SGM2539
High Voltage, USB PD Power Switch

GENERAL DESCRIPTION

The SGM2539 is a 5A unidirectional USB power delivery (PD) high-side switch with under-voltage lockout (UVLO), over-voltage lockout (OVLO), reverse current (RCP) and over-temperature (OTP) protections. This switch can tolerate up to 29V at VBUS pin (22V at VINT pin) when it is turned off. It can automatically turn off and disconnect the terminals under fault conditions. Two SGM2539 devices can be paralleled for connecting two USB power inputs for charging the device battery.

The SGM2539 has a default 22.75V over-voltage protection threshold and it can be changed by an external resistor divider connected to the OVLO pin. To limit the inrush current, a 15ms debounce time followed by a soft-start time is applied before turning the switch on.

The SGM2539 recommended operating voltage range is from 2.5V to 20V. It is typically used for controlling the power delivery from the sources connected to the USB ports of system with necessary protection features. For the USB PD applications such as cell phones, tablets or notebooks, the SGM2539 provides a reliable path to charge the internal battery from the power delivered to the USB ports.

The SGM2539 is available in a Green WLCSP-2.56×1.54-15B package and can operate over a temperature range of -40℃ to +85℃.

FEATURES

- **Wide 2.5V to 20V Operating Voltage Range**
- **5A Maximum Continuous Switch Current**
- **29V Tolerance at VBUS Pin**
- **Low On-Resistance: 30mΩ (TYP)**
- **Adjustable Over-Voltage Lockout (OVLO)**
- **Controlled Slew Rate for Inrush Current Limit**
- **Two-Level Reverse Current Protection (RCP)**
- **Protection Circuitry**
  - **Over-Temperature Protection**
  - **Over-Voltage Protection**
  - **Under-Voltage Lockout**
  - **Reverse Current Protection in All Conditions**
- **Available in a Green WLCSP-2.56×1.54-15B Package**

APPLICATIONS

Smart and Feature Phones
Tablets, eBooks
Notebooks

TYPICAL APPLICATION

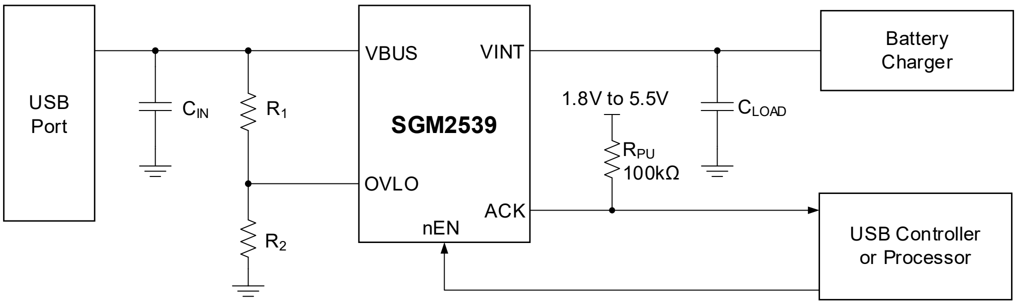


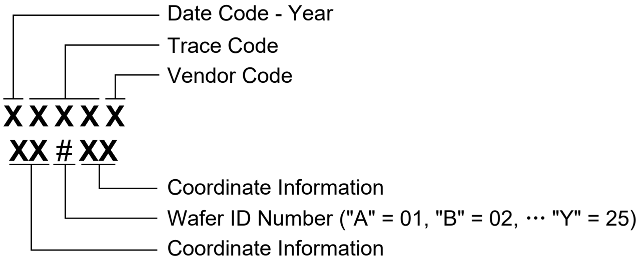
Figure 1. Typical Application Circuit

PACKAGE/ORDERING INFORMATION

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM2539	WLCSP-2.56×1.54-15B	-40℃ to +85℃	SGM2539YG/TR	SGM2539 XXXXX XX#XX	Tape and Reel, 3000

MARKING INFORMATION

NOTE: XXXXX = Date Code, Trace Code and Vendor Code. XX#XX = Coordinate Information and Wafer ID Number.



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

VBUS .... -0.5V to 29V
VINT .... -0.5V to 22V
OVLO .... -0.5V to V_{VBUS}
nEN .... -0.5V to 29V
ACK .... -0.5V to 6V
Continuous Switch Current, I_{SW}, T_J = +25℃ 5A
Peak Switch Current, I_{SW}, (100μs Pulse, 2% Duty Cycle)
.... 10A
Package Thermal Resistance
WLCSP-2.56×1.54-15B, θ_{JA} .... 48.2℃/W
WLCSP-2.56×1.54-15B, θ_{JB} .... 8.1℃/W
WLCSP-2.56×1.54-15B, θ_{JC} .... 16.9℃/W
Junction Temperature .... +150℃
Storage Temperature Range .... -65℃ to +150℃
Lead Temperature (Soldering, 10s) .... +260℃
ESD Susceptibility
HBM 4000V
CDM 1000V
IEC61000-4-2 Contact Discharge on VBUS 8000V

RECOMMENDED OPERATING CONDITIONS

VBUS .... 2.5V to 20V
VINT .... 2.5V to 20V
nEN .... 0V to 20V
ACK .... 0V to 5.5V
Operating Junction Temperature Range ...... -40℃ to +125℃
Operating Ambient Temperature Range .... -40℃ to +85℃

