SGM41106
Primary Protector and Switch with Shipping Mode for Tiny Li+/Poly Battery

GENERAL DESCRIPTION

The SGM41106 is a monolithic primary protector device for small Li-Ion or Li-Ion polymer battery cells. The product integrates all the protections required for safe operation of polymer rechargeable cells. The device is packaged in a tiny and thin package. Its small solution size leaves more space for fitting the battery cell into a given cavity for small size wearable devices.

A bi-direction blocking switch is integrated with all essential protection functions for safe operation of the battery cell, including two for voltage abnormalities and three for currents. As a battery switch, external input is provided to set or release off-state. It can be used for long term stocking and power recycling.

Charging a heavily depleted cell with too low or even zero voltage is allowed by SGM41106.

The SGM41106 is available in a Green XTDFN-1×1-4L package. It can operate (keep charge or discharge blocking) in the -40℃ to +85℃ ambient temperature range.

FEATURES

- **Ultra-Compact Protection Solution**
- **Pass Resistance: 100mΩ (TYP)**
- **Operation Current: 0.7μA (TYP)**
- **Factory Programmable Over-Voltage Threshold Options 4.225V to 4.6V with 0.025V per Step**
- **Over-Charge/Discharge Current Protection 3 Thresholds Combination Options**
- **Battery Under-Voltage Protection 2.8V/3.0V Options**
- **0V Battery Charge Permitted**
- **2nA (TYP) Deep Discharge Shutdown**
- **Input Pin for Latch-Off and Release**
- **Load Short-Circuit Safe**
- **Battery Pack Paralleling Safe**
- **Charge Input Voltage Clamp**
- **Battery Reverse Polarity Safe**
- **Charge Input Reverse Polarity Safe**
- **Available in a Green XTDFN-1×1-4L Package**

APPLICATIONS

Earphone, Stylus, Bracelet, Watch

TYPICAL APPLICATION

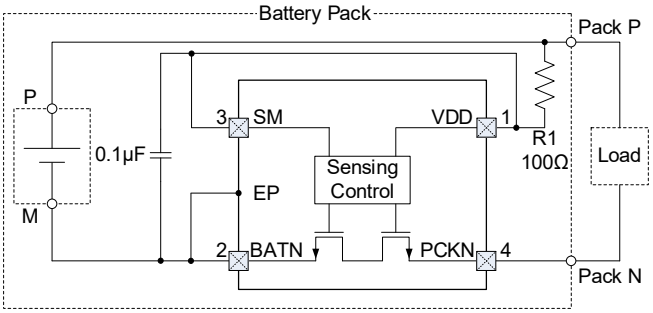
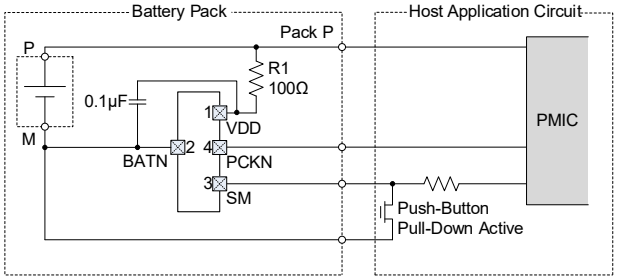


Figure 1. Typical Battery Pack Circuit



NOTE:
Pressing the push-button for t > t_{BOFF} time to turn off the battery switch (when the switch is already on). Applying charge power or pressing the push-button will turn on the battery switch (when it is already off).

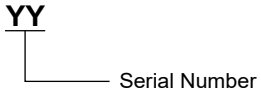
Figure 2. Typical Circuit for Shipping Mode Control

PACKAGE/ORDERING INFORMATION

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM41106-427O21	XTDFN-1×1-4L	-40℃ to +85℃	SGM41106-427O21YXDH4G/TR	28	Tape and Reel, 10000
SGM41106-442O31	XTDFN-1×1-4L	-40℃ to +85℃	SGM41106-442O31YXDH4G/TR	27	Tape and Reel, 10000
SGM41106-447O31	XTDFN-1×1-4L	-40℃ to +85℃	SGM41106-447O31YXDH4G/TR	26	Tape and Reel, 10000
SGM41106-452O62	XTDFN-1×1-4L	-40℃ to +85℃	SGM41106-452O62YXDH4G/TR	25	Tape and Reel, 10000

NOTE: For more parts, please refer to Table 1 and contact with SGMICRO.

