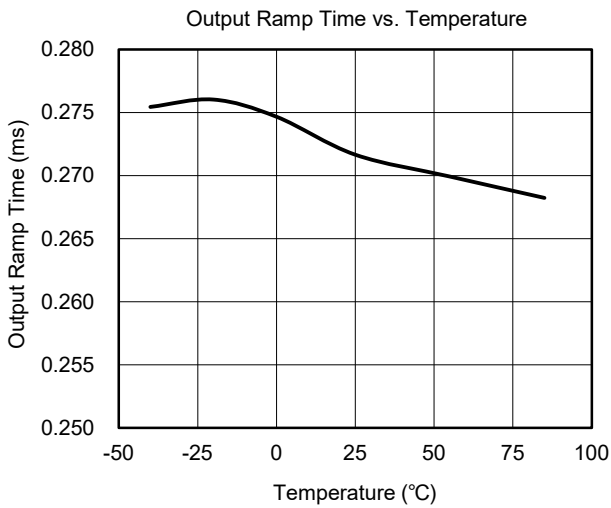
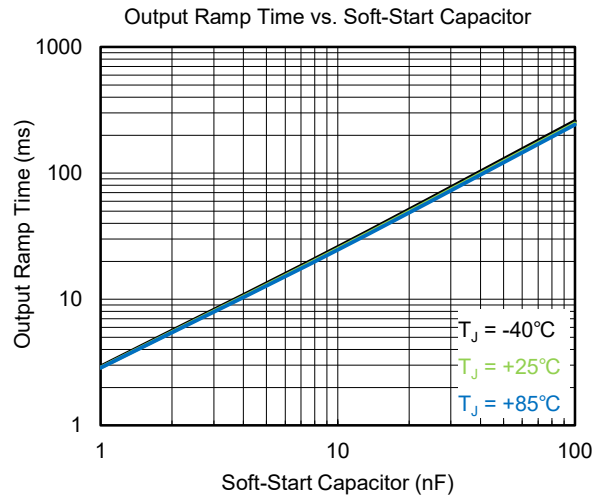
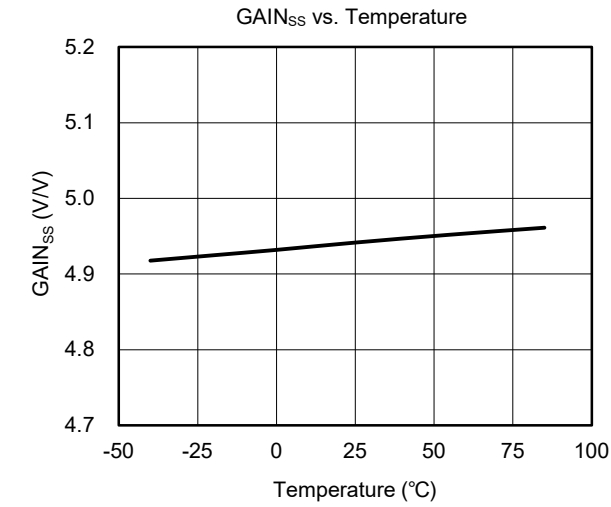
SS Charging Current vs. Temperature