OVERSTRESS CAUTION

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

ESD SENSITIVITY CAUTION

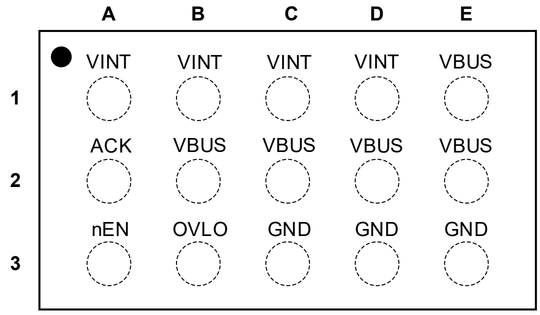
This integrated circuit can be damaged if ESD protections are not considered carefully. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance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

DISCLAIMER

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

PIN CONFIGURATION

(TOP VIEW)



WLCSP-2.56×1.54-15B

PIN DESCRIPTION

PIN	NAME	FUNCTION
A1, B1, C1, D1	VINT	Power Output. Switch terminals for current output to the load.
A2	ACK	Open-Drain Power Good Acknowledge Output. It is pulled low if the switch is turned on. The ACK will be released (Hi-Z) to go high (external pull-up) when the switch is turned off. Pull this pin up to a logic voltage less than 5.5V with a resistor (R_{PU}) range from 10kΩ to 100kΩ.
A3	nEN	Active-Low Enable Input for the Device. Pull this pin low (< 0.4V) to enable the internal circuits and turn on the switch (if other conditions are valid). A 15ms debounce time will apply before turning the switch on. Pull this pin high above 1.2V (up to 20V) to turn off the switch and disable the internal circuits and enter into low power mode. The nEN is weakly pulled low by an internal 1MΩ resistor to assure switch operation with a dead battery.
B2, C2, D2, E1, E2	VBUS	Power Input Supply. Input supply and switch terminal for current input. Recommended operating voltage range is from 2.5V to 20V.
B3	OVLO	V_{OVLO} Threshold Input. Connect this pin to ground (or less than 0.1V) to set the V_{OVLO} threshold to the default 22.75V threshold. A resistor divider can be connected from VBUS to OVLO to reduce and adjust the V_{OVLO} level (between 4V and 22.75V).
C3, D3, E3	GND	Ground.

ELECTRICAL CHARACTERISTICS

(T_J = -40℃ to +85℃, typical values are at T_J = +25℃, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Static Characteristics						
Under-Voltage Lockout Release Voltage	V_{UVLO}	V_{nEN} = 0V, OVLO short to GND, V_{VBUS} rising, until V_{VINT} rising		2.34	2.46	V
Under-Voltage Lockout Hysteresis Voltage	V_{UVLO_HYS}	V_{VBUS} Falling		60		mV
nEN High-Level Input Voltage	V_{IH}	V_{VBUS} = 2.5V to 20V	1.2			V
nEN Low-Level Input Voltage	V_{IL}	V_{VBUS} = 2.5V to 20V			0.4	V
Low-Level Output Voltage	V_{OL_ACK}	I_{LOAD} = 6mA, V_{VBUS} = 2.5V to 20V			0.5	V
nEN Pin Internal Pull-Down Resistance	R_{PD}			1		MΩ
VBUS On-State Quiescent Current	I_Q	V_{nEN} = 0V, V_{VBUS} = 5V, I_{LOAD} = 0A		75	115	μA
		V_{nEN} = 0V, V_{VBUS} = 20V, I_{LOAD} = 0A		115	180	
VBUS Off-State Quiescent Current	I_{SD}	V_{nEN} = 5V, V_{VBUS} = 5V, I_{LOAD} = 0A		0.5	2	μA
		V_{nEN} = 5V, V_{VBUS} = 20V, I_{LOAD} = 0A		3	8	
VBUS Off-State Leakage Current	I_{LEAK_VBUS}	V_{nEN} = 5V, V_{VBUS} = 5V, V_{VINT} = 0V		0.4	2	μA
		V_{nEN} = 5V, V_{VBUS} = 20V, V_{VINT} = 0V		3	8	
VINT Off-State Leakage Current	I_{LEAK_VINT}	V_{nEN} = 5V, V_{VINT} = 5V, V_{VBUS} = 0V		0.41	2	μA
		V_{nEN} = 5V, V_{VINT} = 20V, V_{VBUS} = 0V		3	8	
RCP Leakage Current	I_{LEAK_RCP}	V_{nEN} = 0V, V_{VINT} = 5V, V_{VBUS} = 0V		0.4	2	μA
OVLO Input Leakage Current	I_{LEAK_OVLO}	V_{OVLO} = V_{TH_OVLO}			50	nA
Default Over-Voltage Lockout Voltage	V_{OVLO}	V_{VBUS} Rising, V_{nEN} = 0V, OVLO short to GND	21.85	22.75	23.80	V
		V_{VBUS} Falling, V_{nEN} = 0V, OVLO short to GND		22.4		V
External OVLO Set Threshold Voltage	V_{TH_OVLO}	V_{VBUS} = 2.5V to 20V, nEN = 0V	1.141	1.190	1.240	V
RCP Trigger Voltage	V_{TRIG}	V_{TRIG} = V_{VINT} - V_{VBUS}, V_{VBUS} = 5V	30	55	85	mV
		V_{TRIG} = V_{VINT} - V_{VBUS}, V_{VBUS} = 20V	10	49	110	
On-Resistance	R_{ON}	I_{LOAD} = 0.2A, V_{VBUS} = 5V to 20V, see Figure 2		30	47	mΩ
Thermal Shutdown Temperature	T_{TSD}			156		℃
Thermal Shutdown Hysteresis	T_{HYS}			26		℃
Dynamic Characteristics (See Figure 3 and Figure 4)						
Enable Time	t_{nEN}	From nEN to V_{VINT} = 10% V_{VBUS}, (including 15ms debounce time), V_{VBUS} = 5V, C_{LOAD} = 100μF, R_{LOAD} = 100Ω		20		ms
VINT Rise Time	t_{RISE}	V_{VINT} from 10% to 90% V_{VBUS}, C_{LOAD} = 100μF, R_{LOAD} = 100Ω; V_{VBUS} = 5V		2.9		ms
		V_{VBUS} = 20V		2.5		
OVP Turn-Off Time	t_{OFF_OVP}	From V_{VBUS} > V_{OVLO} to V_{VINT} = 80% V_{VBUS}, R_{LOAD} = 100Ω, C_{LOAD} = 0μF, V_{VBUS} = 20V, OVLO pin short to GND		80		ns
RCP Deglitch Time	t_{DEG}	From V_{VINT} > V_{VBUS} + 55mV to switch off	3	4.5	6	ms
RCP Turn-Off Time	t_{OFF_RCP}	From V_{VINT} > V_{VBUS} + 120mV to switch off		10		μs
Turn-On Time	t_{ON}	nEN to V_{VINT} = 90% V_{VBUS}, C_{LOAD} = 100μF, R_{LOAD} = 100Ω; V_{VBUS} = 5V		23		ms
		V_{VBUS} = 20V		23		
Turn-Off Time	t_{OFF}	nEN to V_{VINT} = 10% V_{VBUS}, C_{LOAD} = 100μF, R_{LOAD} = 100Ω; V_{VBUS} = 5V		22.5		ms
		V_{VBUS} = 20V		23.5		