MARKING INFORMATION



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

VDD to PCKN, 13V (1), 10mA Surge Clamping (2) 5s
VDD to PCKN ..... -5V or +9V (3), Continuous
SM to BATN ..... -0.3V to 5.5V
PCKN to BATN ..... -4.5V (3) or +5.5V
Pack P to Pack N Short-Circuit (4) ..... Continuous
Power Attachment/Detachment Peak Voltage (5) ... +9V/-4.5V
Battery Attachment/Detachment Peak Voltage (6) ..... ±4.5V
Package Thermal Resistance
XTDFN-1×1-4L, θ_{JA} ..... 153.7℃/W
XTDFN-1×1-4L, θ_{JB} ..... 91.6℃/W
XTDFN-1×1-4L, $\theta_{JC\ (TOP)}$ ..... 115.7℃/W
XTDFN-1×1-4L, $\theta_{JC\ (BOT)}$ ..... 88℃/W
Junction Temperature ..... +150℃
Storage Temperature Range ..... -65℃ to +150℃
Lead Temperature (Soldering, 10s) ..... +260℃
ESD Susceptibility
HBM 8000V
CDM 1000V

NOTES:
1. Evaluated with V_{BAT} = 4.5V.
2. The two conditions may apply at the same time.
3. Tested with a regulated voltage source with 2A current limit and less than 1V/ms slew rate. Source is applied from 0V and then the voltage is increased to the specified level.
4. Tested with the circuit in Figure 1 and by applying a 4.5V, 5A power source to the P and M for battery emulation. Short the Pack P and Pack N with a short wire (< 10mΩ).
5. Tested with Figure 4 circuit.
6. Tested with Figure 5 circuit.

RECOMMENDED OPERATING CONDITIONS

Supply Voltage Range ..... 0V to 6V
Battery Voltage Range ..... 0V to 4.6V
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.

DEVICE DESCRIPTION

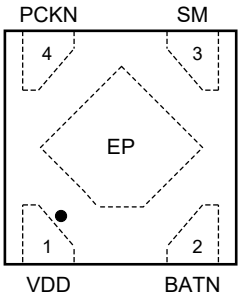
Table 1. Key Parameters and Options/Part Numbering

For All Versions								
Nominal On-State Operation Current	0.7μA							
Nominal Switch Off Leakage Current	2nA							
Battery Off Delay	1.5s							
Nominal Switch On-Resistance	100mΩ							
Model: SGM41106-AAABCD								
Over-Voltage Threshold								
Option Code "**AAA**"	**422**	**425**	**427**	**430**	**432**	**435**	**437**	**440**
Over-Voltage Threshold (V)	4.225	4.250	4.275	4.300	4.325	4.350	4.375	4.400
Option Code "**AAA**"	**442**	**445**	**447**	**450**	**452**	**455**	**457**	**460**
Over-Voltage Threshold (V)	4.425	4.450	4.475	4.500	4.525	4.550	4.575	4.600
Under-Voltage Threshold Options								
Option Code "**B**"	**O**					**P**		
Threshold Voltage (V)	2.8					3.0		
Charge/Discharge Over-Current Threshold Options								
Option Code "**C**"	**2**			**3**			**6**	
Charge/Discharge Over-Current Threshold (mA)	200/230			310/360			625/650	
Suspicious Discharge Short Current Threshold								
Option Code "**D**"	**1**					**2**		
Uncertain Discharge Short Current (A)	1.2					2.5		

NOTE: Samples are only available for some part numbers. Contact SGMICRO for sample availability.

PIN CONFIGURATION

(TOP VIEW)



XTDFN-1×1-4L

PIN DESCRIPTION

PIN	NAME	TYPE	FUNCTION
1	VDD	AI	Device Bias Supply/Battery Voltage Sensing Input.
2	BATN	P	Switch Terminal: Connects to the Negative Pole of the Battery.
3	SM	AI	External On/Off Input. Pull and hold (for a minimum time) low with respect to the BATN, to release or to set the battery switch off-state (shipping mode). No state change occurs if this pin voltage level is not changed.
4	PCKN	P	Switch Terminal: Connects to the Negative Terminal of the System Load.
Exposed Pad	EP	–	Package Exposed Pad with No Internal Connection. External connection to the BATN is recommended.

NOTE: AI = analog input, P = power.

