SGM2546
2.7V to 23V, 7A, 10mΩ eFuse with Accurate Current Monitor and Transient Over-Current Blanking

GENERAL DESCRIPTION

The SGM2546 is a compact electronic fuse (eFuse) with a full suite of protection functions. With very few external components, the SGM2546 can provide multiple protection modes. To encounter overloads, output short-circuit, input voltage surges and high inrush current, the device is suitable as a robust defense.

The V_{OUT} rise time can be programmed by setting an additional capacitor to the SS pin, which can minimize inrush current. Programmable over-voltage protection is used to turn off the device or clamp the output to a fixed voltage (pin-selectable) if the IN rises over a threshold value. Under output overload condition, the over-current protection works which limits the current or cut-off the circuit. The output current limit threshold and the transient over-current blanking timer can be adjusted by the user. The ILIM pin is also used for load current monitoring.

The SGM2546 is available in a Green TQFN-2×2-10L package.

APPLICATIONS

Severs and Block Supplies
Motherboard Power Management
PCIE SSD

FEATURES

- **Input Voltage: 2.7V to 23V, Surge up to 28V**
- **Low On-Resistance: 10mΩ (TYP)**
- **Fast Over-Voltage Protection**
  - **SGM2546AR: Adjustable Over-Voltage Lockout (OVLO) with 1.2μs (TYP) Response Time**
  - **SGM2546BR: Pin-Selectable Threshold (3.91V, 5.81V, 13.95V) Over-Voltage Clamp (OVC) and 3μs Response Time (TYP)**
- **Over-Current Protection (OCP) with Load Current Monitor Output (ILIM)**
  - **Current Limit**
  - **Programmable Current Limit: 0.87A to 7.65A ±10% Accuracy for I_{LIM} > 1.74A**
  - **Programmable Transient Blanking Timer (ITIMER) Allowing Up to 2 × I_{LIM} Peak Currents**
  - **Load Current Monitor Accuracy: ±8% (MAX)**
- **Fast Short-Circuit Protection**
  - **Fast-Trip Response Time: 550ns (TYP)**
  - **Programmable (2 × I_{LIM}) and Fixed Thresholds**
- **Active High Enable Input with Adjustable Under-Voltage Lockout Threshold (EN/UVLO)**
- **Programmable Output Ramp Time (SS)**
- **Over-Temperature Protection**
- **Digital Outputs**
  - **Fault Indication (nFLT)**
  - **Power Good Indication (PG) with Adjustable Threshold (PGTH)**
- **Available in a Green TQFN-2×2-10L Package**

PACKAGE/ORDERING INFORMATION

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM2546AR	TQFN-2×2-10L	-40℃ to +125℃	SGM2546ARXTSP10G/TR	14E XXXX	Tape and Reel, 3000
SGM2546BR	TQFN-2×2-10L	-40℃ to +125℃	SGM2546BRXTSP10G/TR	19X XXXX	Tape and Reel, 3000

MARKING INFORMATION

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

XXXX
- Vendor Code
- Trace Code
- Date Code - Year

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.

SELECTABLE MODEL

Model	Over-Voltage Response	Over-Current Response	PG and PGTH	nFLT	Response to Fault
SGM2546AR	Adjustable OVLO	Active Current Limit	N	Y	Auto-Retry
SGM2546BR	Pin Selectable OVC (3.92V/5.81V/13.95V)		Y	N	Auto-Retry

ABSOLUTE MAXIMUM RATINGS

Input Voltage Range, V_{IN} .... -0.3V to 28V
Output Voltage Range, V_{OUT} ....-0.3V to V_{IN} + 0.3V
Output Voltage Pulse (< 1μs), V_{OUT_PLS} ....-0.8V
Enable Voltage Range, $V_{EN/UVLO}$ .... -0.3V to 6.5V
OVCSEL/OVLO Voltage Range, V_{OV} .... -0.3V to 6.5V
SS Voltage Range, V_{SS} .... Internally Limited
ITIMER Voltage Range, V_{ITIMER} .... Internally Limited
PGTH Voltage Range, V_{PGTH} .... -0.3V to 6.5V
PG Voltage Range, V_{PG} .... -0.3V to 6.5V
nFLT Voltage Range, V_{nFLT} .... -0.3V to 6.5V
ILIM Voltage Range, V_{ILIM} .... Internally Limited
Continuous Switch Current, I_{MAX} .... Internally Limited

Package Thermal Resistance
TQFN-2×2-10L, θ_{JA} ....69.9℃/W
TQFN-2×2-10L, θ_{JB} ....5.2℃/W
TQFN-2×2-10L, θ_{JC} ....50.9℃/W
Junction Temperature .... +150℃
Storage Temperature Range....................... -65℃ to +150℃
Lead Temperature (Soldering, 10s)............................ +260℃
ESD Susceptibility [(1) (2)]
HBM .... ±2000V
CDM .... ±1000V

NOTES:

1. For human body model (HBM), all pins comply with ANSI/ESDA/JEDEC JS-001 specifications.

2. For charged device model (CDM), all pins comply with ANSI/ESDA/JEDEC JS-002 specifications.

RECOMMENDED OPERATING CONDITIONS

Input Voltage Range, V_{IN} .... 2.7V to 23V [(1)]
Output Voltage Range, V_{OUT} .... V_{IN} (MAX)
EN/UVLO Voltage Range, $V_{EN/UVLO}$ .... 5V [(2)] (MAX)
OVLO Voltage Range (SGM2546AR) .... 0.5V to 1.5V
SS Capacitor, C_{SS} .... 3.3nF (MAX)
SS Capacitor Voltage Rating, V_{SS} .... V_{IN} + 5V (MIN)
PGTH Voltage Range, V_{PGTH} .... 5V (MAX)
nFLT Voltage Range, V_{nFLT} .... 5V (MAX)
PG Voltage Range, V_{PG} .... 5V (MAX)
ITIMER Capacitor Voltage Rating, V_{ITIMER} .... 4V (MIN)
ILIM Resistance to GND, R_{ILIM} .... 715Ω to 6650Ω
Continuous Switch Current (T_J ≤ 125℃), I_{MAX} .... 7A (MAX)
Operating Junction Temperature Range ...... -40℃ to +125℃

NOTES:

1. When using SGM2546BR variant, ensure that the input voltage is restricted to the chosen output voltage clamp value specified in the electrical characteristics section.

2. When supply voltages are below 5V, connecting the EN/UVLO pin directly to IN is acceptable. For voltages exceeding 5V, it's advised to employ a pull-up resistor with a minimum value of 350kΩ.

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.

OVERSTRESS CAUTION

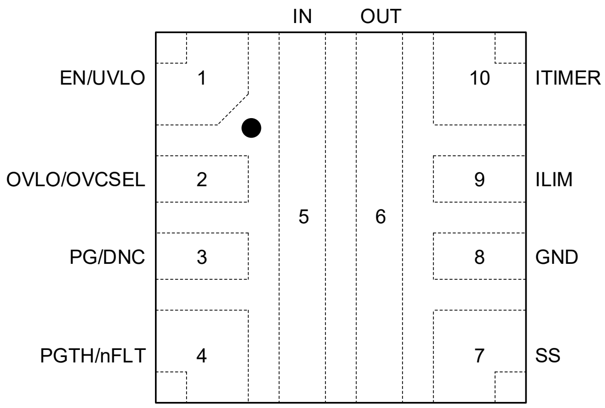
Stresses beyond those listed in Absolute Maximum Ratings may cause permanent damage to the device. Exposure to absolute maximum rating conditions for extended periods may affect reliability. Functional operation of the device at any conditions beyond those indicated in the Recommended Operating Conditions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

DISCLAIMER

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

PIN CONFIGURATION

(TOP VIEW)



TQFN-2×2-10L

PIN DESCRIPTION

PIN	NAME	TYPE	FUNCTION
1	EN/UVLO	AI	Enable and Under-Voltage Lockout Input. Asserting EN/UVLO pin high enables the device. As a UVLO pin, the UVLO threshold is programmed by an external resistor divider. This pin cannot be left floating.
2	OVLO	AI	(SGM2546AR Only) Over-Voltage Lockout Pin. The over-voltage lockout threshold is programmed by the resistor divider from the power supply to the OVLO terminal to GND. The device is enabled when this pin is tied to low level. This pin cannot be left floating.
	OVCSEL	AI	(SGM2546BR Only) Output Clamp Voltage Selection Pin.
3	PG	DO	(SGM2546BR Only) Power Good Indication. This is an open-drain pin, and when the internal FET is fully enhanced and the PGTH voltage is higher than the set value, the pin is set to high level.
	DNC	DO	(SGM2546AR Only) No Connection. Do not connect this pin to anything.
4	nFLT	DO	(SGM2546AR Only) Fault Event Indicator. The nFLT is an open-drain output, and when a fault occurs, it will be low.
	PGTH	AI	(SGM2546BR Only) Power Good Threshold.
5	IN	P	Input Supply Voltage.
6	OUT	P	Output of the Device.
7	SS	AO	Soft-Start Pin. The capacitor between SS and GND pins will set the slew rate according to the application requirements. When this pin is left floating, the device will start up at the fastest rate.
8	GND	G	Ground.
9	ILIM	AO	Current Limit Programming Pin. Use this dual function pin for limiting and monitoring the output current. Connecting this pin to GND can set the output current limit. This pin can also be used to monitor the load current. Do not float this pin.
10	ITIMER	AO	Place a capacitor between this pin and GND can set the over-current blanking time, at this stage, the output current value can temporarily exceed the internally set current limit value (but not exceed the fast-trip threshold). After this time, the device will take action if it is still in over-current state. Leaving this pin open will provide the fastest response to an over-current event.

NOTE: AI = analog input, AO = analog output, DO = digital output, P = power, G = ground.

ELECTRICAL CHARACTERISTICS

(T_J = -40℃ to +125℃, V_{IN} = 12V, OUT pin floating, $V_{EN/UVLO}$ = 2V, V_{OV} = 0V for SGM2546AR, OVCSEL = 390kΩ to GND for SGM2546BR, R_{ILIM} = 715Ω, SS, ITIMER and nFLT pins floating for SGM2546AR, PGTH and PG pins floating for SGM2546BR, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Input Supply (IN)							
Supply Quiescent Current	I_{Q_ON}	SGM2546AR only			172	300	μA
					184	320	
	$I_{Q\_ON\_OVC}$				223	380	μA
IN Supply Off Current	I_{Q_OFF}	V_{SD_F} < V_{EN} < V_{UVLO_F}			56	120	μA
Supply Shutdown Current	I_{SD}	V_{EN} < V_{SD_F}			8	35	μA
Under-Voltage Protection Threshold	V_{UVP_R}	Rising		2.46	2.56	2.64	V
	V_{UVP_F}	Falling		2.23	2.33	2.43	V
Output Voltage Clamp (OUT) SGM2546BR							
Over-Voltage Clamp Threshold	V_{OVC}	OVCSEL = shorted to GND		3.65	3.91	4.1	V
		OVCSEL = open		5.25	5.81	6.2	
		OVCSEL = 390kΩ to GND		13.2	13.95	14.5	
Output Voltage during Clamping	V_{CLAMP}	I_{OUT} = 10mA	OVCSEL = shorted to GND	3.2	3.83	4.2	V
			OVCSEL = open	5	5.72	6.12	
			OVCSEL = 390kΩ to GND	13	13.83	14.6	
Output Load Current Monitor (ILIM)							
Analog Load Current Monitor Gain	G_{IMON}	I_{MON} : I_{OUT}, I_{OUT} = 1A to 7.7A, I_{OUT} < I_{LIM}		99	107.5	116	μA/A
Over-Current Protection (OUT)							
Over-Current Threshold	I_{LIM}	R_{ILIM} = 6.65kΩ		0.75	0.87	0.97	A
		R_{ILIM} = 3.32kΩ		1.55	1.73	1.91	
		R_{ILIM} = 1.65kΩ		3.20	3.48	3.74	
		R_{ILIM} = 750Ω		7.03	7.65	8.20	
Circuit-Breaker Threshold	I_{SPFLT}	ILIM pin open				0.2	A
		ILIM pin shorted to GND			2	3.1	
Scalable Fast-Trip Threshold	I_{SCGain}	I_{SC} : I_{LIM} ratio		143	203	266	%
V_{OUT} Threshold to Exit Current Limit Foldback	V_{FB}	V_{OUT} threshold to exit current limit foldback		1.55	1.91	2.23	V
On-Resistance (IN - OUT)							
On-Resistance	R_{DSON}	2.7V ≤ V_{IN} ≤ 4V, I_{OUT} = 1A			10	18.3	mΩ
		4V < V_{IN} ≤ 23V, I_{OUT} = 1A			10	18.3	
Enable/Under-Voltage Lockout (EN/UVLO)							
EN/UVLO Rising Threshold	V_{UVLO_R}			1.183	1.2	1.228	V
EN/UVLO Falling Threshold	V_{UVLO_F}			1.076	1.1	1.125	V
EN/UVLO Falling Threshold for Lowest Shutdown Current	V_{SD_F}			0.45	0.73	1	V
EN/UVLO Pin Leakage Current	I_{ENLKG}			-0.15		0.15	μA
Over-Voltage Lockout (OVLO) SGM2546AR							
OVLO Rising Threshold	V_{OV_R}			1.183	1.2	1.228	V
OVLO Falling Threshold	V_{OV_F}			1.076	1.1	1.125	V
OVLO Pin Leakage Current	I_{OVLKG}	0.5V < V_{OV} < 1.5V		-0.1		0.1	μA