WAVEFORMS AND TEST CIRCUITS

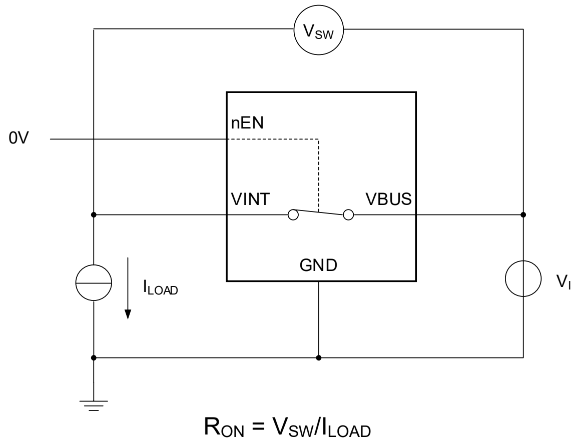


Figure 2. On-Resistance Measurement Test Circuit

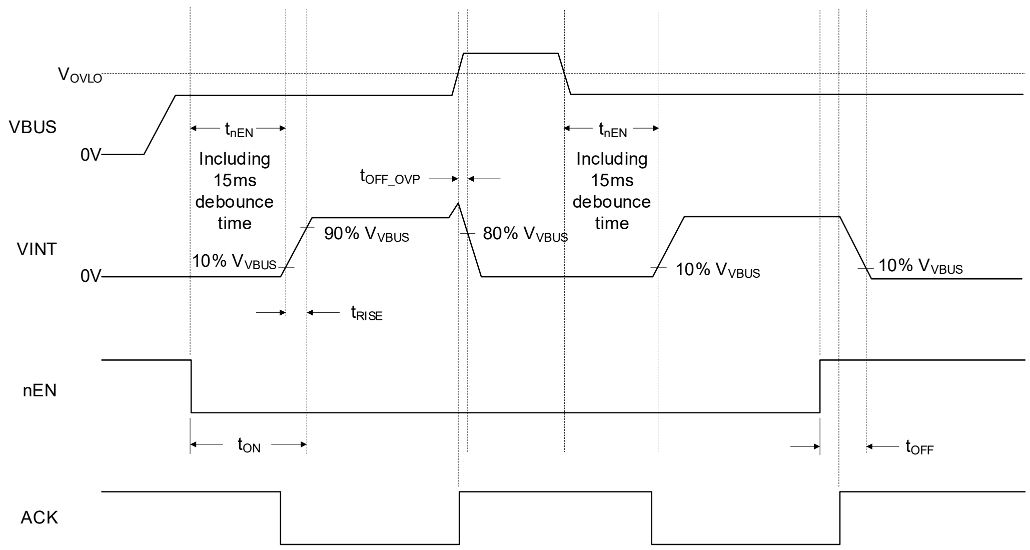
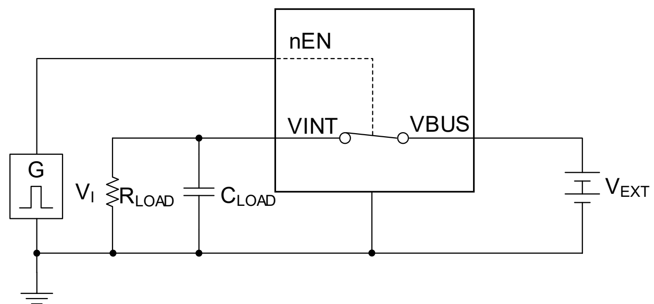


Figure 3. Operating Waveforms and Timing Definitions

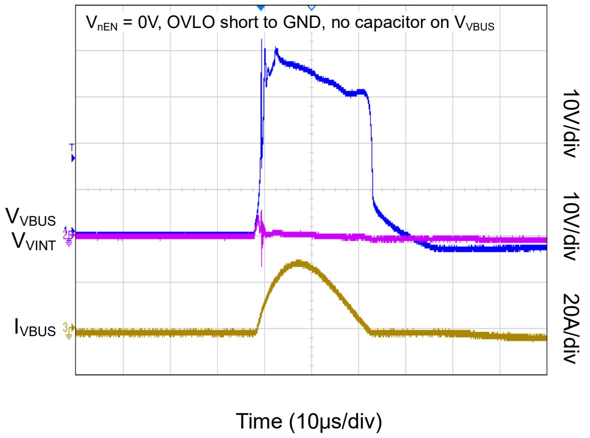


Test conditions are V_{VBUS} = 2.5V to 20V, C_{LOAD} =100μF, R_{LOAD} =100Ω, where:
R_{LOAD} = Load resistance.
C_{LOAD} = Load capacitance.
V_{EXT} = External voltage source applied to VBUS pin for measurements.