ELECTRICAL CHARACTERISTICS

(Battery voltage V_{BAT} = 3.7V, T_J = -40℃ to +85℃, typical values are measured at T_J = +25℃, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Operation Voltage Range (1)	V_{CHG_OP}	Normal charging source voltage range		-0.5		6	V
Normal On Voltage Range (1)	V_{NORM_ON}	The maximum voltage range possibly keeps continuous on in charging		2.8		4.6	V
Switch On-Resistance	R_{ON}	T_J = +25℃		80	100	120	mΩ
		T_J = -40℃ to +85℃		60	100	140	
Operating Current (VDD Current) (1)	I_{OP}	T_J = +25℃			0.7	0.95	μA
		T_J = -40℃ to +85℃			0.7	1.2	
Shutdown Current	I_{SD}	Shutdown occurred due to battery low or due to SM input control	T_J = +25℃		2	50	nA
			T_J = -40℃ to +85℃		2	60	
Over-Voltage Detection Delay (1) (2)	t_{OVD}	T_J = +25℃		0.6	0.8	1	s
Under-Voltage Detection Delay (1) (2)	t_{UVD}	T_J = +25℃		0.6	0.8	1	s
Discharge Over-Current Detection Delay (1) (2)	t_{ODD}	T_J = +25℃		38	72	116	ms
Discharge Over-Current Retry Delay Time (1) (2)	t_{RETRY}	T_J = +25℃		2.4	3	3.75	s
Charge Over-Current Detection Delay (1) (2)	t_{OCD}	T_J = +25℃		38	72	116	ms
Discharge Short-Circuit Cut-Off Delay for 1st Triggered (1) (3) (4)	t_{DSC_1}	T_J = +25℃		0.17	0.3	0.54	ms
Discharge Short-Circuit Cut-Off Delay during SCP Retry (1) (3) (4)	t_{DSC_RTY}	T_J = +25℃		0.3	0.6	1	ms
Charge Battery Over-Voltage							
Over-Voltage Threshold Error	V_{OVERR}	Voltage error to the nominal threshold voltage V_{OV} (V)	T_J = +25℃	-25		25	mV
			T_J = -40℃ to +85℃	-50		50	
Over-Voltage Threshold	V_{OV}	SGM41106-422_ _ _			4.225		V
		SGM41106-425_ _ _			4.250		
		SGM41106-427_ _ _			4.275		
		SGM41106-430_ _ _			4.300		
		SGM41106-432_ _ _			4.325		
		SGM41106-435_ _ _			4.350		
		SGM41106-437_ _ _			4.375		
		SGM41106-440_ _ _			4.400		
		SGM41106-442_ _ _			4.425		
		SGM41106-445_ _ _			4.450		
		SGM41106-447_ _ _			4.475		
		SGM41106-450_ _ _			4.500		
		SGM41106-452_ _ _			4.525		
		SGM41106-455_ _ _			4.550		
		SGM41106-457_ _ _			4.575		
		SGM41106-460_ _ _			4.600		
Over-Voltage Release Hysteresis (1) (2)	V_{OVHYS}				200		mV

ELECTRICAL CHARACTERISTICS (continued)

(Battery voltage V_{BAT} = 3.7V, T_J = -40℃ to +85℃, typical values are measured at T_J = +25℃, unless otherwise noted.)

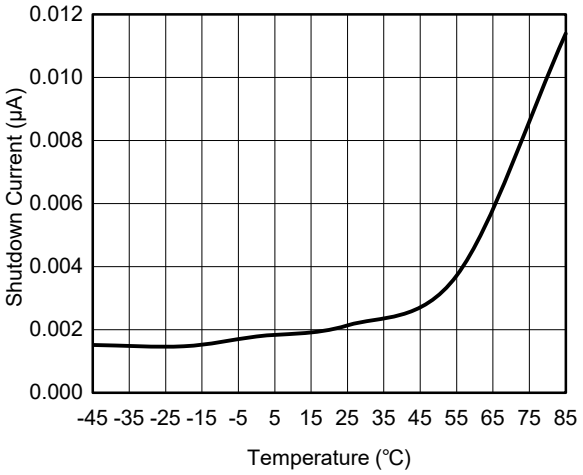
PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Discharge Battery Under-Voltage							
Battery Under-Voltage Threshold	V_{UV}	SGM41106-_ _ _ O _ _	T_J = +25℃	2.74	2.8	2.86	V
			T_J = -40℃ to +85℃	2.72	2.8	2.88	
		SGM41106-_ _ _ P _ _	T_J = +25℃	2.94	3.0	3.06	
			T_J = -40℃ to +85℃	2.92	3.0	3.08	
Under-Voltage Release Hysteresis (1) (2)	V_{UVHYS}				200		mV
Over-Current and Short-Circuit							
Charge Over-Current Threshold	I_{OCC}	SGM41106-_ _ _ _2 _, T_J = +25℃		115	200	280	mA
		SGM41106-_ _ _ _3 _, T_J = +25℃		210	310	400	
		SGM41106-_ _ _ _6 _, T_J = +25℃		500	625	770	
Discharge Over-Current Threshold	I_{OCD}	SGM41106-_ _ _ _2 _, T_J = +25℃		140	230	340	mA
		SGM41106-_ _ _ _3 _, T_J = +25℃		260	360	460	
		SGM41106-_ _ _ _6 _, T_J = +25℃		500	650	790	
Discharge Short-Circuit Threshold (1) (3) (4)	I_{DSC}	SGM41106-_ _ _ _ _1			1.2	1.7	A
		SGM41106-_ _ _ _ _2			2.5	3.3	
SM Input							
Pull-Down Effective Voltage (1)	V_{PD}	Voltage difference to V_{PCKP}			V_{VDD} - 1.5		V
Key-In Deglitch Time (1)	t_{FKeyin}	Hold in the effective pulling level, T_J = +25℃		0.3	0.5	0.7	s
Key-In to Switch-Cut Delay (1) (2)	t_{KeyCut}	Hold in the effective pulling level, T_J = +25℃		1.2	1.5	1.9	s

NOTES:

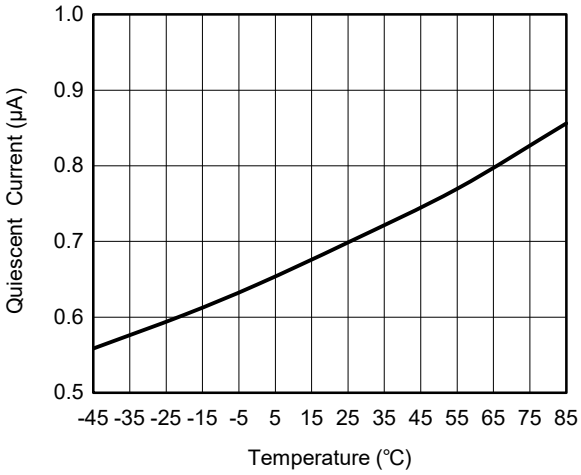
1. The best estimate from product characterization, guaranteed by design, functionality will be verified by other test items in production.
2. The best estimate from product characterization, guaranteed by correlated test in production.
3. The best estimate from product characterization, bench test regularly: one for each production lot.
4. Short with 100mΩ resistor.

TYPICAL PERFORMANCE CHARACTERISTICS

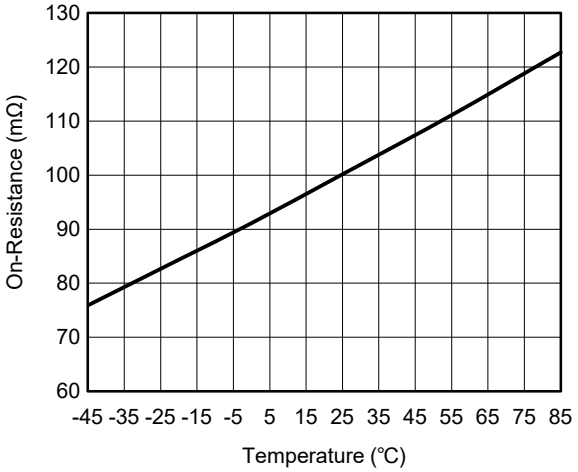
Shutdown Current vs. Temperature



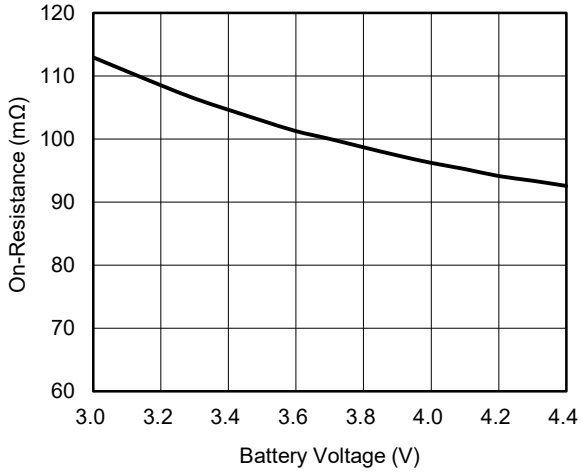
Quiescent Current vs. Temperature