ELECTRICAL CHARACTERISTICS (continued)

(T_J = -40℃ to +125℃, V_{IN} = 12V, OUT pin floating, $V_{EN/UVLO}$ = 2V, V_{OV} = 0V for SGM2546AR, OVCSEL = 390kΩ to GND for SGM2546BR, R_{ILIM} = 715Ω, SS, ITIMER and nFLT pins floating for SGM2546AR, PGTH and PG pins floating for SGM2546BR, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Over-Current Fault Timer (ITIMER)						
ITIMER Internal Discharge Current	I_{ITIMER}	I_{OUT} > I_{LIM}	1.5	2	2.72	μA
ITIMER Internal Pull-Up Resistance	R_{ITIMER}			15.3	35	kΩ
ITIMER Internal Pull-Up Voltage	V_{INT}		2.1	2.58	2.74	V
ITIMER Comparator Threshold	V_{ITIMER_F}	I_{OUT} > I_{LIM}	0.609	1.05	1.37	V
ITIMER Discharge Differential Voltage Threshold	ΔV_{ITIMER}	I_{OUT} > I_{LIM}	1.286	1.53	1.741	V
Power Good Indication (PG) - SGM2546BR						
PG Voltage while De-Asserted	V_{PGD}	V_{IN} < V_{UVP_F}, V_{EN} < V_{SD_F}, weak pull-up (I_{PG} = 26μA)		489	1000	mV
		V_{IN} < V_{UVP_F}, V_{EN} < V_{SD_F}, strong pull-up (I_{PG} = 242μA)		640	1000	
		V_{IN} > V_{UVP_R}, I_{PG} = 10mA		168	600	
PG Leakage Current	I_{PGLKG}	PG asserted			3	μA
Power Good Threshold (PGTH)						
PGTH Rising Threshold	V_{PGTH_R}		1.178	1.2	1.23	V
PGTH Falling Threshold	V_{PGTH_F}		1.071	1.1	1.13	V
PGTH Pin Leakage Current	$I_{PGTHLKG}$		-1		1	μA
Fault Indication (nFLT) - SGM2546AR						
nFLT Leakage Current	$I_{FAULTLKG}$		-1		1	μA
nFLT Internal Pull-Down Resistance	R_{nFLT}			12.4		Ω
Over-Temperature Protection (OTP)						
Thermal Shutdown Rising Threshold	T_{SD}	T_J rising		154		℃
Thermal Shutdown Hysteresis	T_{HYS}	T_J falling		10		℃
SS						
SS Pin Charging Current	I_{SS}		1.4	3.4	5.7	μA

TIMING REQUIREMENTS

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Over-Voltage Lockout Response Time	t_{OVLO}	SGM2546AR, $V_{OV} > V_{OV\_R}$ to $V_{OUT}\downarrow$		1.2		μs
Over-Voltage Clamp Response Time	t_{OVC}	SGM2546BR, $V_{IN} > V_{OVC}$ to $V_{OUT}\downarrow$		3		μs
Current Limit Response Time	t_{LIM}	$I_{OUT} > I_{LIM}$ + 30% to I_{OUT} settling within 5% of I_{LIM}		600		μs
Short-Circuit Response Time	t_{SC}	$I_{OUT} > 3 \times I_{LIM}$ to output current cut off		550		ns
Fixed Fast-Trip Response Time	t_{FT}	$I_{OUT} > I_{FT}$ to $I_{OUT}\downarrow$		550		ns
Thermal Shutdown Auto-Retry Interval	t_{TSD_RST}	Device enabled and $T_J < T_{SD} - T_{HYS}$		127		ms
PG Assertion De-Glitch Time	t_{PGA}	$V_{PGTH} > V_{PGTH\_R}$ to PG↑		14		μs
PG De-Assertion De-Glitch Time	t_{PGD}	$V_{PGTH} < V_{PGTH\_F}$ to PG↓		14		μs

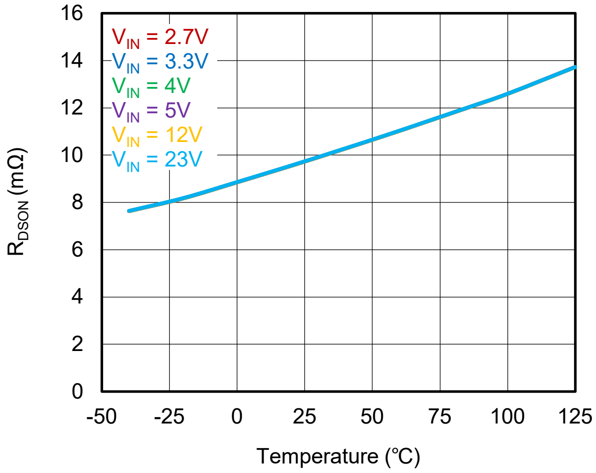
SWITCHING REQUIREMENTS

PARAMETER	SYMBOL	CONDITIONS	C_{SS} = OPEN	C_{SS} = 1800pF	C_{SS} = 3300pF	UNITS
Output Rising Slew Rate	SR_{ON}	2.7V	10.85	1.680	1.02	V/ms
		12V	23.54	1.694	0.973	
		23V	36.88	1.693	0.953	
Turn-On Delay	t_{D_ON}	2.7V	0.212	0.506	0.808	ms
		12V	0.272	1.161	2.183	
		23V	0.27	1.779	2.980	
Rise Time	t_R	2.7V	0.194	1.405	2.172	ms
		12V	0.268	5.356	9.33	
		23V	0.305	10.451	18.78	
Turn-On Time	t_{ON}	2.7V	0.406	1.911	2.98	ms
		12V	0.540	6.517	11.517	
		23V	0.575	12.23	21.761	
Turn-Off Delay	t_{D_OFF}	2.7V	19.4	18.8	17.4	μs
		12V	8.4	8.4	8.6	
		23V	5.0	4.7	5.0	

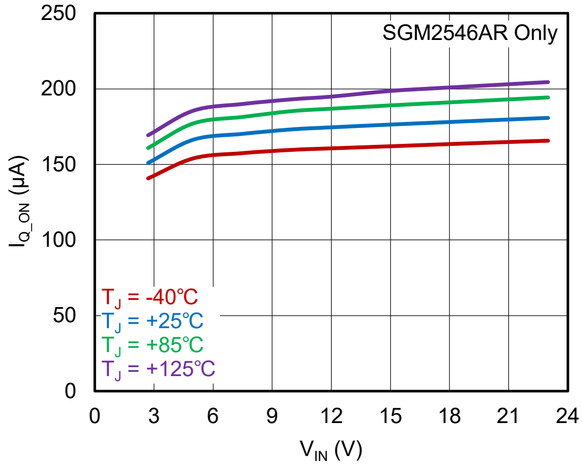
TYPICAL PERFORMANCE CHARACTERISTICS

T_J = -40℃ to +125℃, unless otherwise noted.

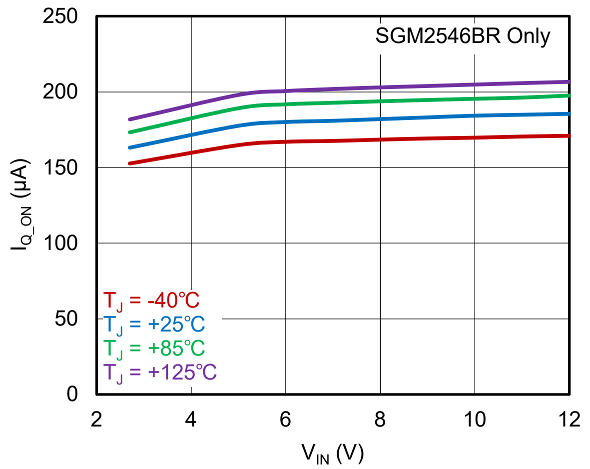
R_{DSON} vs. Temperature



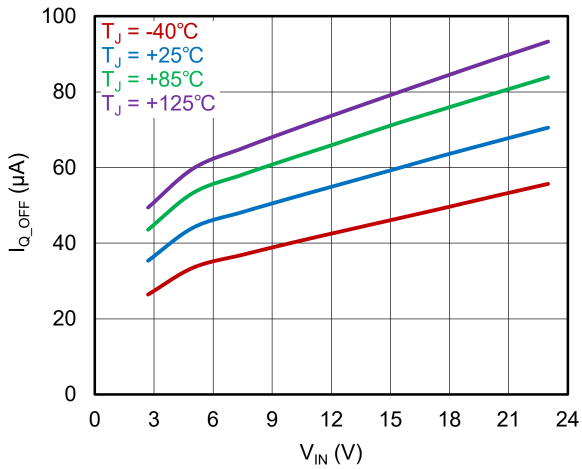
I_{Q_ON} vs. V_{IN}



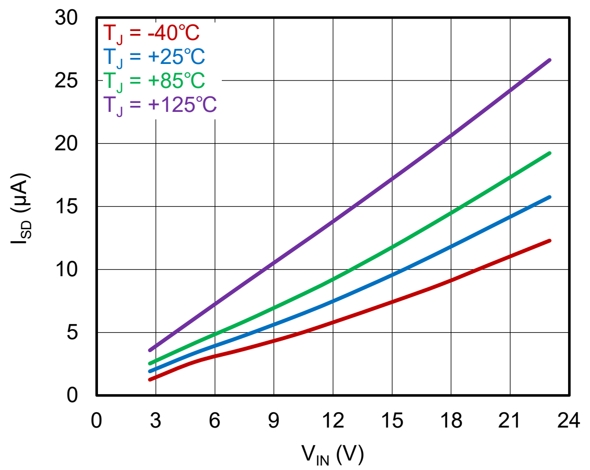
I_{Q_ON} vs. V_{IN}



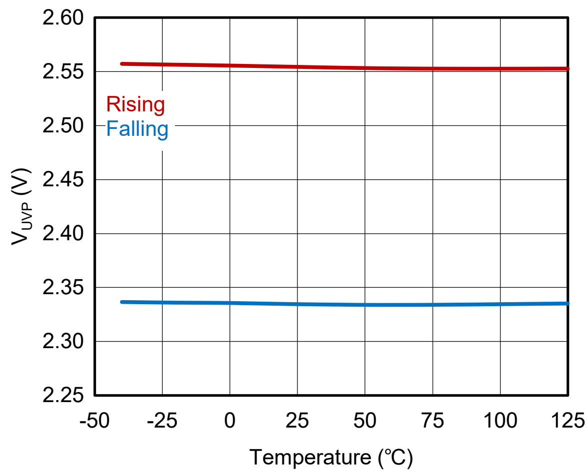
I_{Q_OFF} vs. V_{IN}



I_{SD} vs. V_{IN}

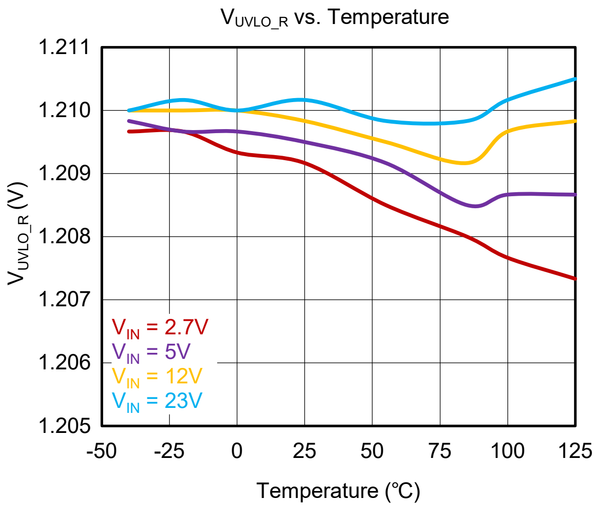


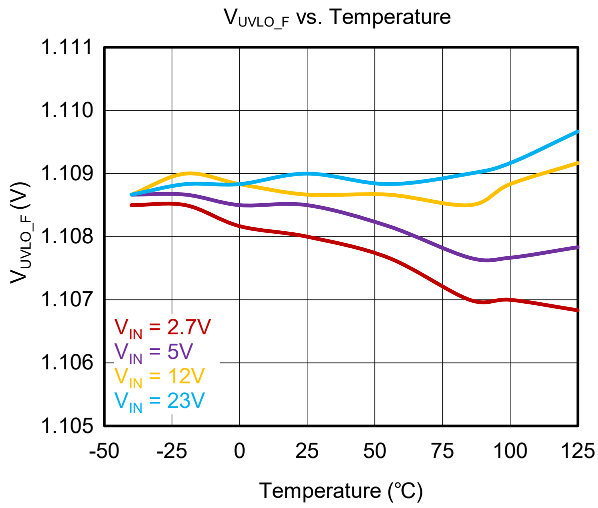
V_{UVP} vs. Temperature

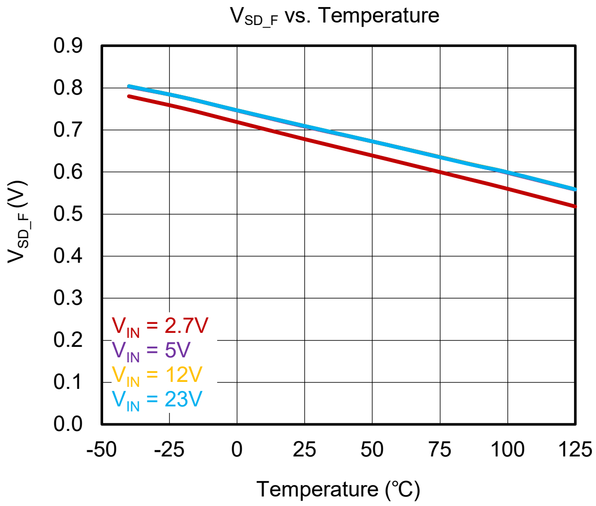


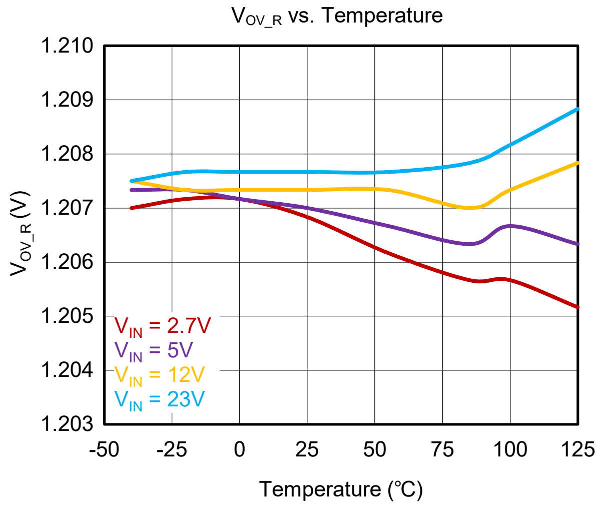
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