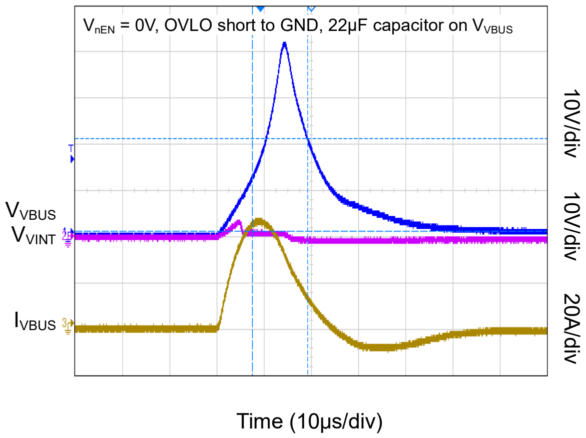
Figure 4. Waveform and Timing Measurements Test Circuit

TYPICAL PERFORMANCE CHARACTERISTICS

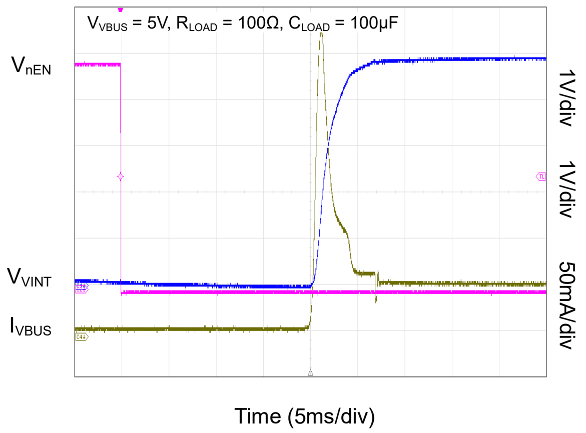
90V Surge Voltage with Device



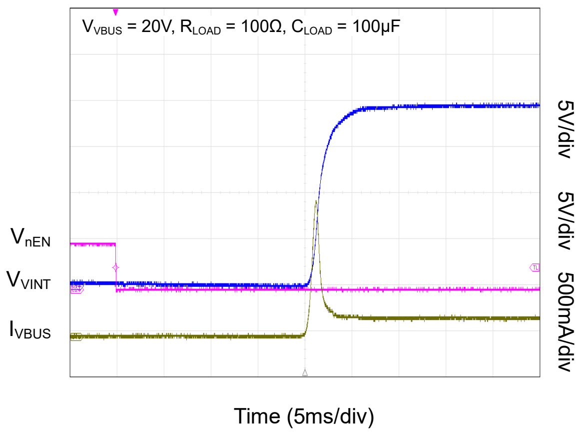
100V Surge Voltage with Device



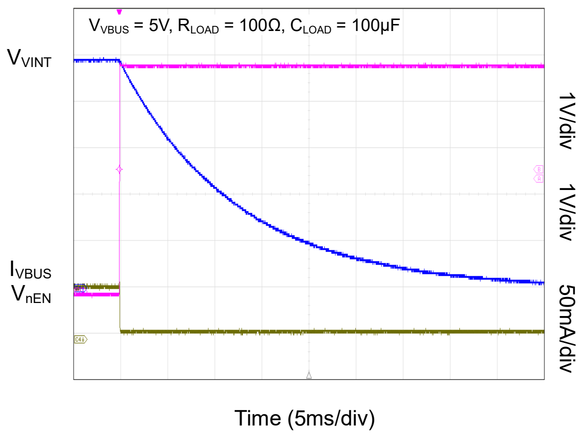
Turn-On Time and Inrush Current at 5V



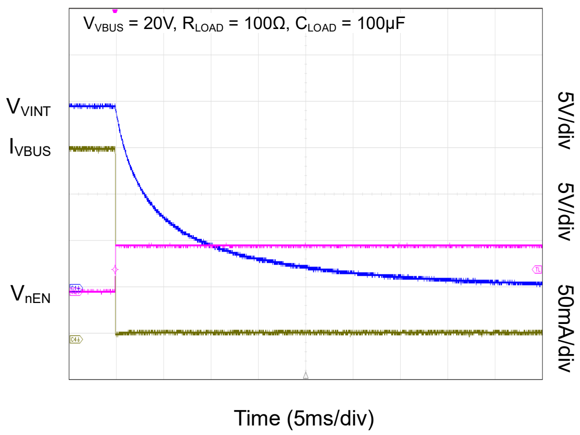
Turn-On Time and Inrush Current at 20V



Turn-Off Time at 5V

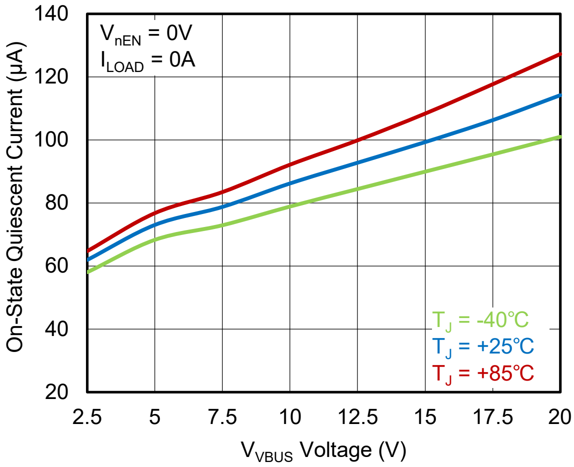


Turn-Off Time at 20V

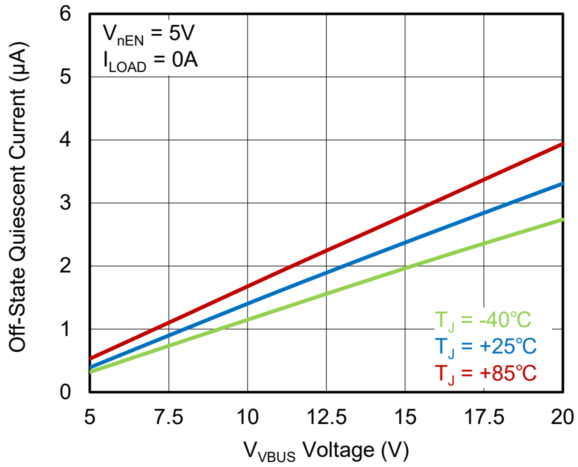