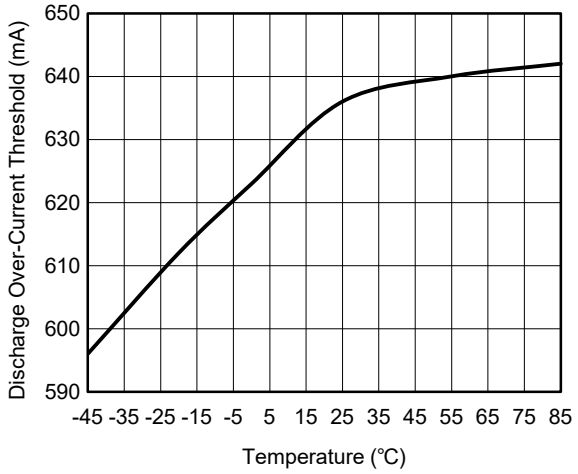
On-Resistance vs. Temperature



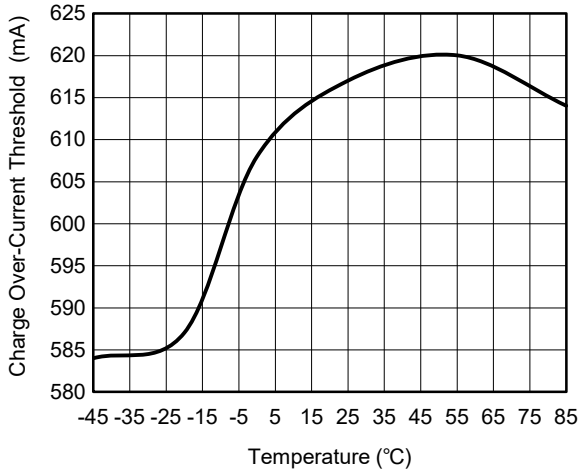
On-Resistance vs. Battery Voltage



Discharge Over-Current Threshold vs. Temperature

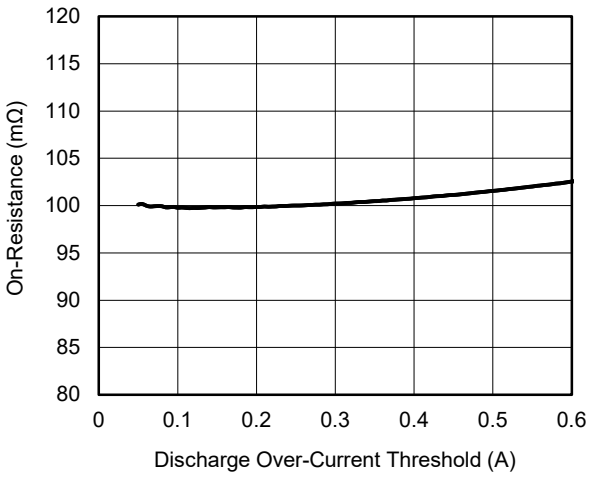


Charge Over-Current Threshold vs. Temperature

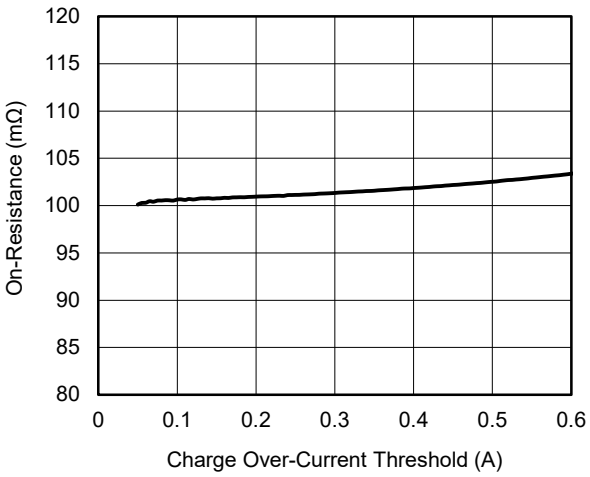


TYPICAL PERFORMANCE CHARACTERISTICS (continued)

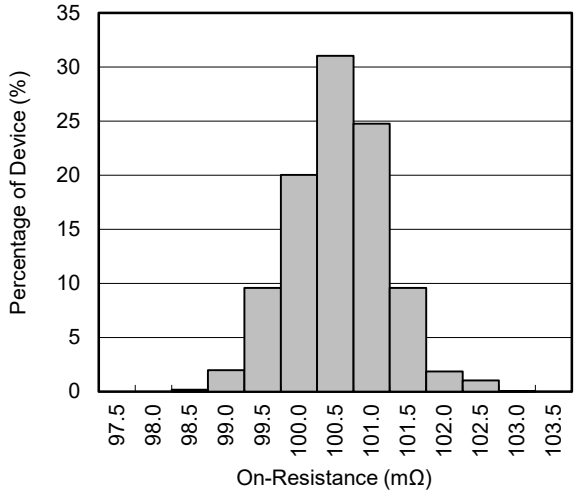
On-Resistance vs. Discharge Over-Current Threshold



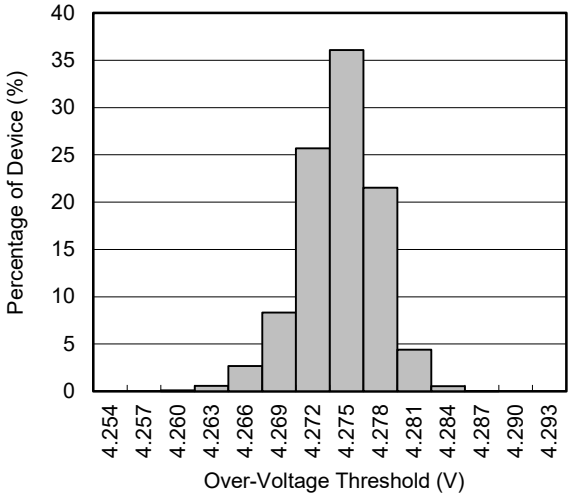
On-Resistance vs. Charge Over-Current Threshold