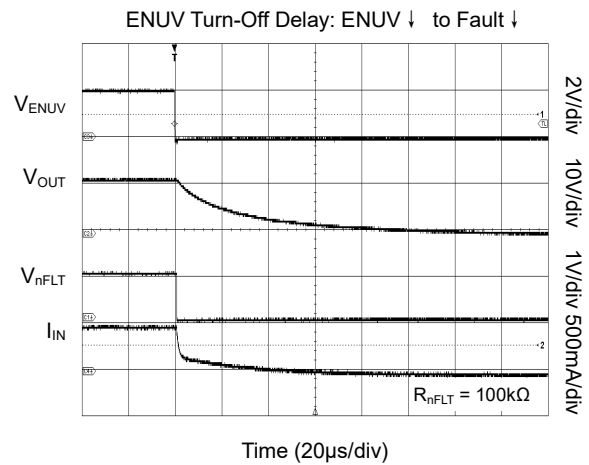
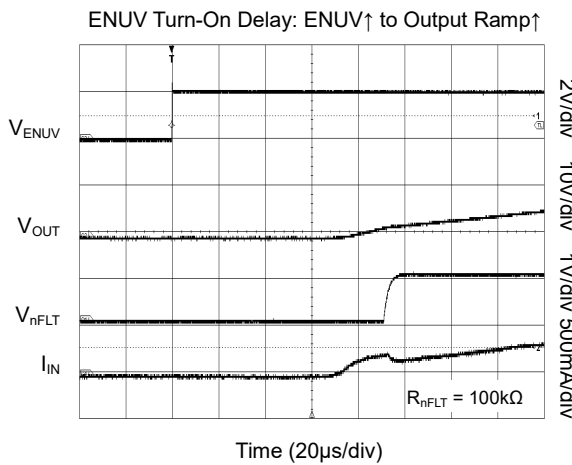
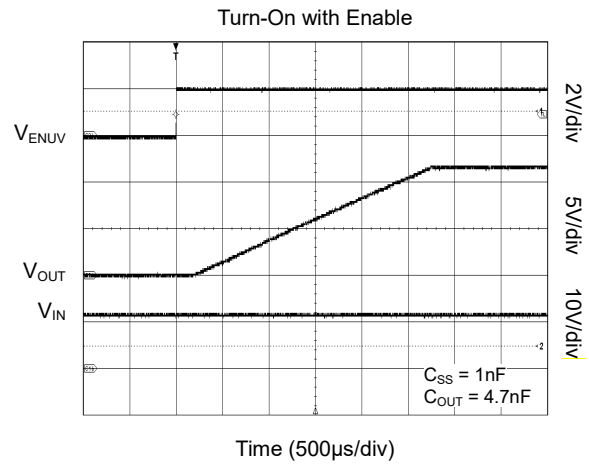
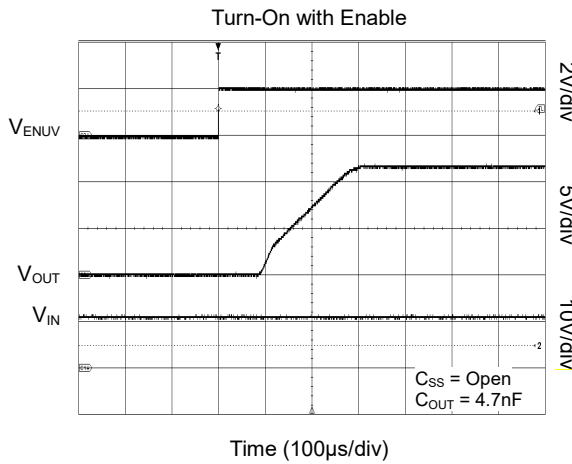
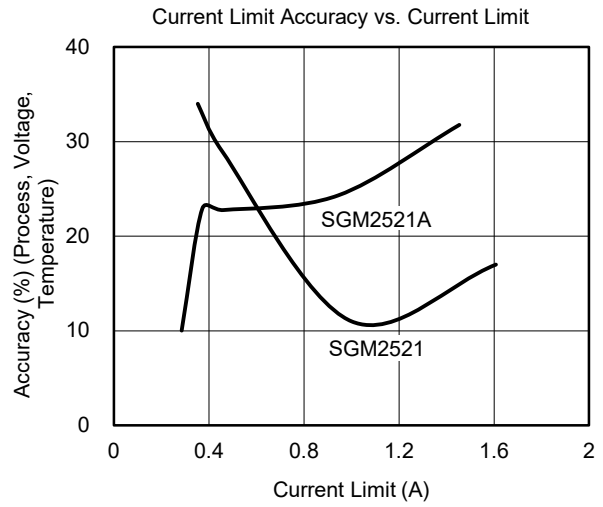
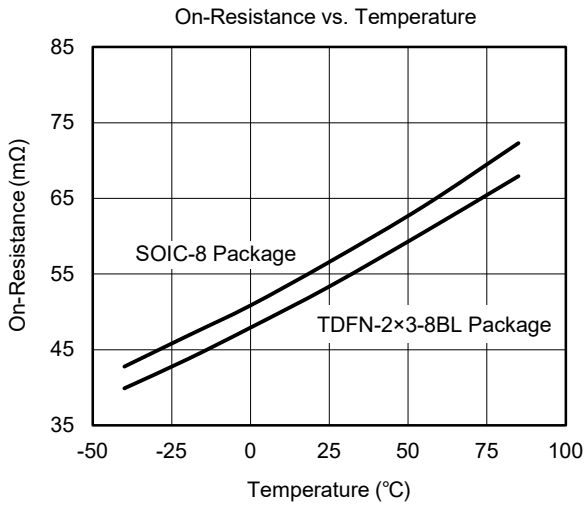
**TYPICAL PERFORMANCE CHARACTERISTICS (continued)**

$T_J = +25^\circ\text{C}$ ,  $V_{IN} = 4.5\text{V to }24\text{V}$ ,  $V_{ENUV} = 2\text{V}$ ,  $V_{OVP} = 0\text{V}$ ,  $R_{ILIM} = 95.3\text{k}\Omega$ ,  $C_{SS} = \text{open}$ ,  $nFLT = \text{open}$ , unless otherwise noted.



**TYPICAL PERFORMANCE CHARACTERISTICS (continued)**

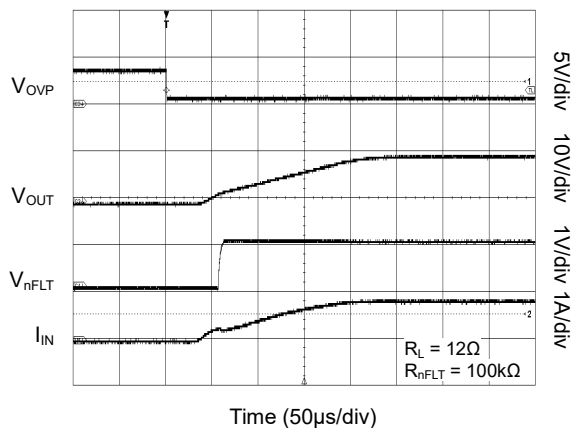
$T_J = +25^\circ\text{C}$ ,  $V_{IN} = 4.5\text{V to } 24\text{V}$ ,  $V_{ENUV} = 2\text{V}$ ,  $V_{OVP} = 0\text{V}$ ,  $R_{ILIM} = 95.3\text{k}\Omega$ ,  $C_{SS} = \text{open}$ ,  $nFLT = \text{open}$ , unless otherwise noted.