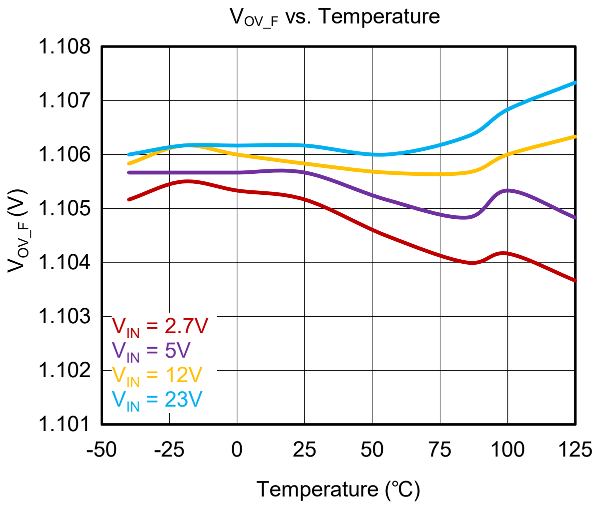
T_J = -40℃ to +125℃, unless otherwise noted.

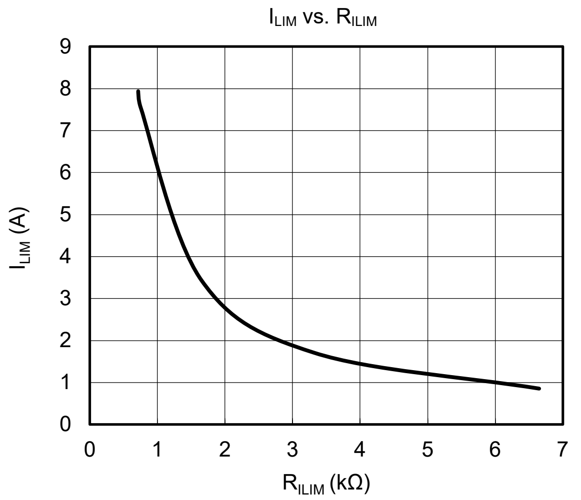






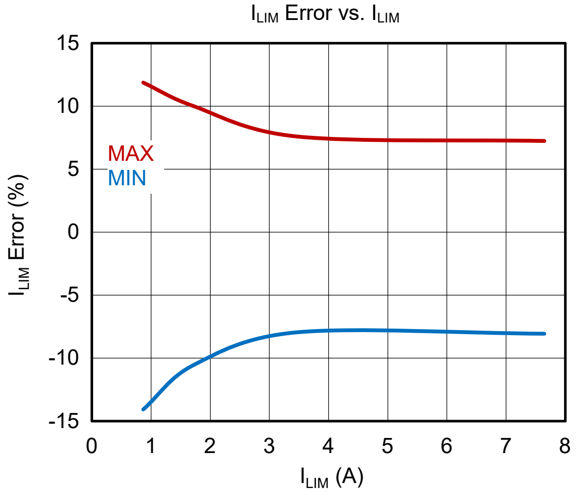


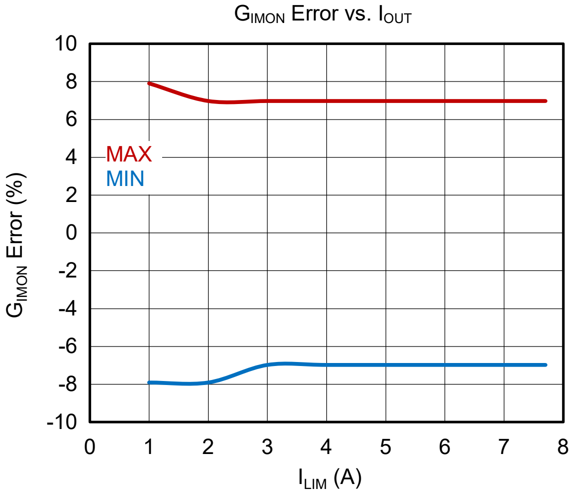


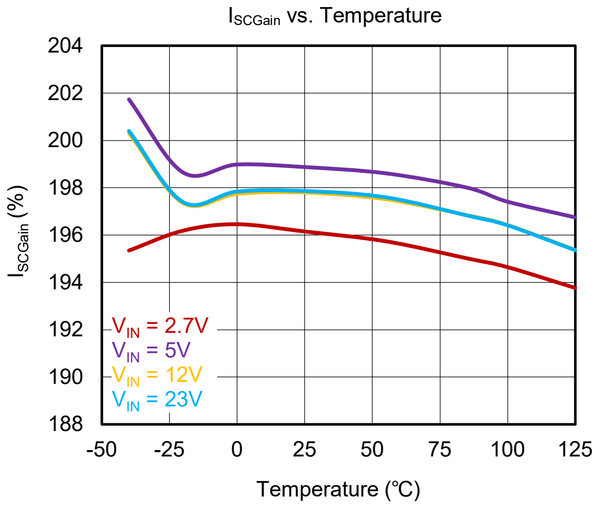


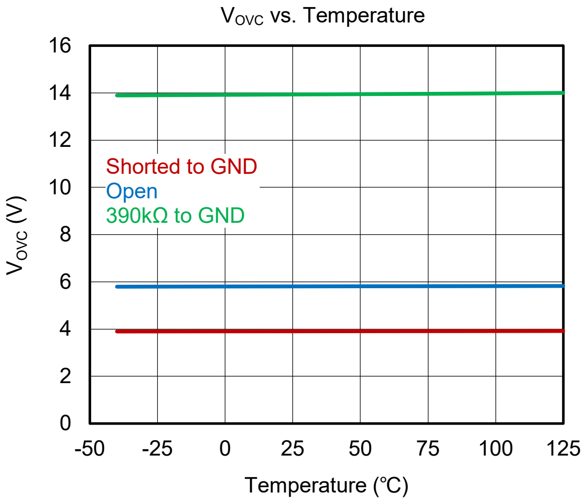
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

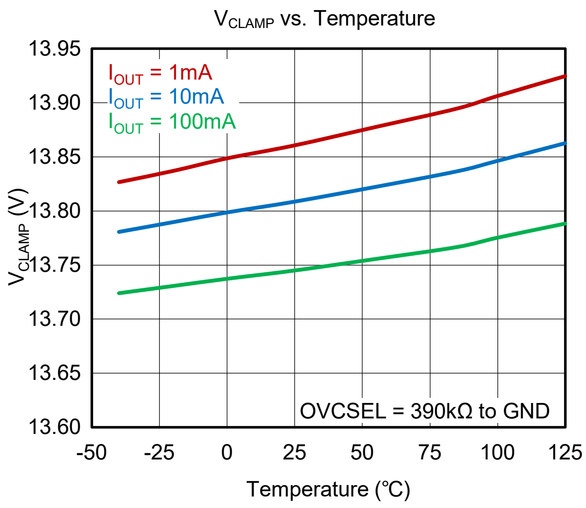
T_J = -40℃ to +125℃, unless otherwise noted.

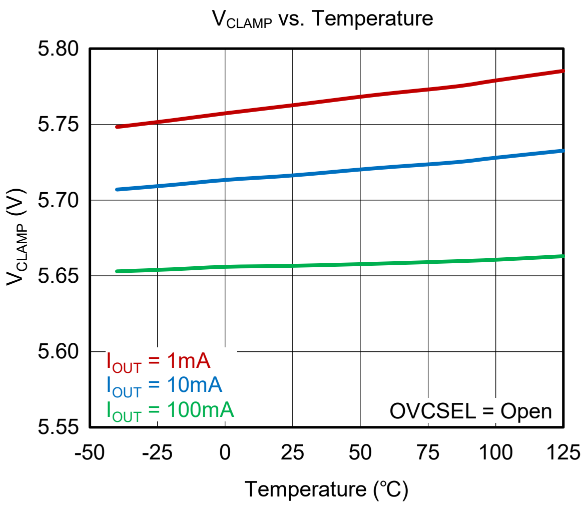






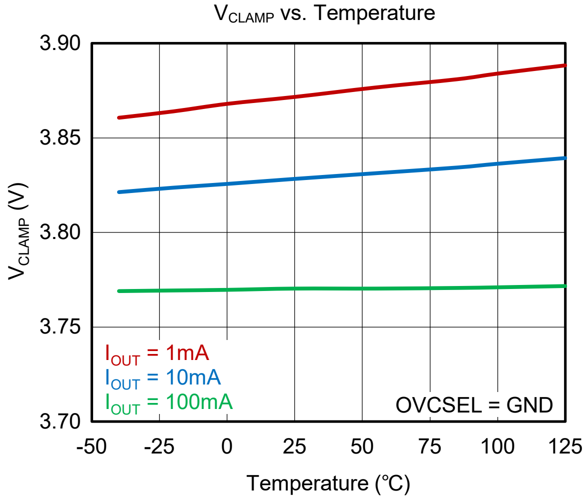


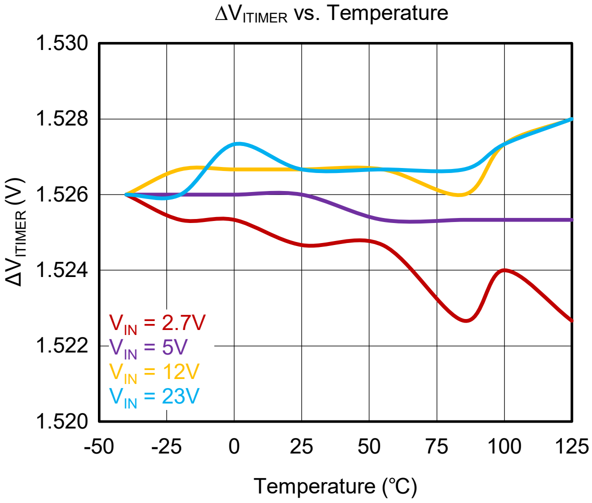


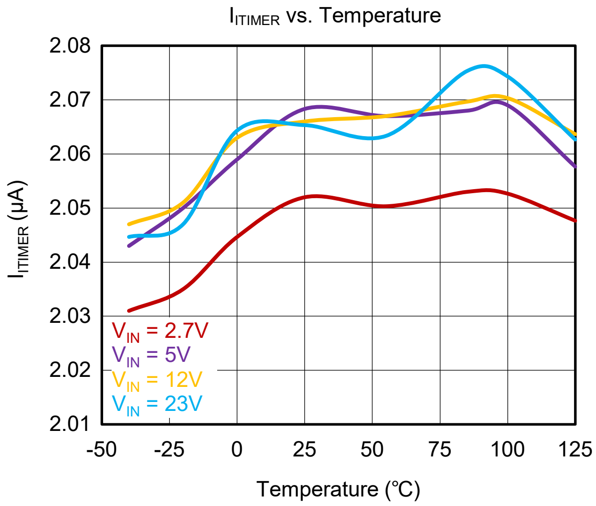


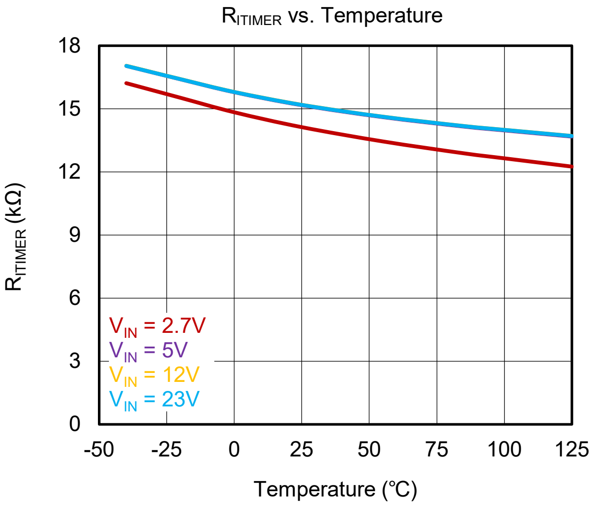
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

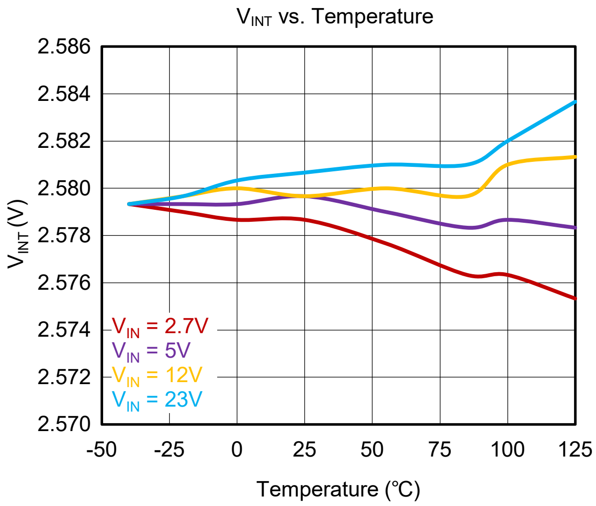
T_J = -40℃ to +125℃, unless otherwise noted.