TYPICAL PERFORMANCE CHARACTERISTICS (continued)

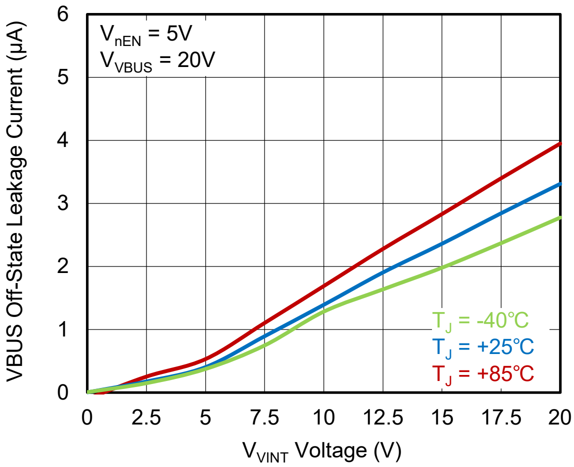
On-State Quiescent Current vs. Input Voltage



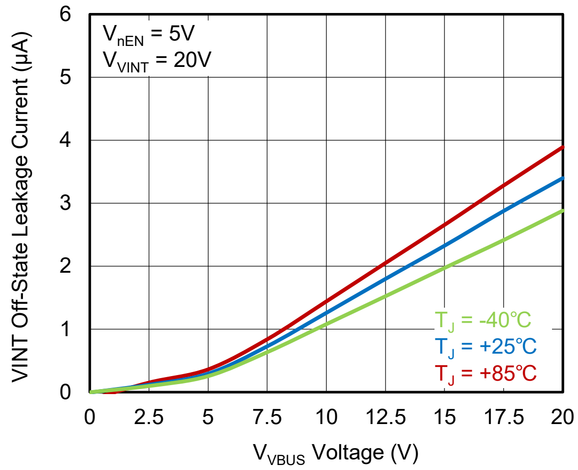
Off-State Quiescent Current vs. Input Voltage



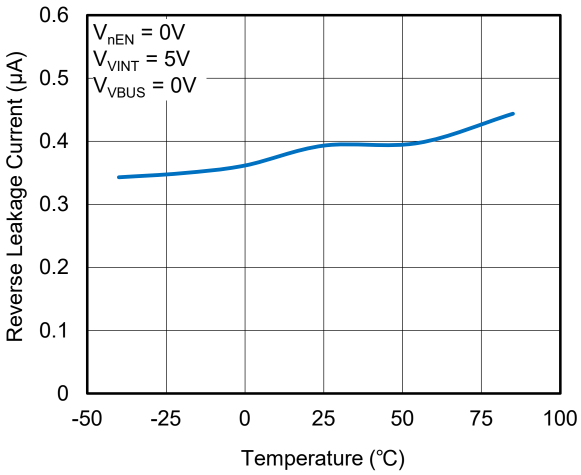
VBUS Off-State Leakage Current



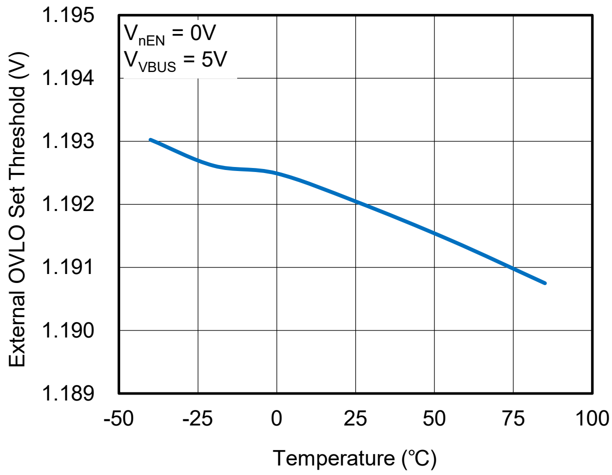
VINT Off-State Leakage Current



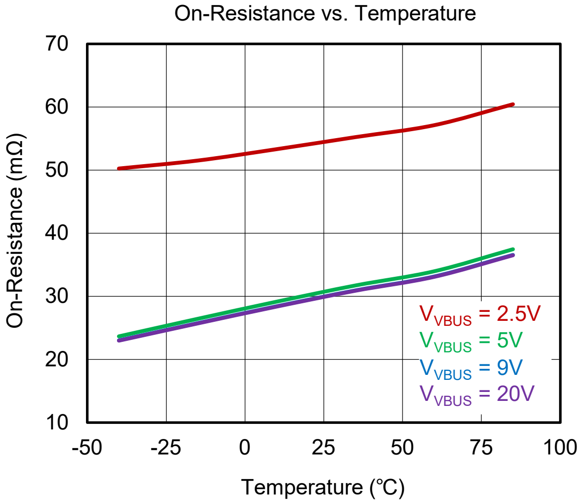
Reverse Leakage Current vs. Temperature



External OVLO Set Threshold vs. Temperature



TYPICAL PERFORMANCE CHARACTERISTICS (continued)