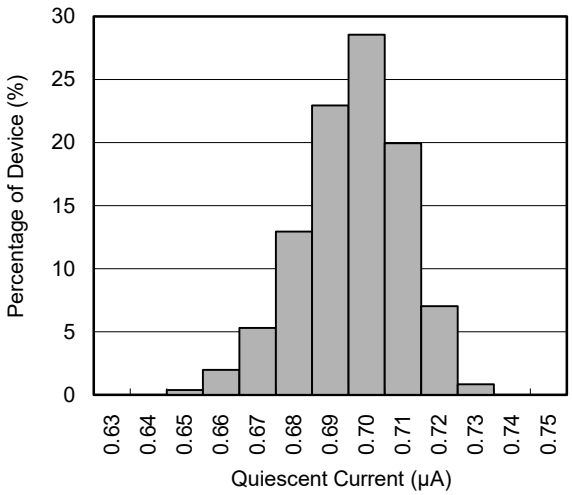
Typical Histogram for On-Resistance



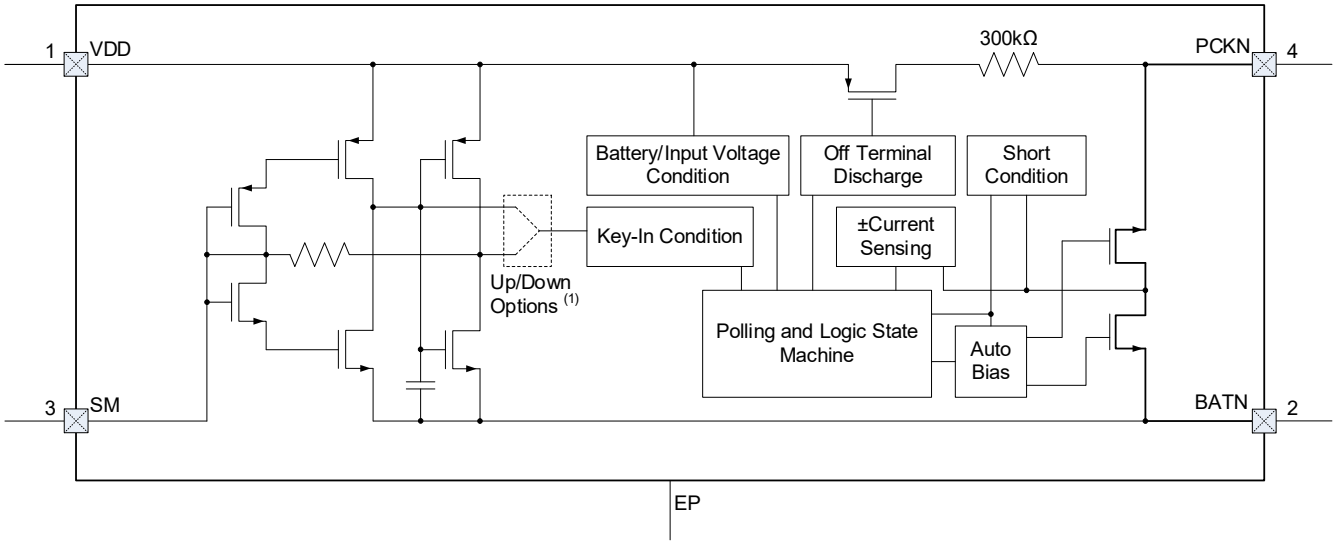
Typical Histogram for Over-Voltage Threshold



Typical Histogram for Quiescent Current



FUNCTIONAL BLOCK DIAGRAM



NOTE:
1. For SGM41106, SM is fixed to active down option.

Figure 3. Block Diagram

TEST SETUP DIAGRAMS

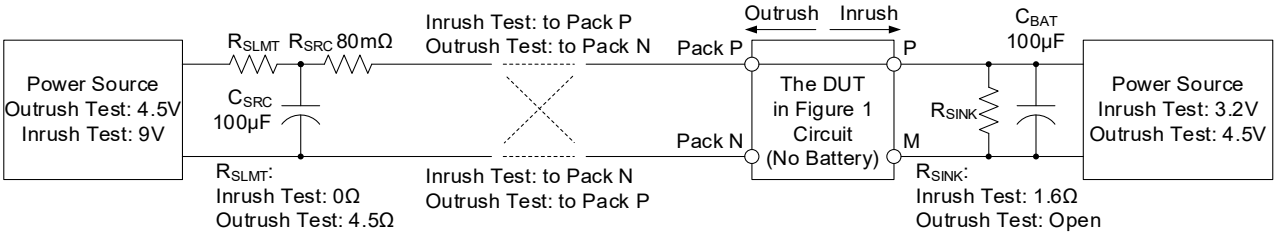


Figure 4. Power Attachment/Detachment Test Setup

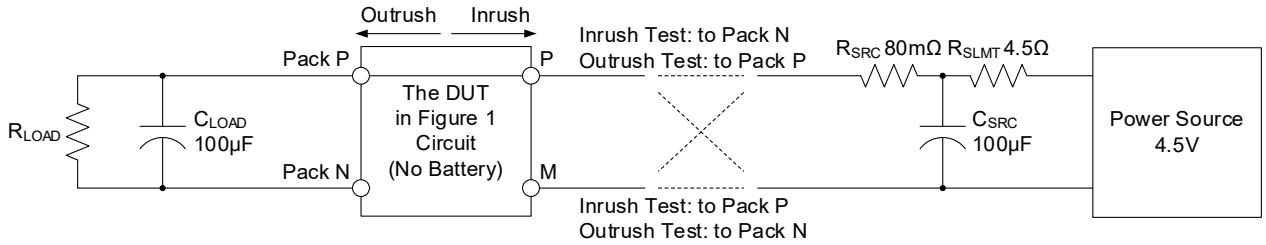


Figure 5. Battery Attachment/Detachment Test Setup

DETAILED DESCRIPTION

The SGM41106 is a Li-Ion/Li-Ion polymer battery protector with integrated battery switch. It provides a full set of protection functions on voltage and current, and can disconnect the battery using the integrated switch. To reduce the power consumption, the battery voltage and current are measured periodically (polling), but the short-circuit condition is continuously monitored when the switch is on so that the device can instantly respond and turn off the switch if a suspicious short is detected in the load.