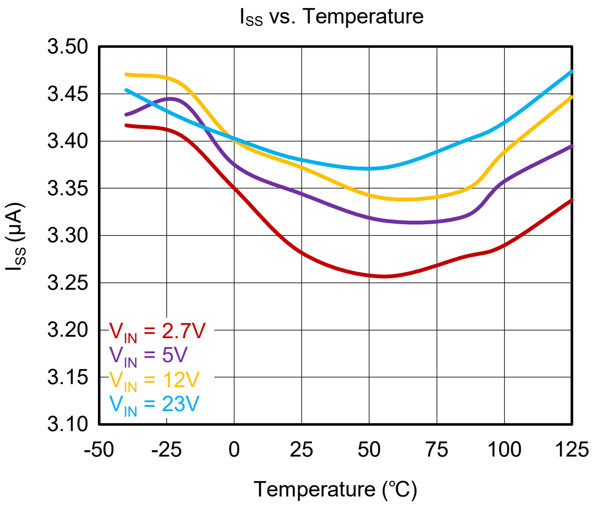








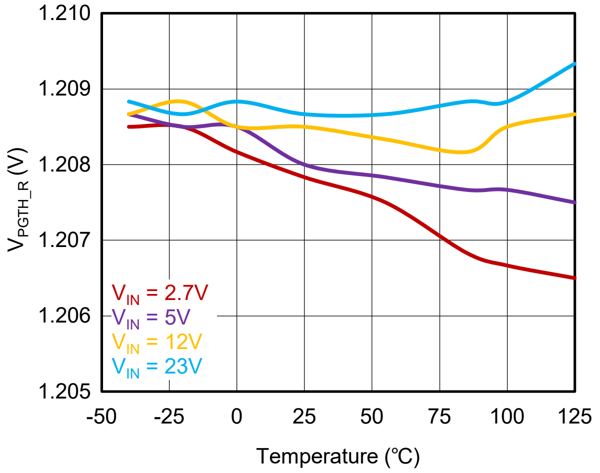




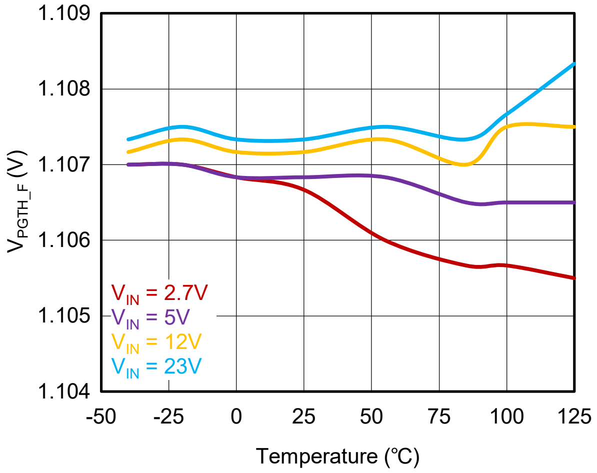
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

T_J = -40℃ to +125℃, unless otherwise noted.

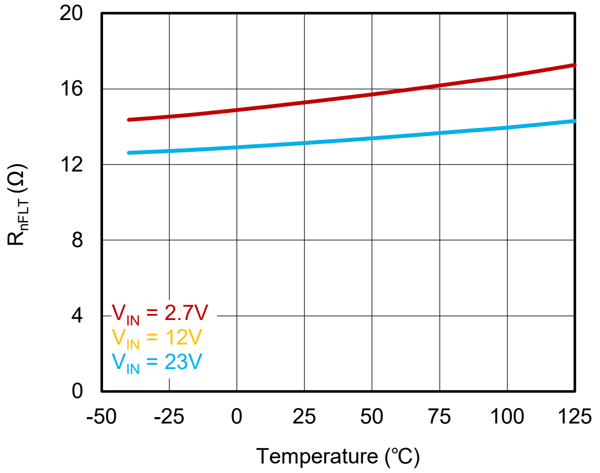
V_{PGTH_R} vs. Temperature



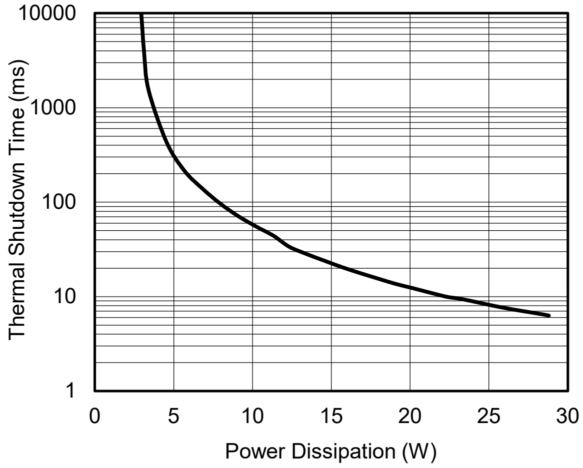
V_{PGTH_F} vs. Temperature



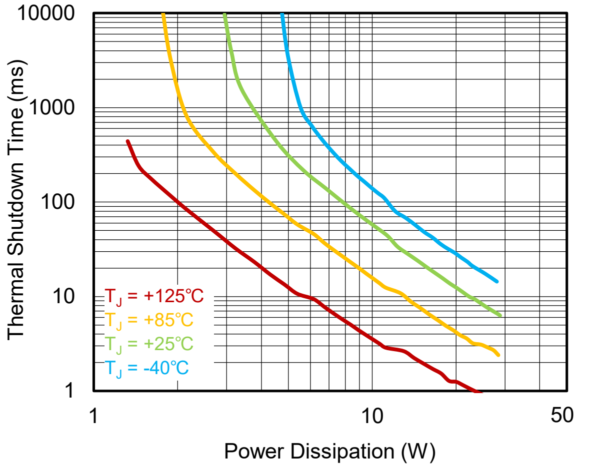
R_{nFLT} vs. Temperature



Thermal Shutdown Time during Inrush State



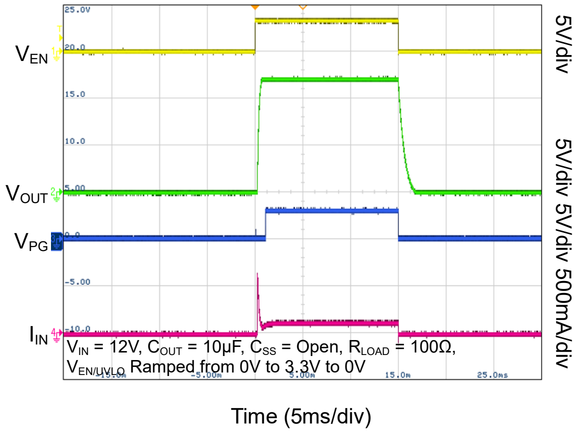
Thermal Shutdown Time during Steady State



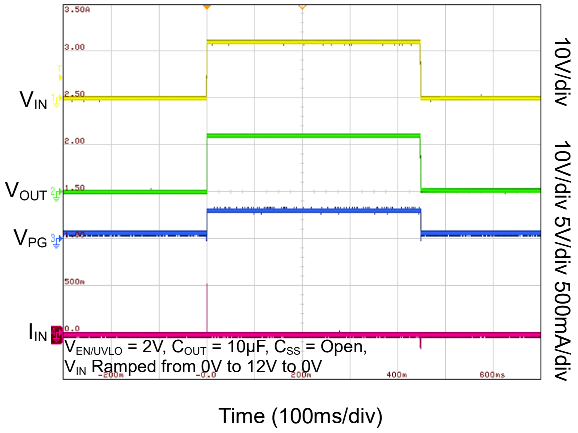
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

T_J = -40℃ to +125℃, unless otherwise noted.

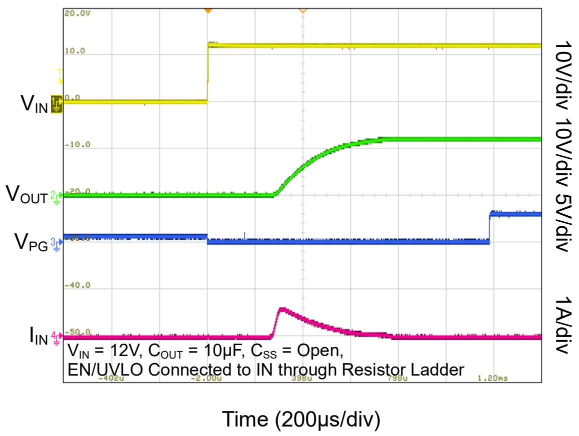
Power-Up and Power-Down with EN/UVLO Control



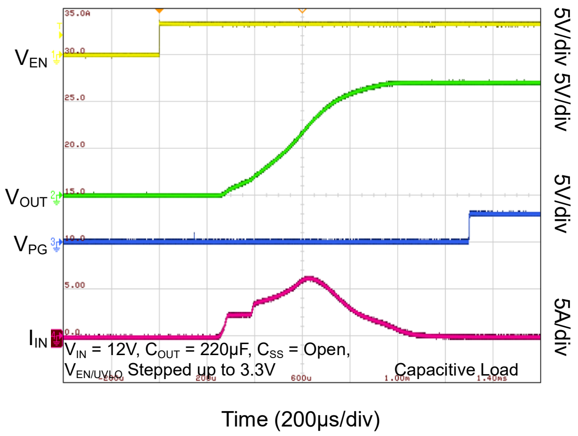
Power-Up and Power-Down with Input Supply



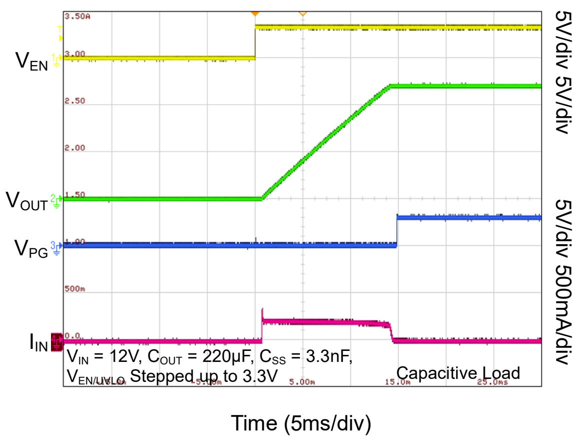
Input Hot-Plug



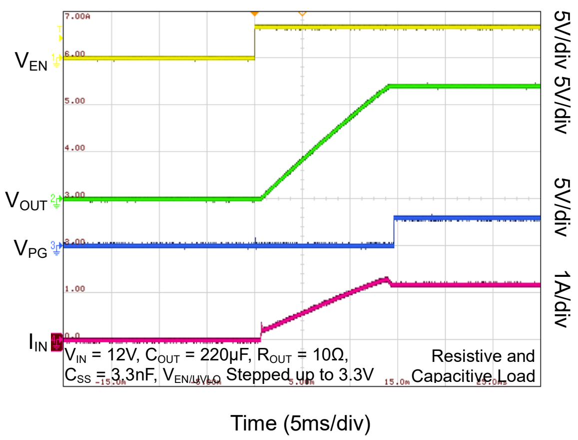
Inrush Current without Slew Rate Control



Inrush Current with Slew Rate Control



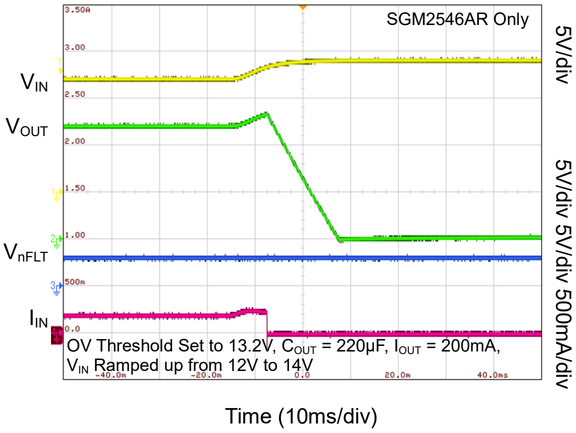
Inrush Current with Slew Rate Control



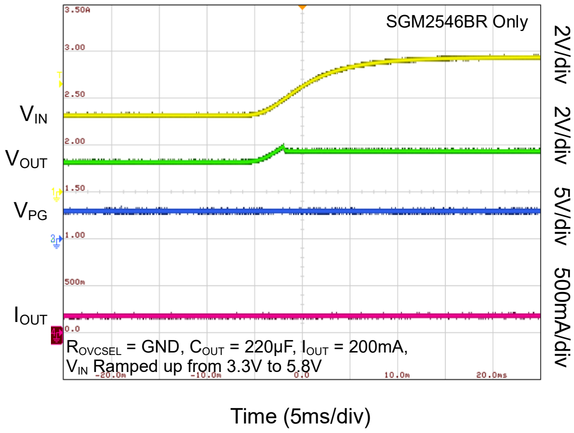
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

T_J = -40℃ to +125℃, unless otherwise noted.