FUNCTIONAL BLOCK DIAGRAM

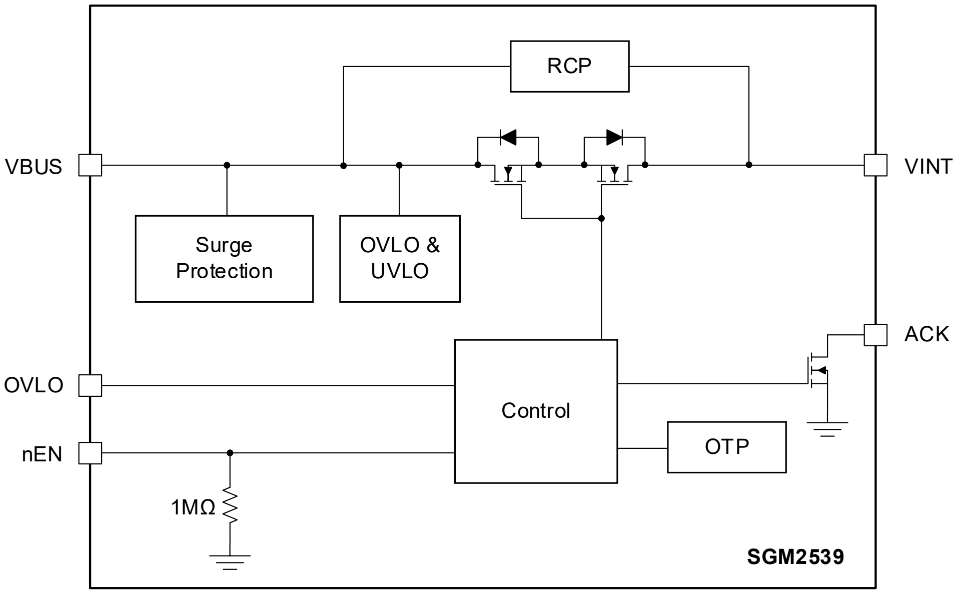


Figure 5. SGM2539 Logic Diagram

DETAILED DESCRIPTION

Table 1. SGM2539 Function and Logic Table

nEN	VBUS	VINT	ACK	Operation Mode
L	< 2.5V	X	Hi-Z	Under-voltage lockout, switch open. (UVLO fault)
L	2.5V < V_{VBUS} < V_{OVLO}	X	L	Enabled, switch closed, charging path on. (Normal on)
L	X	X	Hi-Z	Over-temperature protection, switch open. (OTP fault)
L	> V_{OVLO}	X	Hi-Z	Over-voltage lockout, switch open. (OVP or OVLO fault)
H	X	X	Hi-Z	Disable, switch open. (Normal off)
X	X	V_{VINT} > V_{VBUS}	Hi-Z	Reverse current protection, switch open. (RCP fault)

NOTE: H = logic high level, L = logic low level, Hi-Z = high-impedance (off-state), X = don't care.

The Enable Input (nEN)

The nEN is the active-low enable input of the device. By pulling the nEN to high state, the switch will be turned off and the device goes into low power mode by disabling its internal circuits. The nEN can tolerate up to 29V for high state. Applying a low state to this pin, enables the device and the switch. This pin has an internal 1MΩ pull-down resistor to make sure it can turn on, even with a depleted battery. The nEN is debounced with a 15ms delay period before turning the switch on to provide a clean turn-on in case the nEN signal has some bounce.

Under-Voltage Lockout Protection (UVLO)

If the VBUS input voltage is too low ($V_{VBUS} < V_{UVLO}$), the device will be disabled and the switch will be turned off, even if the nEN is low. When the V_{VBUS} voltage exceeds the V_{UVLO} threshold and there is no other protection in effect, the switch will be controlled by the nEN pin again. The V_{UVLO} rising threshold and hysteresis are typically around 2.34V and 60mV, respectively.

Over-Voltage Lockout Protection (OVLO)

If the V_{VBUS} goes too high and exceeds the V_{OVLO} threshold, the device will be disabled and the switch will be turned off, even if the nEN is low. When the V_{VBUS} drops below V_{OVLO} and there is no other active protection, the switch will follow the nEN again.

The OVLO input pin can be used to adjust the V_{OVLO} threshold. By default, if the OVLO is shorted to GND (or below 0.1V), the V_{OVLO} rising threshold is set to 22.75V and the falling threshold will be 22.40V. To adjust the V_{OVLO} to lower levels between 4V and 22.75V, a resistor divider between VBUS and GND can be connected to OVLO pin as shown in Figure 6. Use Equation 1 to calculate the divider resistors:

$$V_{OVLO} = V_{TH\_OVLO} \times (R_1 + R_2)/R_2 \quad (1)$$

The V_{TH_OVLO} is typically 1.19V.