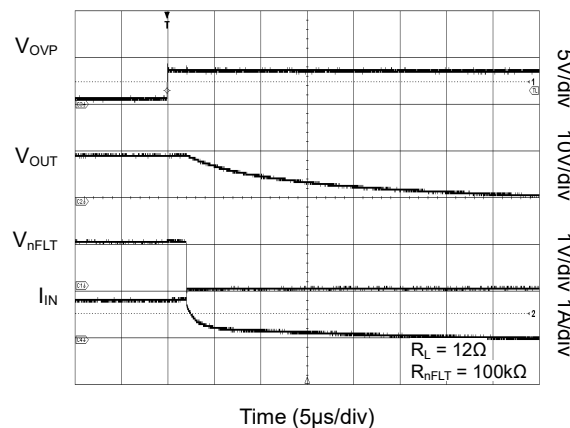
**TYPICAL PERFORMANCE CHARACTERISTICS (continued)**

$T_J = +25^\circ\text{C}$ ,  $V_{IN} = 4.5\text{V to }24\text{V}$ ,  $V_{ENUV} = 2\text{V}$ ,  $V_{OVP} = 0\text{V}$ ,  $R_{LIM} = 95.3\text{k}\Omega$ ,  $C_{SS} = \text{open}$ ,  $nFLT = \text{open}$ , unless otherwise noted.

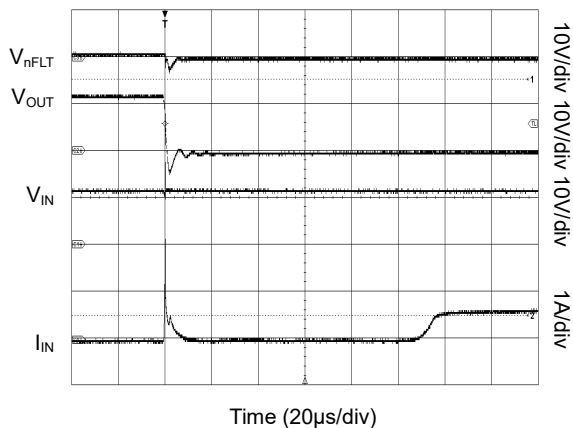
OVP Turn-On Delay: OVP↓ to Output Ramp↑



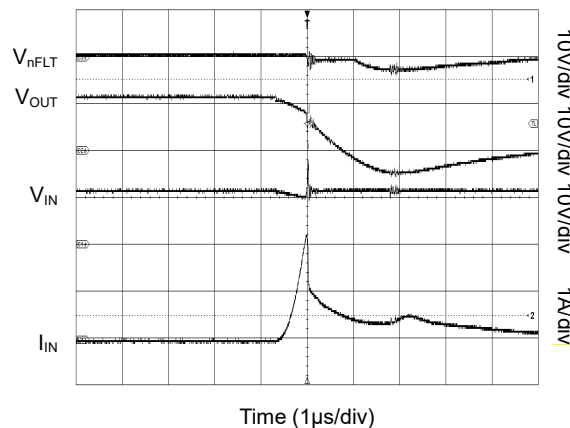
OVP Turn-Off Delay: OVP↑ to Fault↓



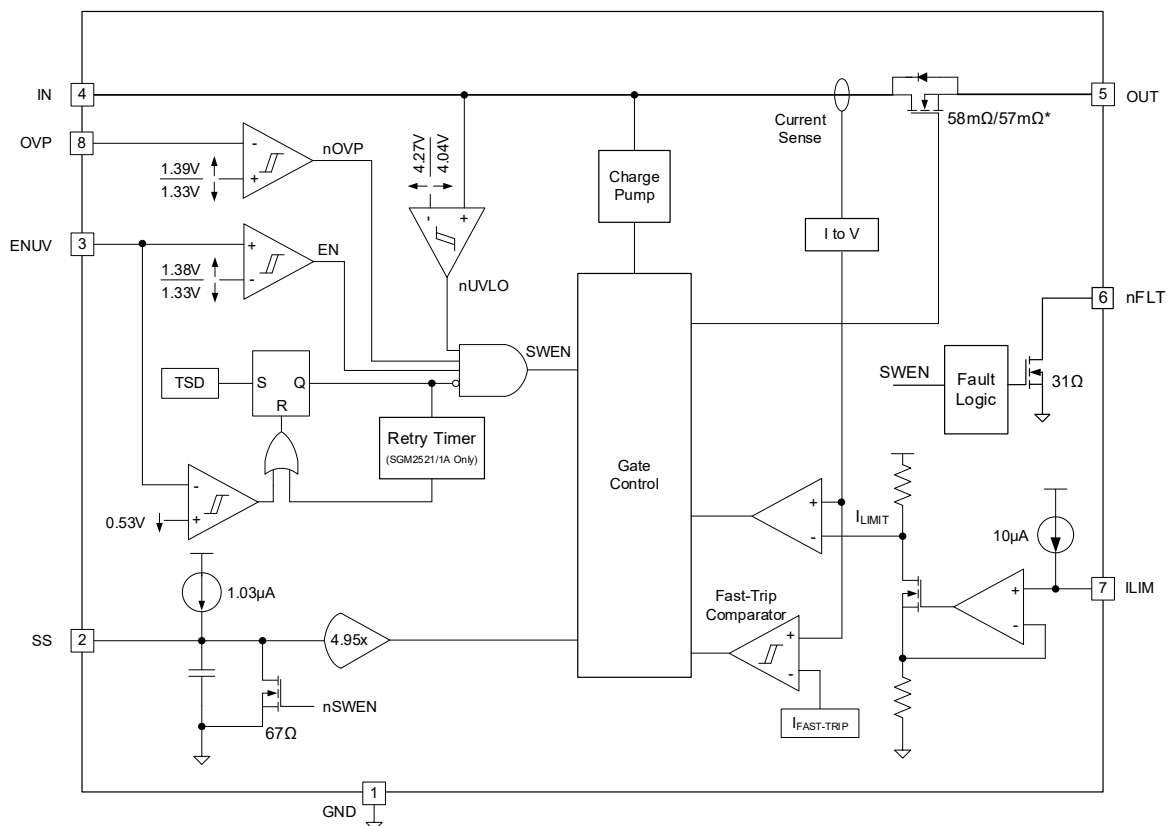
Hot-Short: Fast-Trip Response and Current Regulation



Hot-Short: Fast-Trip Response (Zoomed)



**FUNCTIONAL BLOCK DIAGRAM**



NOTE \*: 58mΩ for SOIC-8 Package  
 57mΩ for TDFN-2×3-8BL Package

**Figure 2. Functional Block Diagram**

**DETAILED DESCRIPTION**

**Overview**

The SGM2521/1A/2/2A family is an 8-pin, 4.5V to 24V eFuse with thermal shutdown. To reduce voltage drop for low voltage and high current rails, the device implements a low on-resistance N-MOSFET which reduces the dropout voltage across the device.