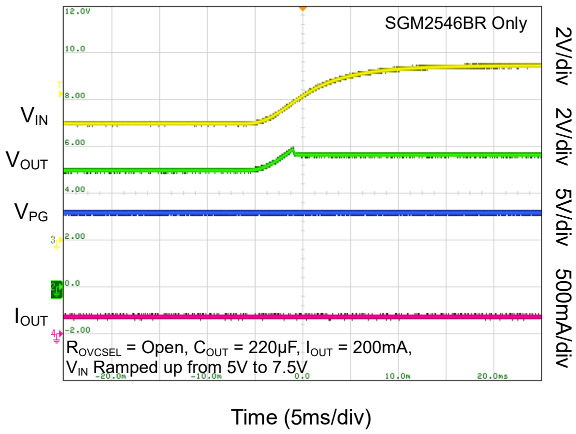
Over-Voltage Lockout Response



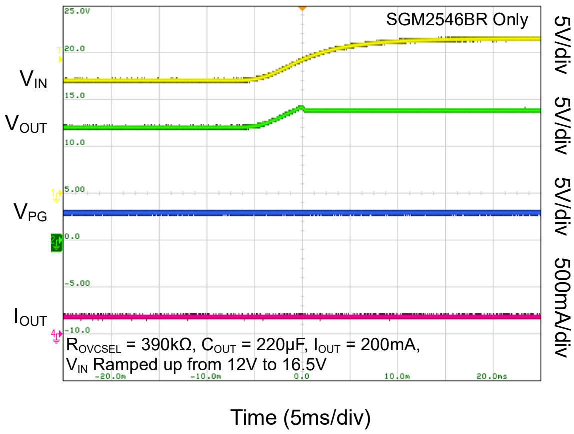
Over-Voltage Clamp Response



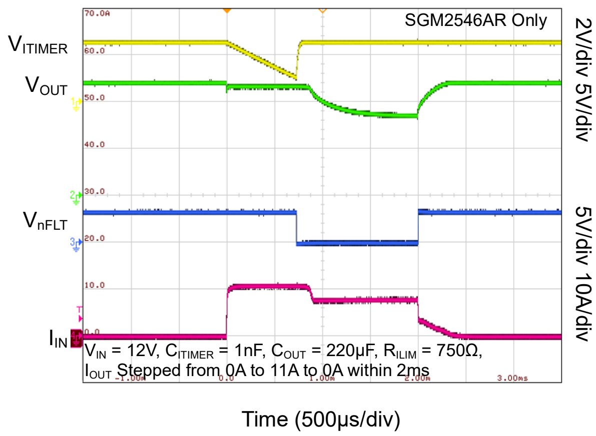
Over-Voltage Clamp Response



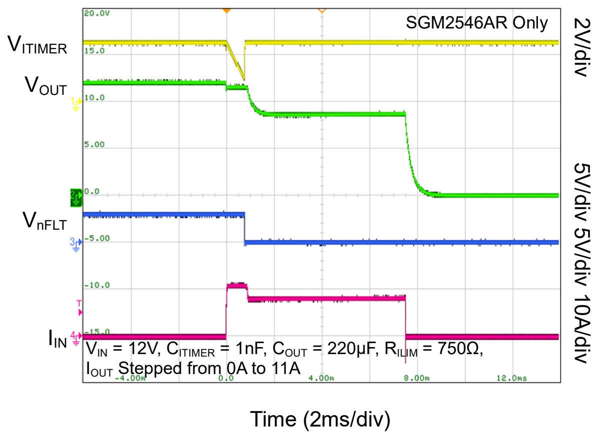
Over-Voltage Clamp Response



Active Current Limit Response



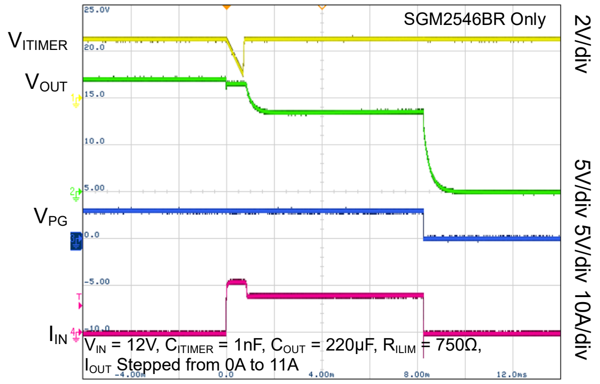
Active Current Limit Response Followed by TSD



TYPICAL PERFORMANCE CHARACTERISTICS (continued)

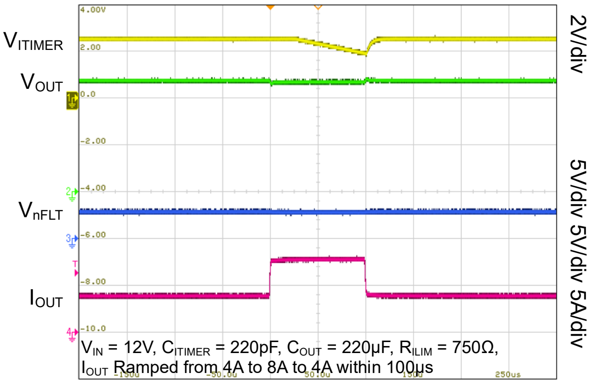
T_J = -40℃ to +125℃, unless otherwise noted.

Active Current Limit Response Followed by TSD



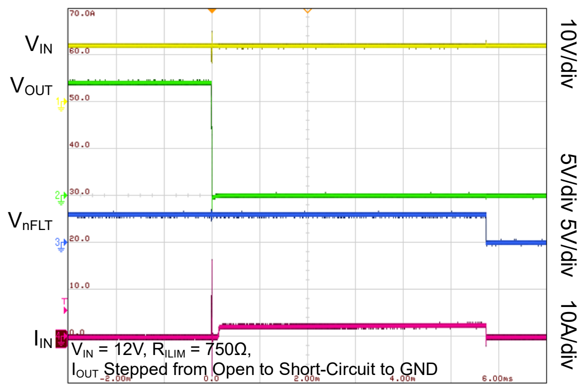
Time (2ms/div)

Transient Over-Current Blanking Timer Response



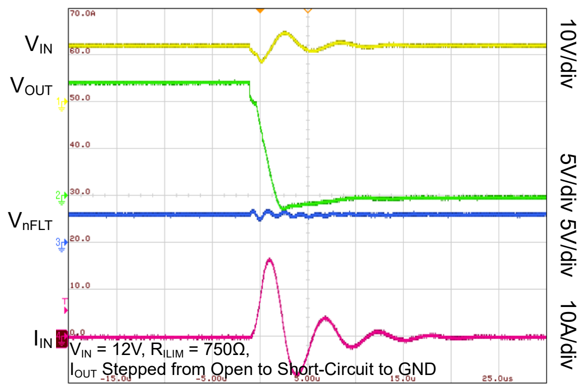
Time (50μs/div)

Output Short-Circuit During Steady State



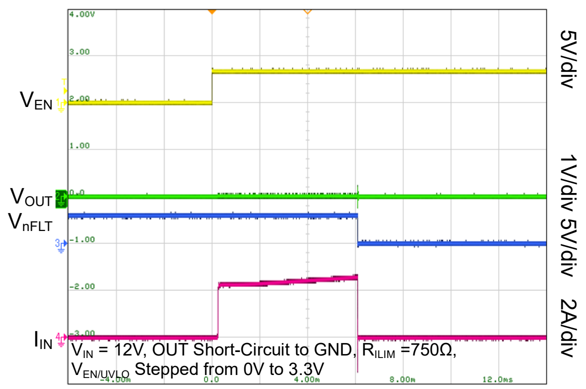
Time (1ms/div)

Output Short-Circuit During Steady State (Zoomed In)



Time (5μs/div)

Power-Up into Short-Circuit



Time (2ms/div)

FUNCTIONAL BLOCK DIAGRAM

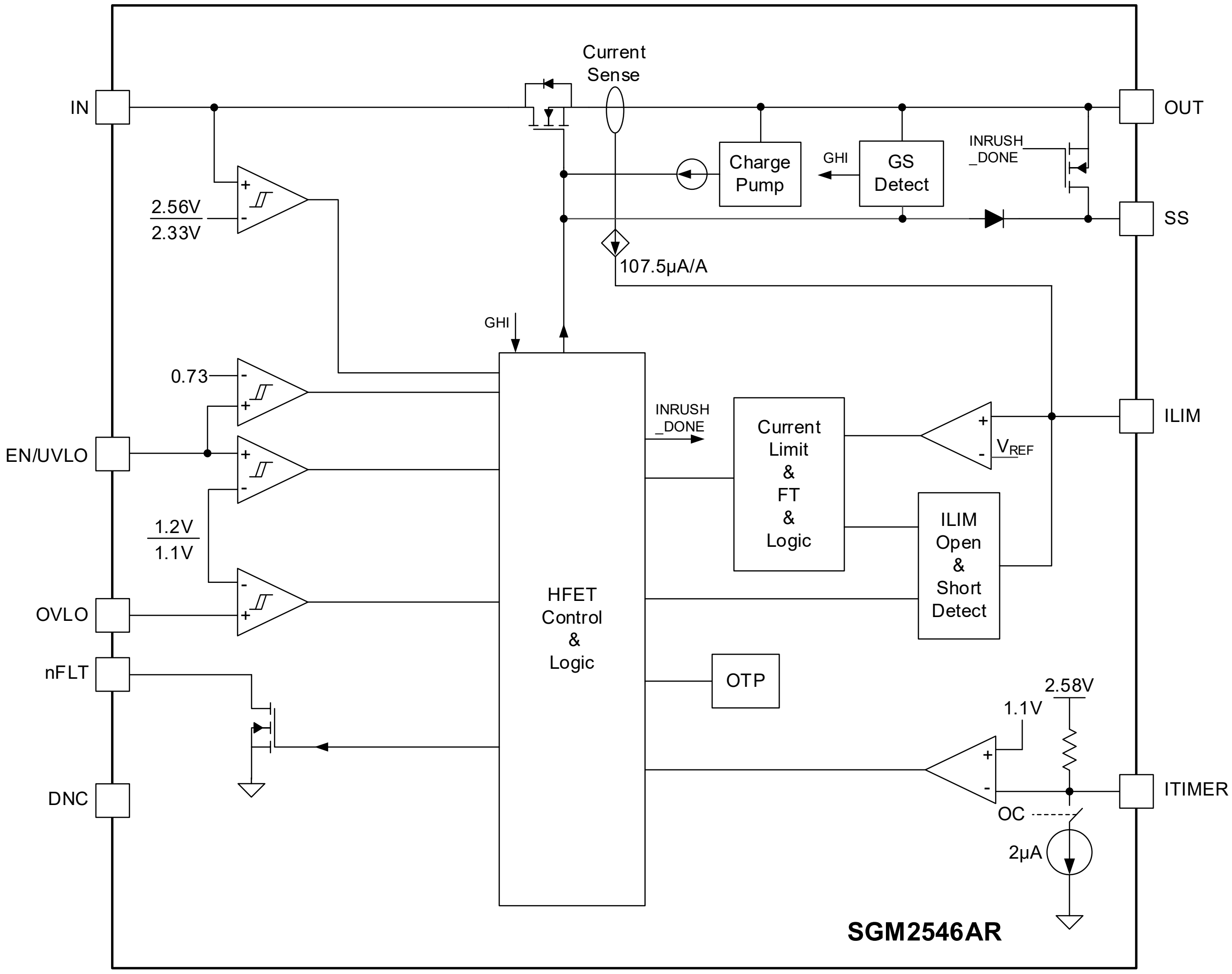


Figure 1. SGM2546AR Block Diagram

FUNCTIONAL BLOCK DIAGRAM (continued)