Over-Temperature Protection (OTP)

If the junction temperature (T_J) exceeds +156℃, the OTP circuit turns off the switch and releases the ACK output to the high-impedance (Hi-Z) state, even if the nEN is low. The control will be returned back to the nEN pin when the T_J falls below +130℃ and there is no other active protection.

The ACK Output

The ACK output is provided to show the state of the switch. It is an open-drain output and should be pulled up by a resistor to a logic high rail less than 5.5V. A 10kΩ to 100kΩ resistor is recommended. If there is no fault and the switch is conducting, the ACK is pulled low; otherwise it remains in Hi-Z state (goes high by the pull-up).

Reverse Current Protection (RCP)

The switch is protected against reverse current in all conditions. If the switch output voltage (V_{VINT}) exceeds the input voltage (V_{VBUS}) by 55mV, the RCP will be activated. If the difference is less than 120mV, RCP will turn off the switch after a 4.5ms deglitch time but if the difference is above 120mV the switch is turned off immediately. During the start-up deglitch time, if a difference above 55mV is detected, the switch will not be turned on.

If the application system has two USB PD ports, the RCP feature allows using both of them and provides power through two parallel SGM2539 devices to supply the system battery charger, without backward leakage to the USB ports.

APPLICATION INFORMATION

The SGM2539 is normally used in portable devices such as cell phones, tablets or notebooks for charging the internal battery from an external source connected to the USB port as shown in Figure 6. The ACK and nEN signals are connected to the internal controller of the portable device and supplied from the same internal supply. The ACK is an open-drain output and must be pulled up to a logic high level compatible with the internal controller (R_{PU} resistor).

To use the default 22.75V OVP threshold, the OVLO pin should be grounded. If a lower OVP threshold is required, the R_1/R_2 divider can be used. The resistor values can be calculated from Equation 1. It is recommended to choose a 1MΩ resistor or higher value for R_1.

Choose a 1μF or larger ceramic capacitor for C_{LOAD} and place it closed to the device between VINT and GND pins. A decoupling ceramic capacitor is also recommended on the input (VBUS) terminal. Keep the connecting traces short for the best performance.

To improve thermal performance, consider a relatively large PCB area at the VINT and VBUS connections as heatsink for better dissipation of the switch heat.

If the portable device has more than one USB port for power delivery, two SGM2539 devices can be paralleled for charging the internal battery at higher current as shown in Figure 7.

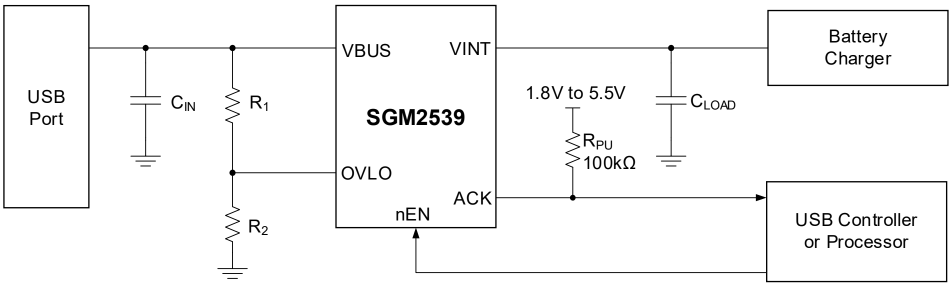


Figure 6. SGM2539 Application with One Charging Input

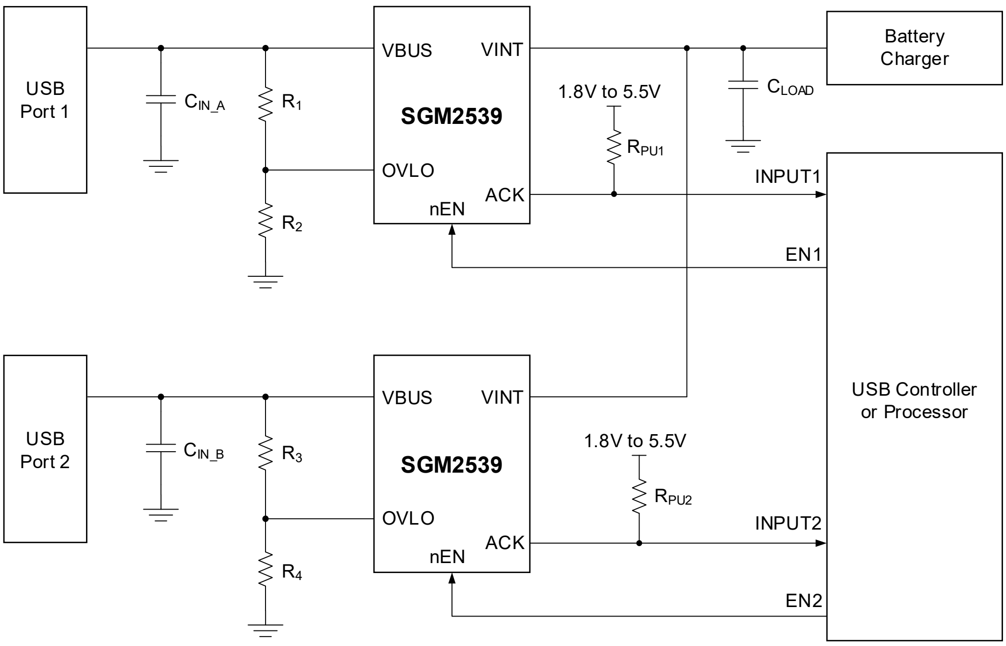


Figure 7. SGM2539 Application with Two Charging USB PD Inputs

REVISION HISTORY

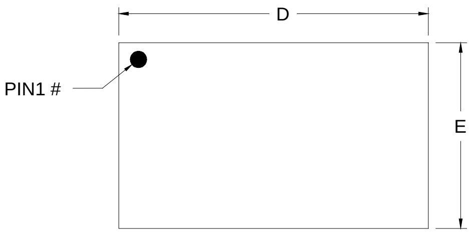
NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