The configurable rise time of the device greatly reduces inrush current caused by large bulk load capacitances or hot-plug boards, thereby reducing or eliminating power supply drop. The current limit threshold can be programmed between 0.26A and 2A through an external resistor.

When the output load exceeds the current limit threshold or a short-circuit event is present, the device limits the output current to a safe level by increasing the on-resistance of the power switch. Continuous heavy overloads and short-circuits that increase power dissipation of the switch can cause the junction temperature to rise, in which case thermal protection circuit will shut off the switch to prevent damage.

The device starts its operation by monitoring the  $V_{IN}$  bus. When  $V_{IN}$  exceeds the under-voltage lockout threshold, the device samples the ENUV pin. A high level on this pin enables the internal N-MOSFET. When  $V_{IN}$  exceeds UVLO threshold and  $V_{ENUV}$  exceeds 1.38V, the internal N-MOSFET of the device starts conducting and allows current to flow from IN to OUT. When  $V_{ENUV}$  is held low (below  $V_{ENF}$ ), internal N-MOSFET is turned off. When the voltage of OVP pin is more than  $V_{OVPR}$ , the internal N-MOSFET is turned off and protects the downstream load. The device also features a fault flag output (nFLT) pin to monitor system status and control downstream load. The device has a thermal protection feature to protect itself against thermal damage due to over-temperature.

**Adjustable Enable and Under-Voltage Lockout (UVLO)**

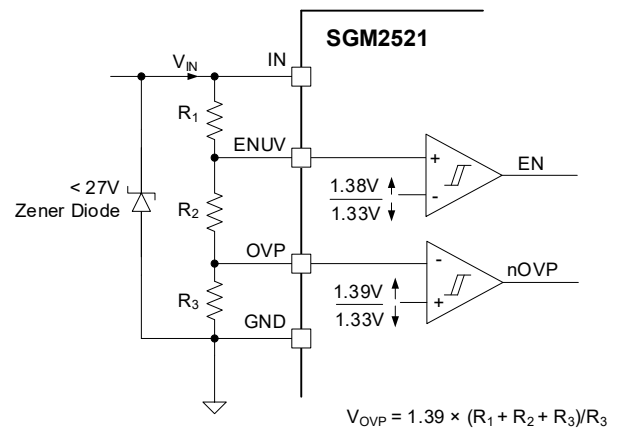
The ENUV pin controls the state of the switch. In its high-state, the internal N-MOSFET is enabled. A low level on this pin turns off the internal N-MOSFET. High and low levels are specified in the electrical

characteristics of the datasheet.

It is recommended to add an external bypass capacitor between ENUV and GND pins to avoid the noise of instability power or probabilistic power failure. As an under-voltage lockout pin, the UVLO threshold is programmed by an external resistor divider, as shown in Figure 3.

Once the input rail under-voltage occurs, the N-MOSFET will be turned off quickly. Connect the ENUV pin to the  $V_{IN}$  rail to avoid this function if it is not needed. Do not leave the ENUV pin floating.

The device implements the input UVLO and sets two UVLOs in combination with ENUV. If  $V_{IN} < V_{UVF}$ , the device is disabled and ENUV can set the  $V_{IN}$  rise threshold, so the device can set the section active voltage to avoid the input rail fluctuation.



**Figure 3. ENUV and Input OVP Set by  $R_1$ ,  $R_2$  and  $R_3$**

**Over-Voltage Protection (OVP)**

The SGM2521/1A/2/2A family features over-voltage protection function. The over-voltage threshold is programmed by the resistor divider from the power supply to the OVP terminal and to GND, as shown in Figure 3. If the voltage of OVP pin is higher than  $V_{OVPR}$ , the device turns off the internal N-MOSFET. If not used, connect this pin to GND.

**DETAILED DESCRIPTION (continued)**

**Hot-Plug and Inrush Current Restrict**

In the use of hot-plug boards, the surge current limits the voltage drop of the backplane power supply voltage and will lead to the unintended resets of the system power supply. The capacitor between SS and GND pins will set the slew rate according to the application requirements. An approximate formula for the relationship between  $C_{SS}$  and slew rate is shown in Equation 1:

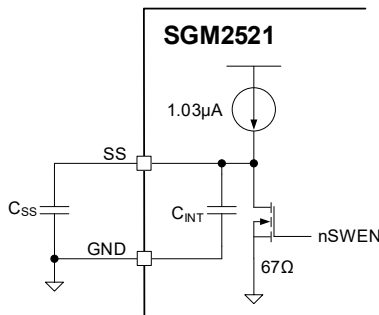
$$I_{SS} = \frac{C_{SS}}{GAIN_{SS}} \times \frac{dV_{OUT}}{dt} \tag{1}$$

where:

$$I_{SS} = 1.03\mu A \text{ (TYP)}$$

$$dV_{OUT}/dt = \text{Target output slew rate}$$

$$GAIN_{SS} = \Delta V_{OUT}/\Delta V_{SS} = 4.95$$



**Figure 4. Output Ramp Time  $t_{SS}$  is Set by  $C_{SS}$**

Equation 2 shows how to calculate the total output ramp time ( $t_{SS}$ ) when the output rises from 0V to  $V_{IN}$ :

$$t_{SS} = 20.04 \times 10^4 \times V_{IN} \times C_{SS} \tag{2}$$

where  $C_{SS}$  is in Farad.