Voltage Related Protections

The battery voltage, sensed between the VDD and BATN pins, is monitored periodically (with deglitch time) while the charge input and battery connection are detected instantly.

During charge, in every detection cycle, the battery is checked for over-voltage. When a high battery voltage is detected (V_{BAT} > V_{OV}), the battery switch is turned into charge block mode to prohibit any further charging and allows current only in the discharge direction. The charge is unblocked when the battery voltage drops to a safe level due to discharge. The battery over-voltage threshold (V_{OV}) depends on the selected "AAA" code of the device.

If the battery voltage is not in the over-voltage range, it is checked every detection cycle for low voltage. When a low battery voltage is detected (V_{BAT} < V_{UV}), the battery switch blocks battery discharge direction and the device goes to the lossless off-state. The battery switch allows current only in the charge direction, and the charge over-current detection does not function in the under-voltage protection status. The battery low voltage threshold (V_{UV}) depends on the selected "B" code of the device.

Current Related Protections

The battery current (I_{BAT}) is monitored periodically while the battery switch is on. Both charge and discharge are protected against over-current, each with its own threshold and delay timer (t_{OCD} = 72ms for charging, t_{ODD} = 72ms for discharging). Charge or discharge is blocked if the corresponding over-current is detected. Charge or discharge over-current threshold (I_{OCC} or I_{OCD}) depends on the selected "C" code of the device. Charge block is released when charge status is invalidated by detecting a switch forward voltage. Discharge recovery is by hiccup mode and the block time is t_{RETRY} = 3s after it is detected. If a discharge over-current is detected again, it is blocked for another t_{RETRY} time.

Load Short Protection

If the discharge current exceeds I_{DSC} (1.2A or 2.5A depends on "D" code), the battery switch is turned into discharge block mode and the battery attaching timer starts for retrying (hiccup).

Battery Reverse Polarity Attachment

In case of reverse battery attachment, the current into the load is not blocked by the device. The reverse current cannot damage the device and it is safe unless the current is too high and results in overheating damage.

Charging Input Reverse Polarity Attachment

Reverse attachment of a charging input with less than 5V is safe and does not cause damage to the device (no current flows out of the battery). The reverse attaching of charger causes a discharge over-current event and the switch is turned into the discharge block mode.

Battery On/Off by Keying the SM Pin

The battery switch can be turned on or off by changing the SM pin voltage to low (V_{BATN}). Note that SM pin is edge sensitive and must change state. The input state is latched to the last applied state even if the input floats a short time after transition. The battery voltage is detected and only when it is higher than V_{UV}, the SM pin key-in is allowed to close the battery switch, otherwise the switch state keeps unchanged and key-in is ignored. See Figure 2.

DETAILED DESCRIPTION (continued)

The SGM41106-xxxxxx is a pull-down effective device. If the switch is off and the SM pin voltage is pulled from V_{VDD} down to V_{BATN} and held for ~0.5s deglitch time, the switch is turned on. If the switch is on, by holding the SM pin for more than 1.5s, the switch is turned off. As shown in Figure 2, in most applications with a digital processor, manual or commanded control of system power is possible by a pull-down effective device that is sharing the power control line with the main system power push-button. In summary, SGM41106 offers the following features:

1. System is turned on by push-button when the battery switch is off.
2. Force system turn-off by holding the push-button for 1.5s (battery disconnect), that is helpful when the controller is not responding due to a hardware or software issue.
3. The application (host) can turn off the battery switch by holding the SM pin at low voltage. This voltage automatically goes high later because when the host is turned off due to the battery disconnect, the whole host circuit floats to the VDD (PCKN is open).

Parallel Battery Packs

When two battery packs are connected in parallel utilizing SGM41106s, a momentary current surge may cause charge over-current protection in the pack with the lower voltage. The higher voltage pack could enter a discharge over-current protection. The charge over-current or discharge over-current protection resets only after the higher voltage battery pack discharges to a voltage slightly higher than the lower voltage pack. After this discharge, both packs can conduct.

APPLICATION INFORMATION

For the device and battery cell, the short-circuit and ESD tests are critical on the assembled battery and protector packs (with and without a battery cell). ESD or short surges may degrade the overall reliability and cause early aging on both parts.

If such tests are conducted on the assembled pack, use a low voltage source with low inductance for the short-circuit protection test.