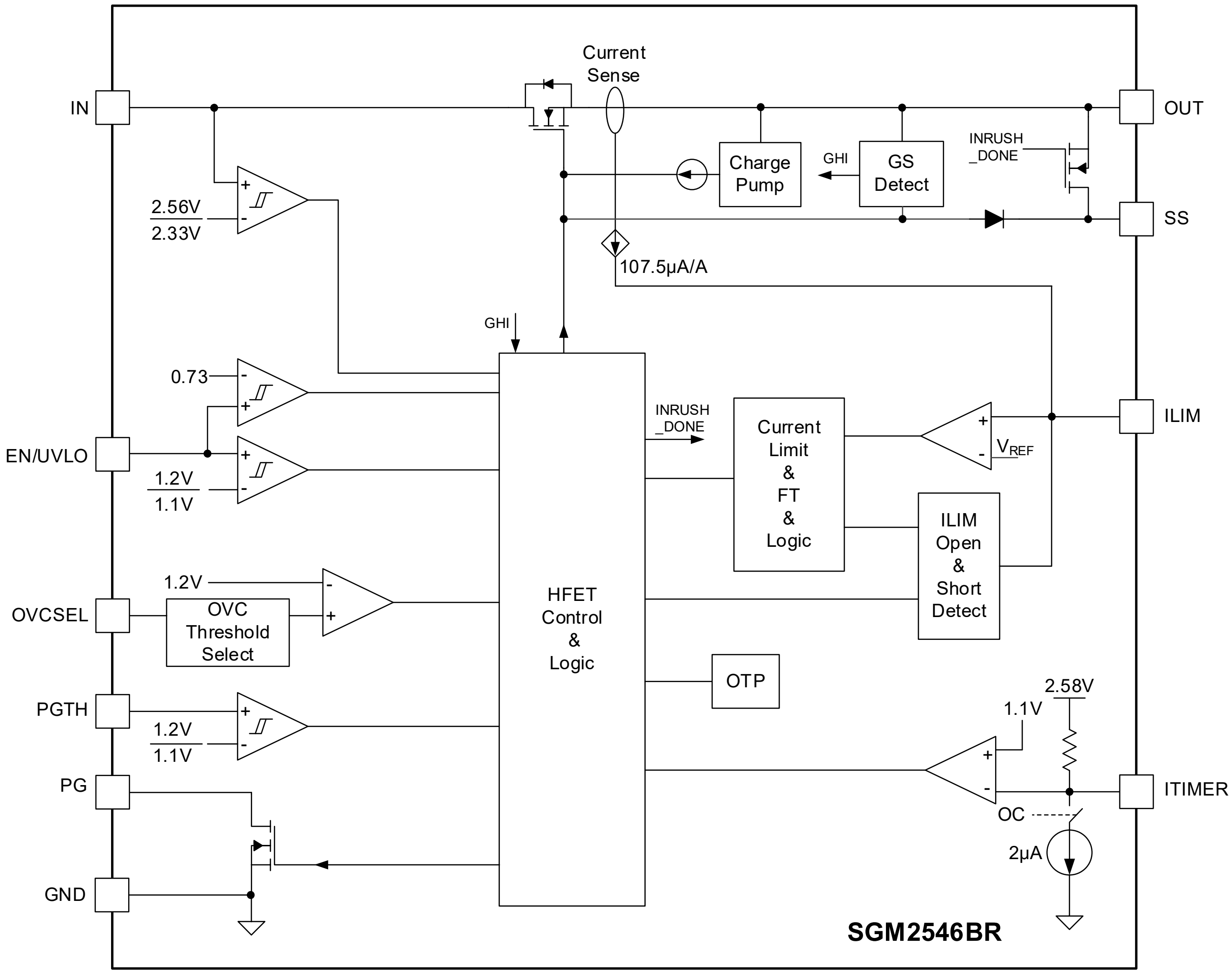


Figure 2. SGM2546BR Block Diagram

DETAILED DESCRIPTION

SGM2546 is an eFuse with internal integration of FET. It ensures the safety of the power delivery system due to its rich features. When the V_{IN} is greater than V_{UVP_R}, the device starts to sample the voltage of the EN/UVLO pin ($V_{EN/UVLO}$). If $V_{EN/UVLO}$ exceeds V_{UVLO_R}, the internal FET starts conducting and the current can flow in both directions. When the V_{IN} is less than V_{UVP_F} or $V_{EN/UVLO} < V_{UVLO\_F}$, the internal FET is turned off.

After device start-up, the SGM2546 will monitor the V_{IN} and forward current (from IN to OUT). By controlling the internal FET, the load current is limited to the set current limit threshold (I_{LIM}). During over-voltage event, the output voltage will be clamped to the chosen threshold (V_{OVC}) or be cut-off if it exceeds the user-adjustable over-voltage lockout threshold (V_{OV}). The fast-trip response of the device can provide rapid protection against serious over-current during short-circuit of OUT pin, so as to prevent the system from being damaged by harmful voltage and current. In addition, the device also provides a user-adjustable over-current blanking timer to allow short-time over-current in the power path without tripping the device frequently. Therefore, SGM2546 not only provides complete protection functions, but also ensures the maximum system uptime during transient events.

There is an integrated thermal sensor to protect itself when the device temperature exceeds the T_{SD}.

Under-Voltage Lockout (UVLO and UVP)

The SGM2546 implements under-voltage protection at IN pin to prevent IN voltage from being too low for normal operation of system and equipment. A fixed locking threshold voltage (V_{UVP}) is provided inside the device for under-voltage protection. In addition, the comparator on the EN/UVLO terminal can be used to set the user-adjustable under-voltage protection threshold through the external resistor divider. Figure 3 and Equation 1 show how to set the specific value of under-voltage protection threshold using an external resistor divider.

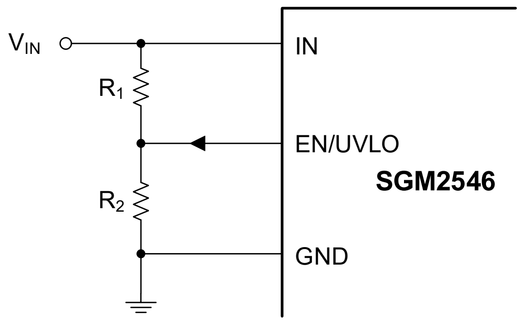


Figure 3. Adjustable Under-Voltage Protection

$$V_{IN\_UV} = \frac{V_{UVLO} \times (R_1 + R_2)}{R_2} \quad (1)$$

Over-Voltage Lockout (OVLO)

The SGM2546AR implements over-voltage lockout at OVLO pin to prevent IN voltage from being too high for normal operation of system and equipment. The comparator on the OVLO pin is used to set the user-adjustable over-voltage protection threshold through the external resistor divider. If the voltage of OVLO pin exceeds the V_{OV_R}, the device will shut down the power path. When the voltage of OVLO pin is lower than the V_{OV_F}, the power path will be reopened with inrush control. There is a hysteresis between the rising threshold and falling threshold of OVLO. The Equation 2 and Figure 4 show how to set the specific value of over-voltage protection threshold using an external resistor divider.

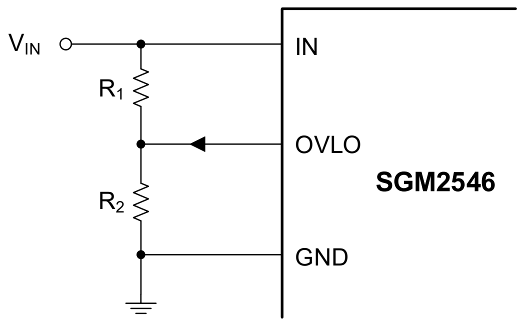


Figure 4. Adjustable Over-Voltage Protection

$$V_{IN\_OV} = \frac{V_{OV} \times (R_1 + R_2)}{R_2} \quad (2)$$

DETAILED DESCRIPTION (continued)

While recovering from an OVLO event, the SGM2546AR variant starts up with inrush control (SS).

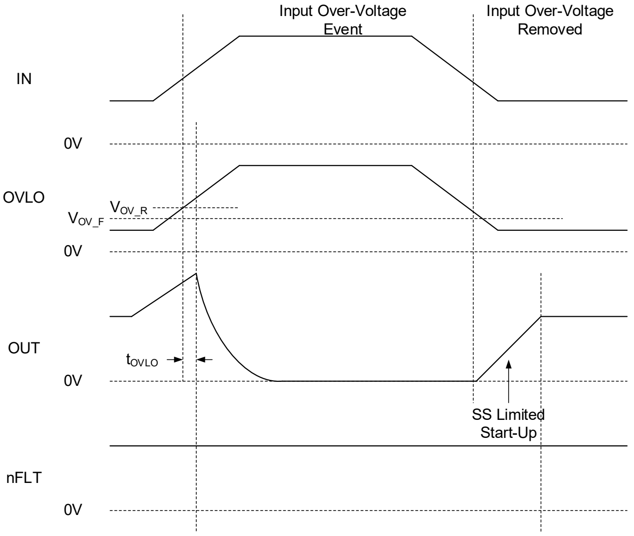


Figure 5. SGM2546AR Over-Voltage Lockout and Recovery

Over-Voltage Clamp (OVC)

The SGM2546BR performs an output voltage clamp under input over-voltage event. When the input voltage exceeds the over-voltage clamp threshold (V_{OVC}), the device acts quickly within t_{OVC} and clamps the output voltage. The device will be regulated as long as the input over-voltage event is present.

If the device stays in clamp state driving certain load for a long time, considerable power will be dissipated on the device, which could cause over-temperature and thermal shutdown (TSD). After thermal shutdown, the SGM2546BR would re-start after a delay time of T_{SD} when the junction temperature falls below T_{SD} - T_{HYS}.

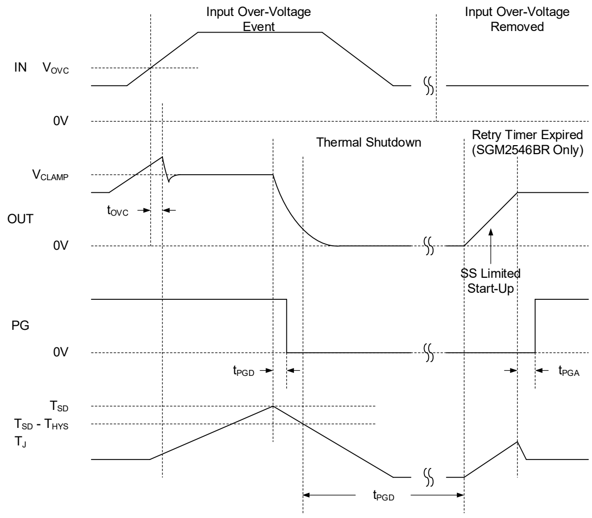


Figure 6. SGM2546BR Over-Voltage Response (Auto-Retry)

The SGM2546BR provides three available over-voltage clamp threshold values, which can be configured using the OVCSEL pin.

Table 1. SGM2546BR Over-Voltage Clamp Threshold Selection

OVCSEL Pin Connection	Over-Voltage Clamp Threshold
Shorted to GND	3.91V
Open	5.81V
Connected to GND through a 390kΩ resistor	13.95V

Inrush Current, Over-Current, and Short-Circuit Protection

SGM2546 adopts four levels of forward over-current protection function:

- Programmable slew rate (SR) for inrush current protection.
- Programmable current limit threshold (I_{LIM}) for over-current in steady state or start-up.
- Programmable threshold (I_{SC}) for severe over-current in steady state or start-up.
- Fixed I_{FT} for fast-trip function when short-circuit of OUT occurs.

DETAILED DESCRIPTION (continued)

Slew Rate (SS) and Inrush Current Control

When hot-plug or system charging large capacitive load occurs, a large inrush current is generated in the equipment power path. The input connector may be damaged or the input power rail voltage may drop, which affects the normal operation and even restarts other equipment in the system.