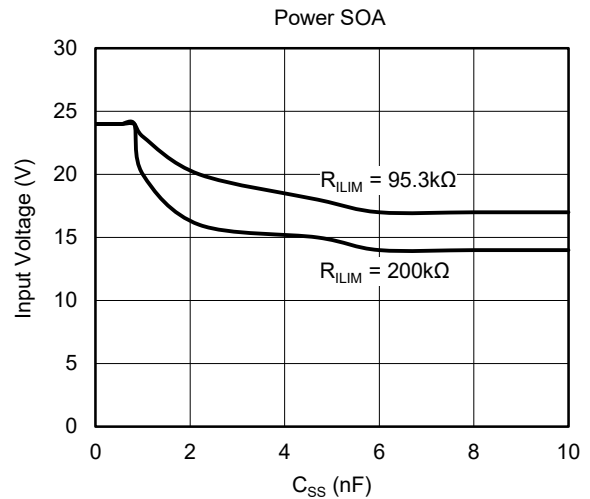
The inrush current ( $I_{INRUSH}$ ) can be calculated as:

$$I_{INRUSH} = C_{OUT} \times \frac{V_{IN}}{t_{SS}} \tag{3}$$

Rise time can be calculated by multiplying the input voltage by the slew rate. If floating this pin, the slew rate of the output obtains a default value  $\sim 50V/ms$  (minimum  $t_{SS}$ ).

For existing load power on conditions, input maximum current will be limited to  $I_{LIMIT}$  point.

If  $V_{OUT}$  is shorted, SGM2521/SGM2521A will try to restart automatically, the chips have to take all the power at this time, and  $C_{SS}$  needs to be limited to protect these chips from excessive power damage. Figure 5 is SOA (Safe Operating Area) when restarted at short-circuit state.



**Figure 5. Power SOA**

NOTES:

- $C_{SS}$  less than 10nF is recommended when  $V_{IN}$  is between 4.5V and 12V.
- $C_{SS}$  less than 5nF is recommended when  $V_{IN}$  is between 12V and 15V.
- $C_{SS}$  less than 0.56nF is recommended when  $V_{IN}$  is between 15V and 24V.

**DETAILED DESCRIPTION (continued)**

**Over-Current and Short-Circuit Protections**

The device limits current to the output in case of output shorts and overloads. If an event occurs, device goes into current limit action, and the value of the current limit ( $I_{LIMIT}$ ) is set by  $R_{ILIM}$  resistor:

SGM2521/2:

$$I_{LIMIT} = 10.95 \times 10^{-3} \times R_{ILIM} - 0.043 \quad (4)$$

$$R_{ILIM} = \frac{I_{LIMIT} + 0.043}{10.95 \times 10^{-3}} \quad (5)$$

SGM2521A/2A:

$$I_{LIMIT} = 9.78 \times 10^{-3} \times R_{ILIM} + 0.021 \quad (6)$$

$$R_{ILIM} = \frac{I_{LIMIT} - 0.021}{9.78 \times 10^{-3}} \quad (7)$$

where:

$I_{LIMIT}$  is the value of overload current limit in A.

$R_{ILIM}$  is the current limit programming resistor in  $k\Omega$ .

In addition to the general over-current protection, the SGM2521/1A/2/2A family also integrates fast-trip over-current protection with quicker response time. Thermal stress will reduce the limited current to protect the device shown in Figure 6.

Internal current limit comparator bias voltage is set by bias current and external resistor, no noise interference and high precision resistor increase current limit accuracy.

**Overload Protection**

When the output load exceeds the current limit threshold, the internal current limit amplifier limits the output current to the predetermined value by increasing the on-resistance of the power switch. When continuous heavy overloads increase the power dissipation in the switch, causing the junction temperature to reach the thermal shutdown threshold, the internal N-MOSFET is turned off. The fault pin (nFLT) is asserted and will be pulled low to indicate a fault until the thermal shutdown condition is released.

**Short-Circuit Protection**

A transient short-circuit occurs, due to the limited bandwidth of the current limit amplifier, which cannot respond quickly to this event. The SGM2521/1A/2/2A family contains a fast-trip comparator with a threshold

( $I_{FAST-TRIP}$ ). If  $I_{OUT} > I_{FAST-TRIP}$ , the comparator turns off the N-MOSFET and terminates the short-circuit peak current across the N-MOSFET rapidly. The fast-trip threshold is 1.8 times the overload current limit. The fast-trip comparator can terminate the transient short-circuit peak current, and then the current limit function limits the output current to  $I_{LIMIT}$ .

See Equation 8 for the calculation.

$$I_{FAST-TRIP} = 1.8 \times I_{LIMIT} \quad (8)$$

The  $I_{FAST-TRIP}$  is fast-trip current limit.

After turning off internal power N-MOSFET for some microseconds, the device restarts to power on. The same applies to short-circuit power on condition, input current will be limited to  $I_{LIMIT}$  point.

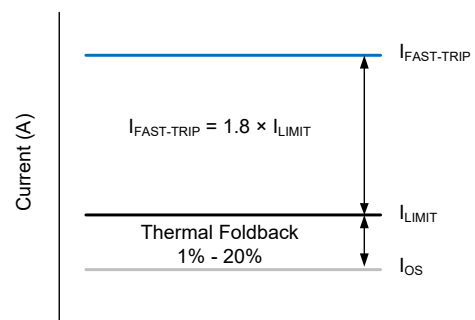
When the switching voltage of SGM2521/1A/2/2A is more than 15V, customer should add a no more than 27V (> 0.5W) Zener diode to prevent the input voltage spike from damaging the SGM2521/1A/2/2A (as shown in Figure 3).