APRIL 2024 – REV.A to REV.A.1	Page
Updated Package Thermal Resistance	2
Updated Electrical Characteristics section	4

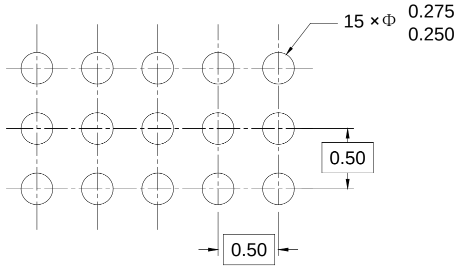
Changes from Original (NOVEMBER 2021) to REV.A	Page
Changed from product preview to production data	All

PACKAGE OUTLINE DIMENSIONS

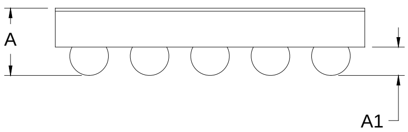
WLCSP-2.56×1.54-15B



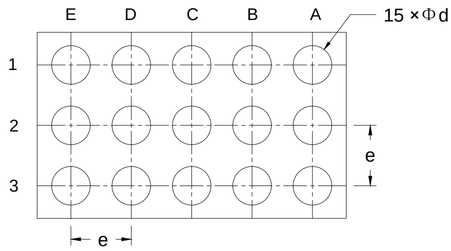
TOP VIEW



RECOMMENDED LAND PATTERN (Unit: mm)



SIDE VIEW



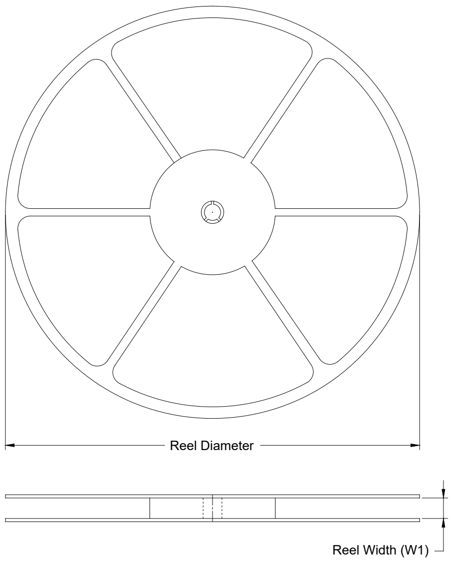
BOTTOM VIEW

Symbol	Dimensions In Millimeters		
	MIN	MOD	MAX
A	0.515	0.555	0.595
A1	0.214	0.234	0.254
D	2.530	2.560	2.590
E	1.510	1.540	1.570
d	0.300	0.320	0.340
e	0.500 BSC		

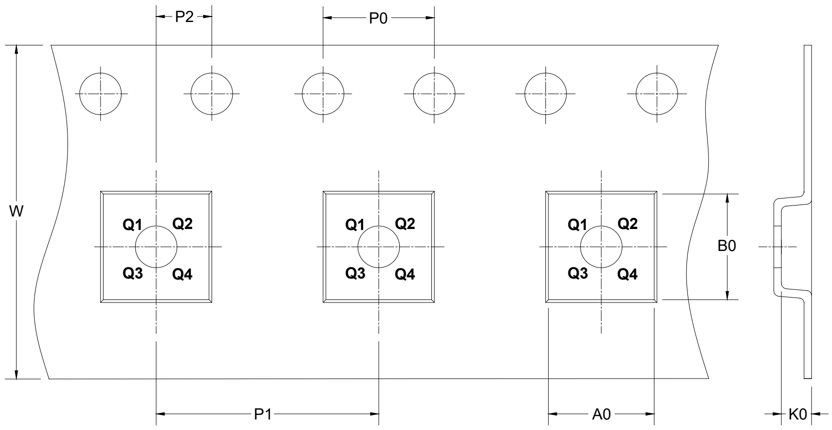
NOTE: This drawing is subject to change without notice.

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



DIRECTION OF FEED

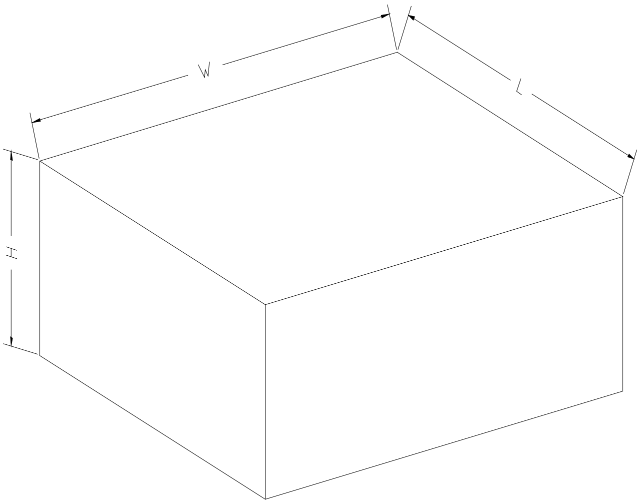
NOTE: The picture is only for reference. Please make the object as the standard.

KEY PARAMETER LIST OF TAPE AND REEL

Package Type	Reel Diameter	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	P1 (mm)	P2 (mm)	W (mm)	Pin1 Quadrant
WLCSP-2.56×1.54-15B	7″	12.4	1.72	2.74	0.70	4.0	4.0	2.0	12.0	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