For a given C_{OUT}, the relationship between the slew rate (SR) and inrush current (I_{INRUSH}) is shown in Equation 3.

$$SR(V/ms) = \frac{I_{INRUSH}(mA)}{C_{OUT}(\mu F)} \quad (3)$$

The slew rate can be controlled by connecting a capacitor at the SS pin to reduce inrush current. For a given slew rate, the corresponding C_{SS} can be calculated by Equation 4. When the SS pin is left floating, the fastest output slew rate can be obtained.

$$C_{SS}(pF) = \frac{3300}{SR(V/ms)} \quad (4)$$

Active Current Limiting

The SGM2546AR and SGM2546BR implement an over-current limiting response under over-current condition. The device actively regulates the current at the current-limit threshold (I_{LIM}) after the user-programmable over-current blanking time. When the load current exceeds the over-current threshold I_{LIM} (set by the resistor at ILIM pin) but lower than the fast-trip threshold (2 × I_{LIM}), the capacitor at ITIMER pin C_{ITIMER} starts discharging through the internal 2μA current. If the load current falls below I_{LIM} before the C_{ITIMER} discharges by ΔV_{ITIMER}, the ITIMER pin is reset by re-charging C_{ITIMER} to the internal pull-up voltage V_{INT}, and the current limit will not be activated. If the over-current event persists, once C_{ITIMER} discharges by ΔV_{ITIMER}, the device actively limits the current at I_{LIM}. Meanwhile, C_{ITIMER} is re-charged to V_{INT} for the next over-current condition. This design ensures full blanking time is provided for every over-current fault. Use Equation 5 to calculate the R_{ILM} value for a desired over-current threshold.

$$R_{ILIM}(\Omega) = \frac{5747}{I_{LIM}(A)} \quad (5)$$

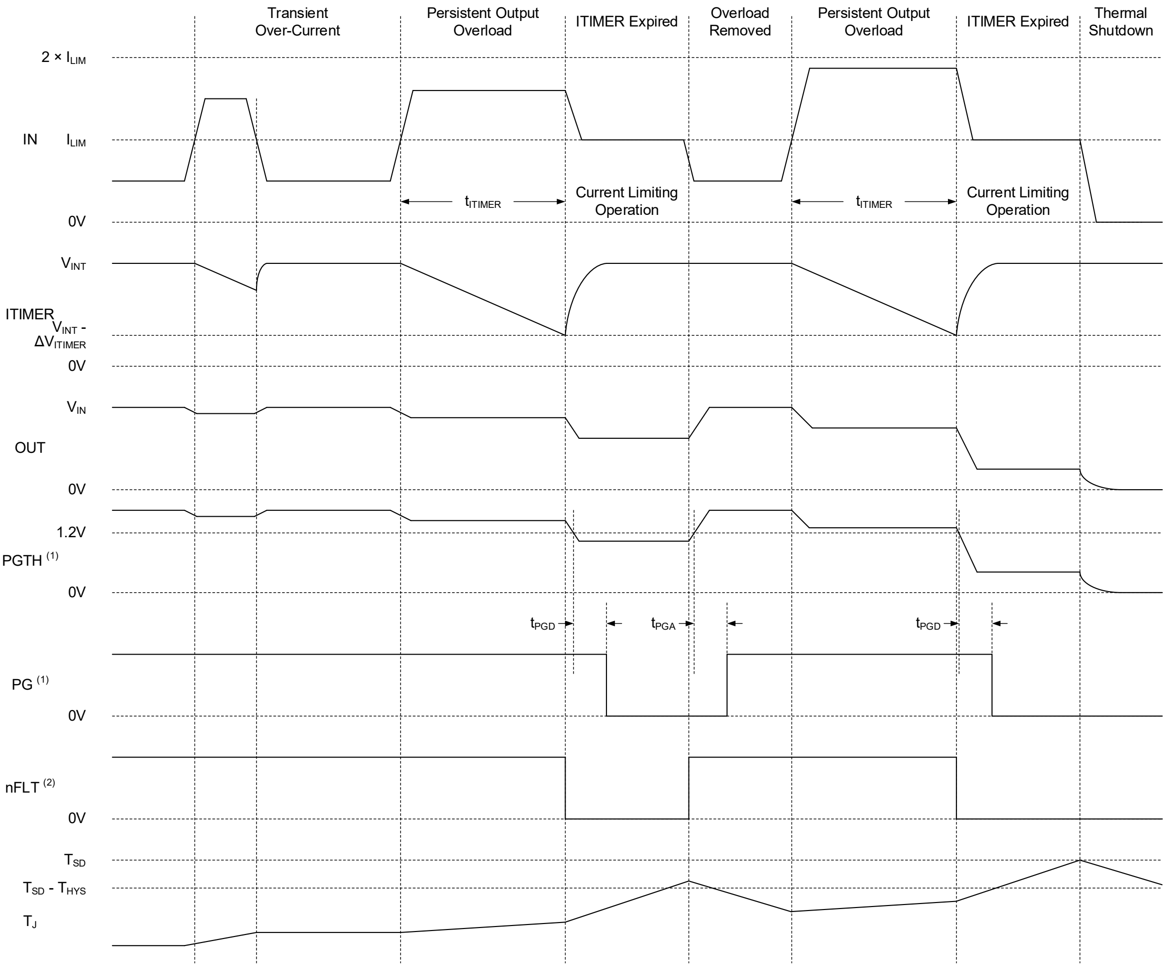
NOTES:

1. Leave the ILIM pin floating to set the over-current threshold near zero, and the device can hardly be loaded.
2. The current limit circuit implements the fold-back mechanism. In the fold-back region (0V < V_{OUT} < V_{FB}), the current limit threshold is smaller than the current limit threshold (I_{LIM}) under steady state.
3. When the ILIM is short to the GND under normal operations, it will be detected as a fault case. The load current should reach a minimum threshold I_{nFLT} for the device to detect LIM short pin.

The blanking time can be adjusted by changing the capacitance connected to the ITIMER pin. Over-current blanking time can be calculated by Equation 6.

$$t_{ITIMER}(ms) = \frac{\Delta V_{ITIMER}(V) \times C_{ITIMER}(nF)}{I_{ITIMER}(\mu A)} \quad (6)$$

DETAILED DESCRIPTION (continued)



NOTES:

1. Applicable only to SGM2546BR variant.
2. Applicable only to SGM2546AR variant.

Figure 7. SGM2546AR and SGM2546BR Active Current Limit Response

NOTES:

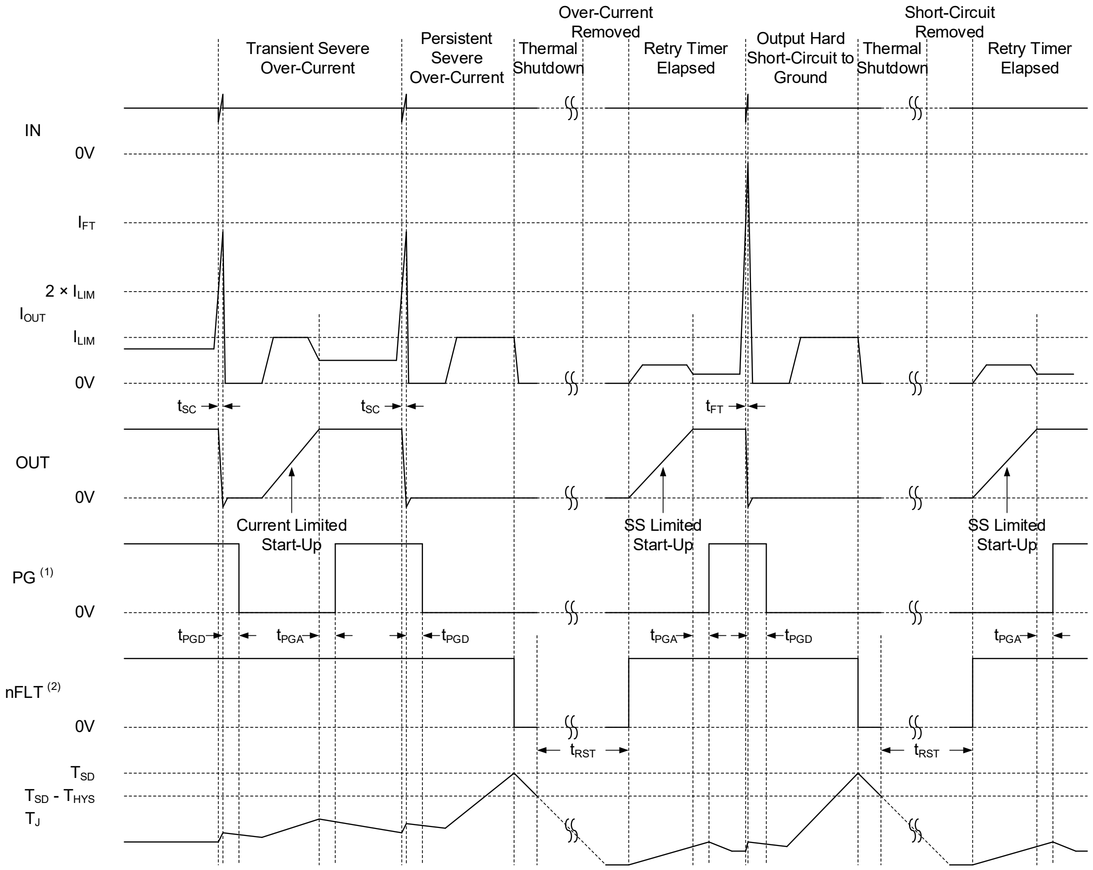
1. Leaving the ITIMER pin open would make the device to cut off the circuit with the minimum possible delay.
2. Leaving the ITIMER pin floating or short to GND sets the minimum over-current blanking time. But it is not recommended to leave ITIMER pin short to GND, because it increases the current consumption of the device.
3. The active current limit set by R_{ILIM} is still valid for SGM2546AR and SGM2546BR during start-up, which ensures that the load current does not exceed I_{LIM} during start-up. However, there is no over-current blanking time in the start-up process.
4. For the SGM2546BR, during over-voltage clamp condition, if an over-current event occurs, the current limit is activated immediately without the ITIMER delay.
5. Increasing C_{ITIMER} can increase the over-current blanking time, but it also increases the time for C_{ITIMER} to charge to V_{INT}. If the next over-current case occurs before the C_{ITIMER} is fully charged to the V_{INT}, the current blanking time of this event will be shorter than intended.

During the active current limit, there is more power dissipation on the internal FET because the output voltage drops. If the internal temperature of the device exceeds the T_{SD}, the internal FET will be turned off, and the device will either be restarted automatically after a certain time interval.

DETAILED DESCRIPTION (continued)

Short-Circuit Protection

When a serious over-current event similar to a short-circuit event occurs, the SGM2546 triggers a fast-trip response to prevent the system from being damaged by excessive current flowing through the device. A fast-trip comparator with scalable threshold (I_{SC} = 2 × I_{LIM}) is adopted inside the device, which allows users to program the fast-trip threshold in low current system. A fixed fast-trip threshold is also set inside the device for fast protection against hard short-circuit events in steady state. The fixed fast-trip threshold is higher than the maximum fast-trip threshold configured by user within the recommended operating range. The internal FET will be completely turned off within t_{FT} if the current exceeds I_{FT} or I_{SC}. Then the device will turn on the internal FET again after a short of deglitch time in a current limit mode. In this way, the rapid recovery of internal FET can be realized after a transient severe over-current event, and the drop of OUT voltage can be minimized. If the fault persists, the devices continue to operate in the current limit mode, causing the internal temperature of the device to rise until the thermal shutdown.



NOTES:

1. Applicable only to SGM2546BR variant.

2. Applicable only to SGM2546AR variant.

Figure 8. SGM2546 Short-Circuit Response

Analog Load Current Monitor

The device provides an analog current sensing output proportional to the load current at the ILIM pin, which enables the device to monitor the load current (from IN to OUT). The user can calculate the load current through the voltage of the ILIM pin connected to the R_{ILIM}. The relationship between V_{ILIM} and I_{OUT} is shown in Equation 7.

$$I_{OUT}(A) = \frac{V_{ILM}(\mu V)}{R_{ILIM}(\Omega) \times G_{IMON}(\mu A / A)} \quad (7)$$

DETAILED DESCRIPTION (continued)

The waveform below shows the analog load current monitor response to a load step at the output.

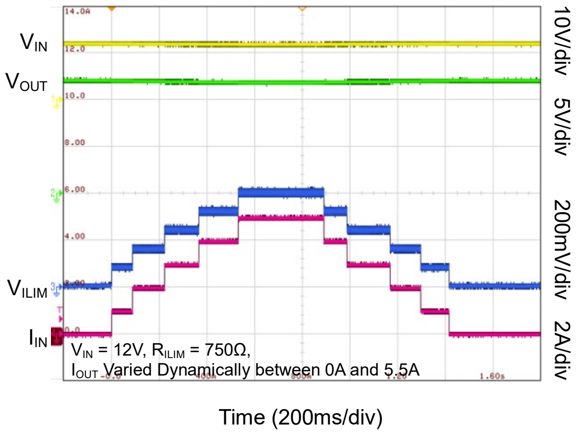


Figure 9. Analog Load Current Monitor Response

NOTE:

1. ILIM pin is sensitive to capacitive loads. In order to ensure the normal operation of the device, the parasitic capacitance of the ILIM pin needs to be less than 50pF.

Over-Temperature Protection (OTP)

The SGM2546 continuously monitors the temperature (T_J) of the internal die. Once the internal temperature exceeds the T_{SD}, the device shuts down immediately. The SGM2546 will not turn on until the internal temperature is lower than a safe threshold (T_{SD} - T_{HYS}).

When SGM2546 triggers the thermal shutdown, it remains in the shutdown state until the internal temperature of the equipment drops by T_{HYS}. After that, it will retry to turn on automatically after a t_{RST} delay time if the device is still enabled.

Table 2. Thermal Shutdown

Part Number	ENTER Thermal Shutdown	EXIT Thermal Shutdown
SGM2546	$T_J \geq T_{SD}$	$T_J < T_{SD} - T_{HYS}$ t_{RST} time out.

Fault Response and Indication (nFLT)

Table 3 shows the protection response of equipment under different fault conditions. The SGM2546AR provides an active-low external fault flag pin.