**Startup with Output Shorted**

For short-circuit power on conditions, input current will be limited to  $I_{LIMIT}$  point.

**Thermal Foldback**

1% to 20% current derating effectively reduces thermal dissipation and improves PCB layout flexibility.



**Figure 6. Over-Current Protection Levels**

**DETAILED DESCRIPTION (continued)**

**Fault Response**

The SGM2521/1A/2/2A family has a fault output signal to indicate the operation state of the device. When any of over-voltage, under-voltage, thermal shutdown or short-circuit occurs, the nFLT pin is pulled low. The nFLT pin is open-drain output which can be connected to OUT or another external voltage through an external pull-up resistor. If not used, leave it floating or connect to GND.

**IN, OUT and GND Pins**

To limit the voltage drop on the input supply caused by transient inrush current when the switch turns on into a fully discharged load capacitor, a capacitor needs to be placed between IN and GND pins. Use a bypass capacitor as close as possible between IN and GND pins. In the on-state condition,  $V_{OUT}$  can be calculated using the Equation 9.

$$V_{OUT} = V_{IN} - (R_{DS(ON)} \times I_{OUT}) \tag{9}$$

where  $R_{DS(ON)}$  is the on-resistance of the internal FET. GND is the lowest potential of the circuit, unless otherwise noted.

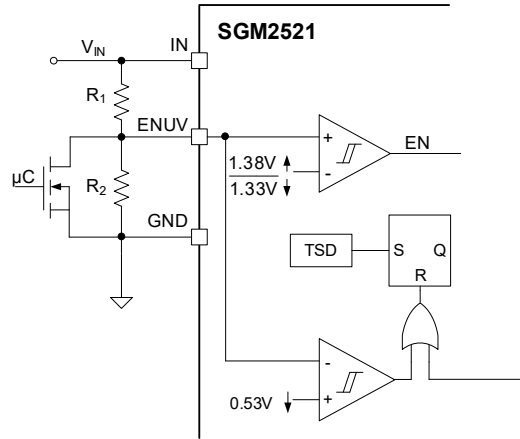
**Thermal Shutdown (TSD)**

Thermal shutdown protects the device from excessive temperature. Once the device is shut down due to  $T_{SD}$  fault, it would either stay latch-off (SGM2522/SGM2522A) or restart automatically after  $T_J$  drops below  $[T_{SD} - 20^\circ C]$  (SGM2521/SGM2521A).

**Shutdown Control**

The device has a built-in over-temperature shutdown circuitry designed to protect the internal N-MOSFETs if the junction temperature exceeds  $T_{SD}$ . The internal N-MOSFET can be remotely turned off by taking the ENUV pin below its 0.53V threshold as shown in Figure 7.

Upon releasing the ENUV pin, the device turns on with soft-start cycle.



**Figure 7. Shutdown Control**

**Operational Overview of Device Functions**

The device function is shown in Table 1.

**Table 1. Device Functions**

| Device                 | SGM2521/SGM2521A/SGM2522/SGM2522A  |
|------------------------|--|
| Startup                | Inrush ramp controlled by SS pin via an external capacitor.  |
|                        | Limit inrush current to $I_{LIMIT}$ level.   |
|                        | If $T_J > T_{SD}$ , the device is shut down.   |
| Over-Current Response  | Current is limited to $I_{LIMIT}$ level.   |
|                        | Power dissipation increases as $V_{IN} - V_{OUT}$ grows  |
|                        | $T_J > T_{SD}$ , the device is turned off.   |
|                        | SGM2522/SGM2522A remain off<br>SGM2521/SGM2521A will attempt restart $t_{SD\_DLY}$ after $T_J < [T_{SD} - 20^\circ C]$ |
| Short-Circuit Response | Fast shut-off when $I_{LOAD} > I_{FAST-TRIP}$  |
|                        | According to the standard startup cycle, fast refresh and limit the current to $I_{LIMIT}$ .                           |



**SYSTEM EXAMPLES**

The SGM2521/1A/2/2A family provides a complete set of protection functions for overload or inrush current. The wide operating voltage range (4.5V to 24V) is specifically designed for many popular DC buses, and the maximum load current of 2A can meet the power delivery requirements of many devices.

**Protection and Current Limit for AC/DC Power Supplies**

In many small household appliances, portable devices, consumer products and other application scenarios, the primary-side power supplies and adapter are dominant. These power supplies generally have a rated power of 5W - 30W, which is generally characterized by high efficiency, low cost and few components. However, there are also the following shortcomings:

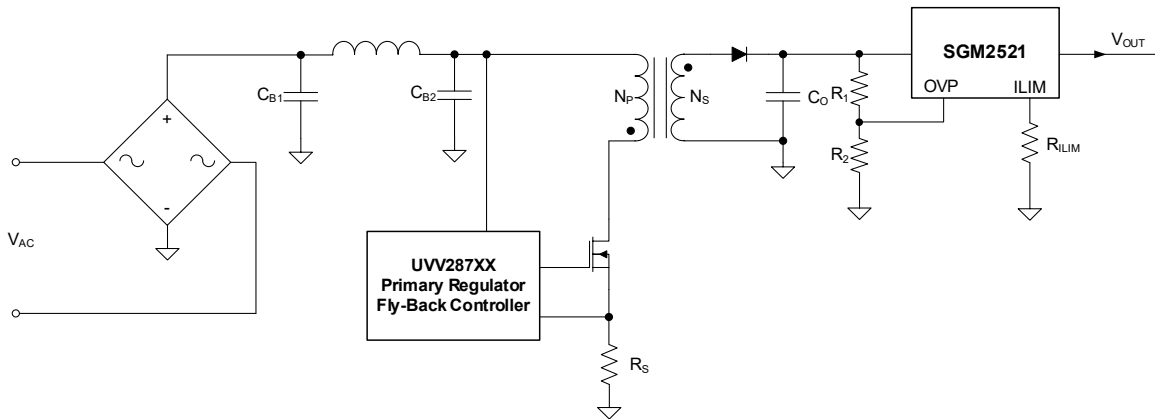
- No secondary-side protection which can stop short-circuit and other key faults immediately.
- Cannot provide precision current limit for overload transients.

- Poor ability to regulate the output voltage during sudden fluctuation of the AC input voltage, when the output over-voltage condition is triggered.

Therefore, accurate current sensing and overload protection are required for the secondary side output port in the above applications. This requires the use of precision operational amplifiers for additional circuit implementation. It adds complexity to the solution and leads to a loss of sensing. The SGM2521/1A/2/2A adopting N-MOSFET with low on-resistance is a simple and efficient solution. The typical application circuit of SGM2521/1A/2/2A is shown in Figure 8.

During short-circuit fault, the internal fast comparator shuts down the FET within 3μs (TYP) after the input current increases rapidly and exceeds  $I_{FAST-TRIP}$  which is set by the external  $R_{ILIM}$  resistor.

Furthermore, the SGM2521/1A/2/2A family provides inrush current limit during the output ramp-up procedure.



**Figure 8. Current Limit and Protection for AC/DC Power Supplies**

**SYSTEM EXAMPLES (continued)**

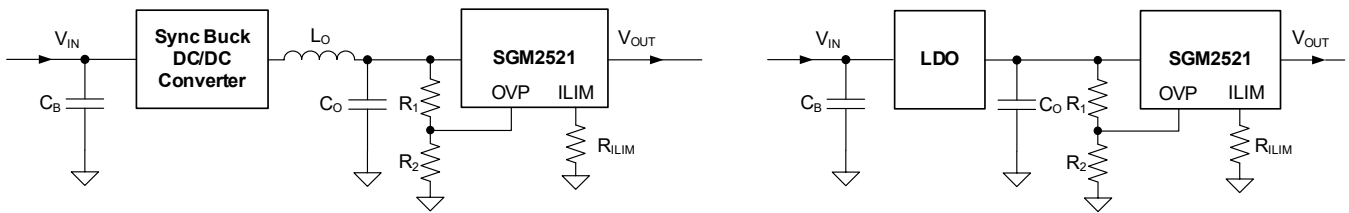
**Precision Current Limit in Intrinsic Safety Applications**

The safe operation of electrical and electronic equipment in dangerous area environment has a more and more urgent requirements for intensive safety (IS). IS requires that the total energy available during equipment operation is not enough to ignite the surrounding explosive environment by means of electric sparks or heat transfer. This requires precision current limits to ensure that the set current limits are not exceeded over a wide operating temperature range and variable environmental conditions. Applications such as gas analyzers, medical devices, portal industrial equipment, etc., need to meet these importance safety standards. As a simple over-voltage and over-load protection solution, the SGM2521/1A/2/2A family is

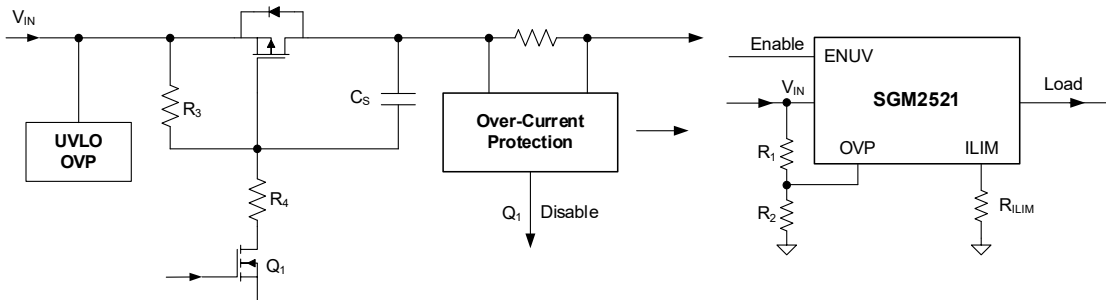
applicable to each power rail inside the system application. The typical implementation circuit of SGM2521/1A/2/2A is shown in Figure 9.

**Smart Load Switch**

The smart load switch is a series of MOSFETs used to switch the load (resistance or capacitance). It also provides protection in case of failure. Figure 10 shows a typical discrete implementation of load switch, which requires more components and more complex circuits to achieve fault protection. The SGM2521/1A/2/2A can be used as a load switch for the applications whose operating range is from 4.5V to 24V. Programmable current limits, programmable soft-start, over-temperature protection, fault flag and under-voltage lockout are provided in the SGM2521/1A/2/2A.