Table 3. Fault Summary

EVENT	PROTECTION RESPONSE	FAULT LATCHED INTERNALLY	nFLT PIN STATUS (1)	nFLT ASSERTION DELAY (1)
Over-Temperature	Shutdown	Y	L	
Under-Voltage (UVP or UVLO)	Shutdown	N	H	
Input Over-Voltage	Shutdown (1)(2)	N	H	
	Voltage Clamp (2)	N	N/A	
Transient Over-Current ($I_{LIM} < I_{OUT} < 2 \times I_{LIM}$)	None	N	N	
Persistent Over-Current	Current Limit	N	L	t_{ITIMER}
Output Short-Circuit to GND	Circuit-Breaker followed by Current Limit	N	H	
ILM Pin Open (During Steady State)	Shutdown	N	L	t_{ITIMER}
ILM Pin Shorted to GND	Shutdown	Y	L	

NOTES:

1. Applicable to SGM2546AR variant only.

2. Applicable to SGM2546BR variant only.

DETAILED DESCRIPTION (continued)

A latched fault can be cleared by power cycling (pulling VIN to 0V) or re-enable (pulling EN/UVLO pin below V_{SD}). This will reset the nFLT pin and the t_{RST} for the SGM2546AR.

During a latched fault, pulling the EN/UVLO just below the UVLO threshold cannot clear the latched fault.

After the retry delay t_{RST}, the device restarts automatically and the nFLT pin is released (SGM2546AR).

Power Good Indication (PG)

The SGM2546BR provides an active-high open-drain output (PG) as the indication pin of power good. It is asserted as high according to the PGTH pin voltage and the device working state. PG pin needs to be pulled up to an external power supply.

At the initial stage of power-on, PG is pulled down. Then the device enters the start-up sequence, in which the internal FET has been controlled and not fully conductive. When the gate voltage of the internal FET reaches overdrive, it is fully conductive and the start-up sequence is completed, V_{PGTH} is higher than V_{PGTH_R}, and PG is asserted high after a deglitch time (t_{PGA}).

The PG will be de-asserted when the PGTH voltage falls below V_{PGTH_F} or when the system has faults other than over-current during steady state. The deglitch time is t_{PGD}, when PG is de-asserted.

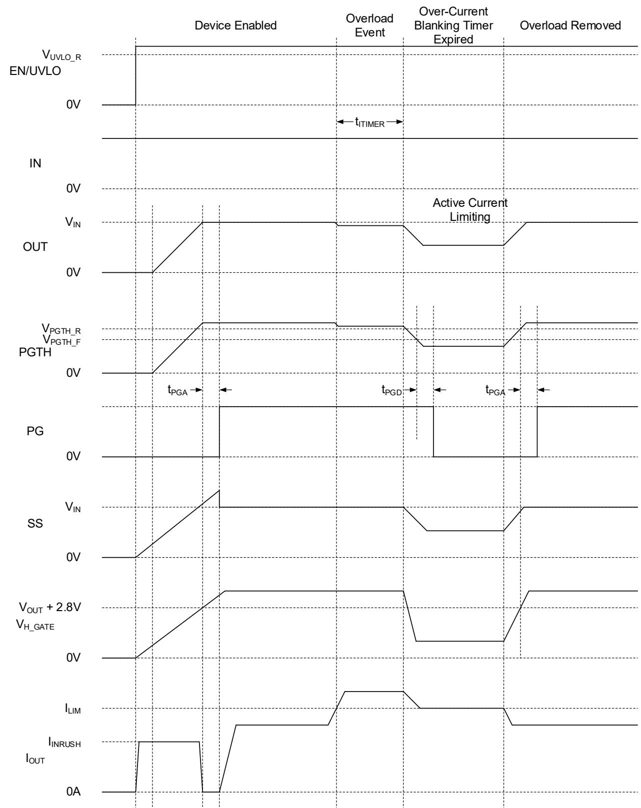


Figure 10. SGM2546BR PG Timing Diagram

Table 4. SGM2546BR PG Indication Summary

EVENT	DEVICE STATUS	PG PIN STATUS	PG PIN TOGGLE DELAY
Under-Voltage UVP or UVLO)	OFF	L	
Over-Voltage	ON (Clamping)	H (If PGTH pin voltage > V_{PGTH_R}) L (If PGTH pin voltage < V_{PGTH_F})	t_{PGA} t_{PGD}
Steady State	ON	H (If PGTH pin voltage > V_{PGTH_R}) L (If PGTH pin voltage < V_{PGTH_F})	t_{PGA} t_{PGD}
Transient Over-Current	ON	H (If PGTH pin voltage > V_{PGTH_R}) L (If PGTH pin voltage < V_{PGTH_F})	t_{PGA} t_{PGD}
Persistent Overload	ON (Current Limiting)	H (If PGTH pin voltage > V_{PGTH_R}) L (If PGTH pin voltage < V_{PGTH_F})	t_{PGA} t_{PGD}
Output Short-Circuit to GND	Fast-Trip Followed by Current Limit	H (If PGTH pin voltage > V_{PGTH_R}) L (If PGTH pin voltage < V_{PGTH_F})	t_{PGA} t_{PGD}
ILM Pin Open	OFF	L	t_{PGD}
ILM Pin Shorted to GND	OFF	L	t_{PGD}
Over-Temperature	OFF	L	t_{PGD}

DETAILED DESCRIPTION (continued)

When the device is not powered, the PG pin should be low. However, there is no effective power supply to drive the PG pin down to GND in this case. If the PG is pulled up by an independent power supply and the device is not powered, there may be a small voltage on the PG caused by sink current, which is a function of the pull-up supply and pull-up resistance connected to the PG. In order to avoid the small voltage on the PG pin being detected as logic high by the external related circuit, the sink current of the pin should be minimized.

Device Functional Modes

The SGM2546AR has only one functional mode within recommended operation conditions.

The SGM2546BR offers three different OVC features according to the OVCSEL pin connection.

Table 5. SGM2546BR Over-Voltage Clamp Threshold Selection

OVCSEL Pin Connection	Over-Voltage Clamp Threshold
Shorted to GND	3.91V
Open	5.81V
Connected to GND through a 390kΩ Resistor	13.95V

REVISION HISTORY

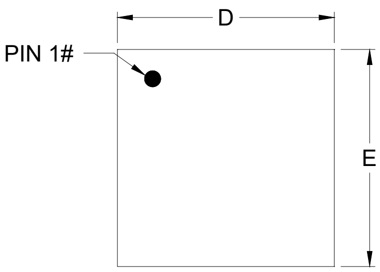
NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

APRIL 2025 – REV.A to REV.A.1	Page
Updated Electrical Characteristics	5

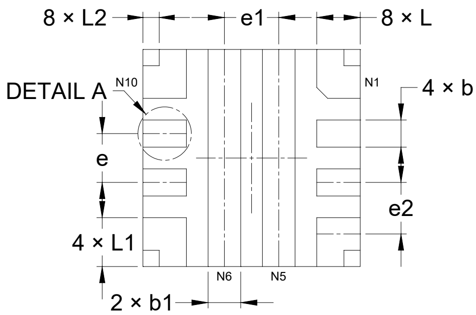
Changes from Original (DECEMBER 2024) to REV.A	Page
Changed from product preview to production data	All

PACKAGE OUTLINE DIMENSIONS

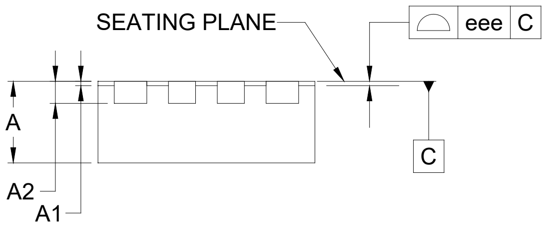
TQFN-2×2-10L



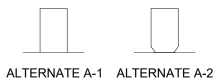
TOP VIEW



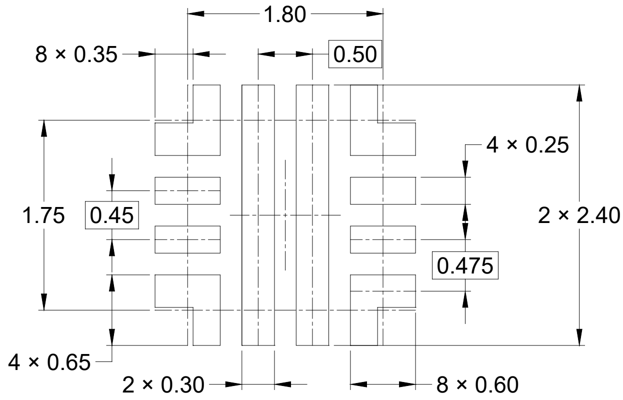
BOTTOM VIEW



SIDE VIEW



DETAIL A
ALTERNATE TERMINAL CONSTRUCTION



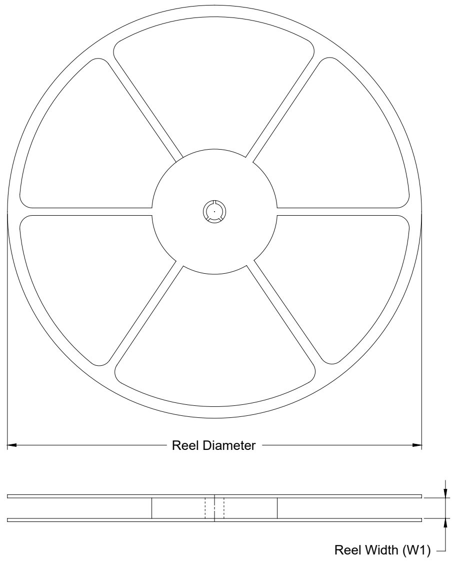
RECOMMENDED LAND PATTERN (Unit: mm)

Symbol	Dimensions In Millimeters		
	MIN	NOM	MAX
A	0.700	-	0.800
A1	0.000	-	0.050
A2	0.203 REF		
b	0.200	-	0.300
b1	0.250	-	0.350
D	1.900	-	2.100
E	1.900	-	2.100
e	0.450 BSC		
e1	0.500 BSC		
e2	0.475 BSC		
L	0.300	-	0.500
L1	0.350	-	0.550
L2	0.150 REF		
eee	0.080		

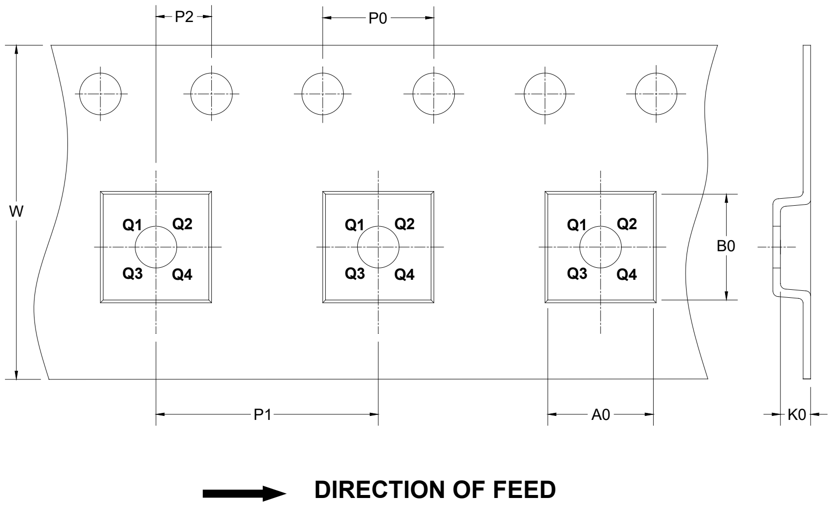
NOTE: This drawing is subject to change without notice.

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



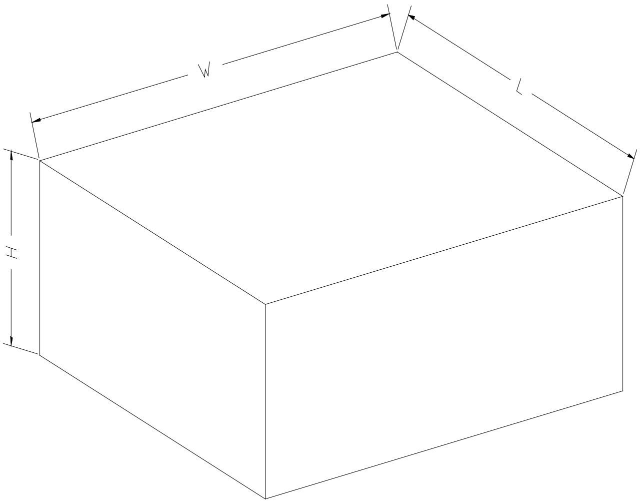
NOTE: The picture is only for reference. Please make the object as the standard.

KEY PARAMETER LIST OF TAPE AND REEL

Package Type	Reel Diameter	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	P1 (mm)	P2 (mm)	W (mm)	Pin1 Quadrant
TQFN-2×2-10L	7"	9.5	2.30	2.30	1.10	4.0	4.0	2.0	8.0	Q2

DD0001

CARTON BOX DIMENSIONS



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

KEY PARAMETER LIST OF CARTON BOX

Reel Type	Length (mm)	Width (mm)	Height (mm)	Pizza/Carton
7″ (Option)	368	227	224	8
7″	442	410	224	18

DD0002