**Figure 9. Precision Current Limit and Protection of Internal Rails**



**Figure 10. Smart Load Switch Implementation**

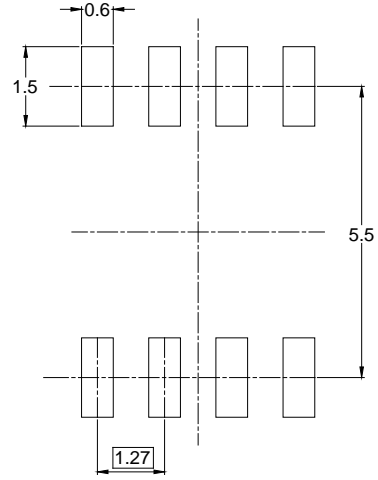
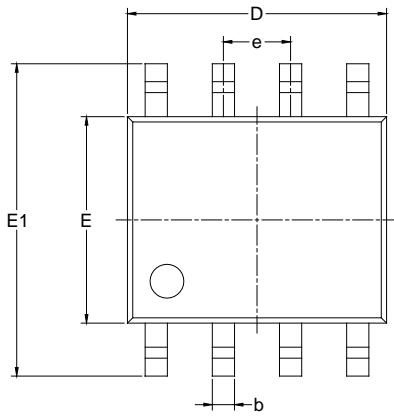
## REVISION HISTORY

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

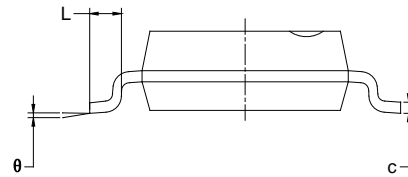
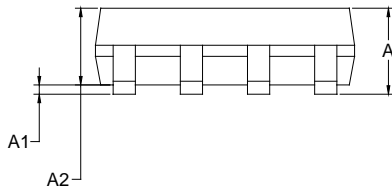
|   | <b>Page</b> |
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| <b>FEBRUARY 2024 – REV.A.4 to REV.B</b>               |             |
| Updated Detailed Description .....                    | All         |
| <hr/>   |             |
| <b>FEBRUARY 2021 – REV.A.3 to REV.A.4</b>             | <b>Page</b> |
| Updated Marking Information section.....              | 2           |
| <hr/>   |             |
| <b>JANUARY 2021 – REV.A.2 to REV.A.3</b>              | <b>Page</b> |
| Updated Electrical Characteristics section .....      | 4, 5        |
| <hr/>   |             |
| <b>JANUARY 2020 – REV.A.1 to REV.A.2</b>              | <b>Page</b> |
| Updated Detailed Description section .....            | 13          |
| <hr/>   |             |
| <b>DECEMBER 2018 – REV.A to REV.A.1</b>               | <b>Page</b> |
| Added CDM parameter .....                             | 2           |
| Changed Electrical Characteristics section .....      | 4, 5        |
| <hr/>   |             |
| <b>Changes from Original (NOVEMBER 2018) to REV.A</b> | <b>Page</b> |
| Changed from product preview to production data.....  | All         |
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PACKAGE OUTLINE DIMENSIONS

SOIC-8



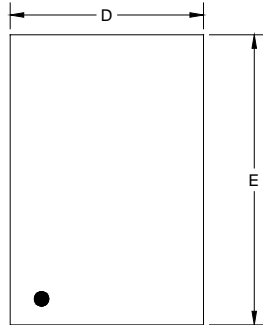
RECOMMENDED LAND PATTERN (Unit: mm)



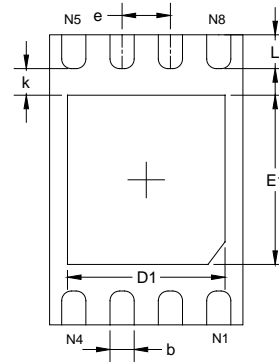
| Symbol | Dimensions<br>In Millimeters |       | Dimensions<br>In Inches |       |
|--------|------------------------------|-------|-------------------------|-------|
|        | MIN                          | MAX   | MIN                     | MAX   |
| A      | 1.350                        | 1.750 | 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

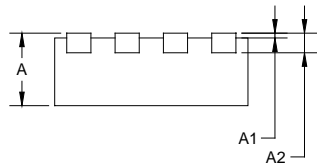
TDFN-2x3-8BL



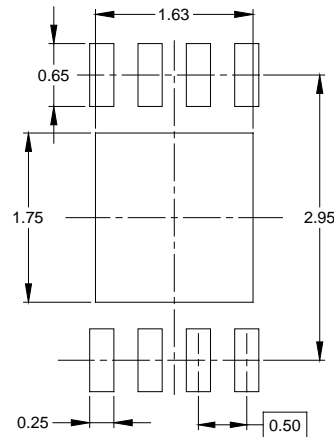
TOP VIEW



BOTTOM VIEW



SIDE VIEW



RECOMMENDED LAND PATTERN (Unit: mm)

| Symbol | Dimensions<br>In Millimeters |       | Dimensions<br>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      | 1.950                        | 2.050 | 0.077                   | 0.081 |
| D1     | 1.530                        | 1.730 | 0.060                   | 0.068 |
| E      | 2.950                        | 3.050 | 0.116                   | 0.120 |
| E1     | 1.650                        | 1.850 | 0.065                   | 0.073 |
| b      | 0.200                        | 0.300 | 0.008                   | 0.012 |
| e      | 0.500 BSC                    |       | 0.020 BSC               |       |
| k      | 0.250 REF                    |       | 0.010 REF               |       |
| L      | 0.300                        | 0.450 | 0.012                   | 0.018 |

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               | 6.40    | 5.40    | 2.10    | 4.0     | 8.0     | 2.0     | 12.0   | Q1            |
| TDFN-2×3-8BL | 7"            | 9.5                | 2.30    | 3.30    | 1.10    | 4.0     | 4.0     | 2.0     | 8.0    | Q2            |

DD0001

# PACKAGE INFORMATION

## 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           |
| 13"         | 386         | 280        | 370         | 5            |

DD0002

单击下面可查看定价，库存，交付和生命周期等信息

[>>SGMICRO\(圣邦微电子\)](#)