ESD Interference and Air-Gap Discharge Test

If the battery is the largest conducting object in the assembly and shields other parts of the equipment, a careful ESD discharging path design is needed to direct the ESD current to the free wires or free PCB copper stripes for uninterrupted operation.

If the ESD passes through the protection circuit, it may trigger a protection and lead to power recycle.

To reduce the sensitivity of the device to ESD, two small bypass capacitors can be added as illustrated in Figure 6. The penalty is that the small size capacitors are ESD sensitive due to their thin terminal clearance. A coating defect caused by corrosion may increase their leakage or even cause shorts. In summary, the capacitors can potentially degrade the reliable and safe operation of the system by introducing new failure modes.

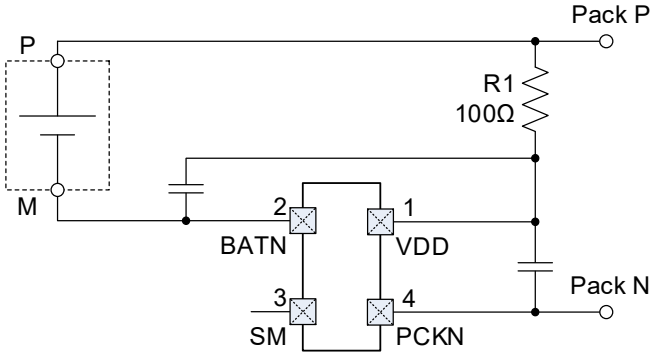


Figure 6. Adding Capacitors for Lowering ESD Sensitivity

Input Clamp and Discharge

If a charging input with over-voltage is applied to the pack, the VDD-PCKN is protected by the serial resistor R1 and the VDD-PCKN break-down. The voltage difference between the input and battery appears on the switch (BATN to PCKN). This switch has a break-down (clamp) with above 10mA discharge capability without damage. The battery pack terminal voltage (PCKP to PCKN) initiates clamping, and it is about 13V when the battery voltage is 4.5V.

REVISION HISTORY

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

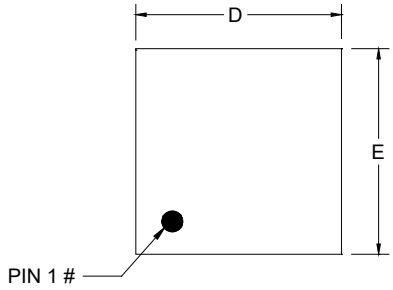
APRIL 2024 – REV.A.1 to REV.A.2	Page
Updated Package/Ordering Information	2
Updated Device Description section	3
Updated Electrical Characteristics section	5, 6

JANUARY 2024 – REV.A to REV.A.1	Page
Updated Electrical Characteristics section	5, 6
Updated Detailed Description section	10

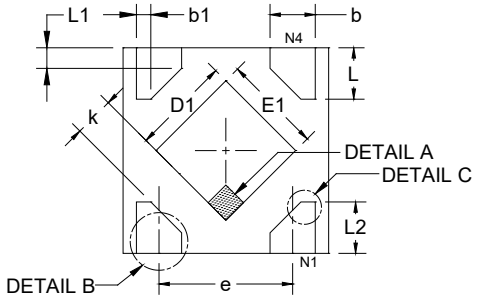
Changes from Original (NOVEMBER 2023) to REV.A	Page
Changed from product preview to production data	All

PACKAGE OUTLINE DIMENSIONS

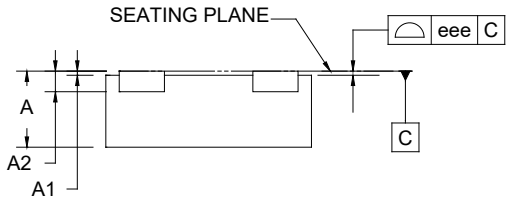
XTDFN-1×1-4L



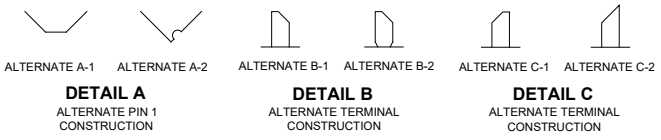
TOP VIEW



BOTTOM VIEW



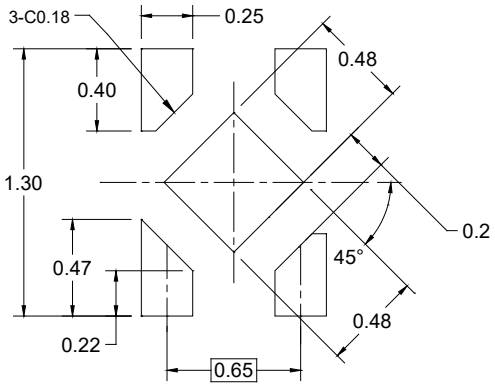
SIDE VIEW



DETAIL A
ALTERNATE PIN 1 CONSTRUCTION

DETAIL B
ALTERNATE TERMINAL CONSTRUCTION

DETAIL C
ALTERNATE TERMINAL CONSTRUCTION



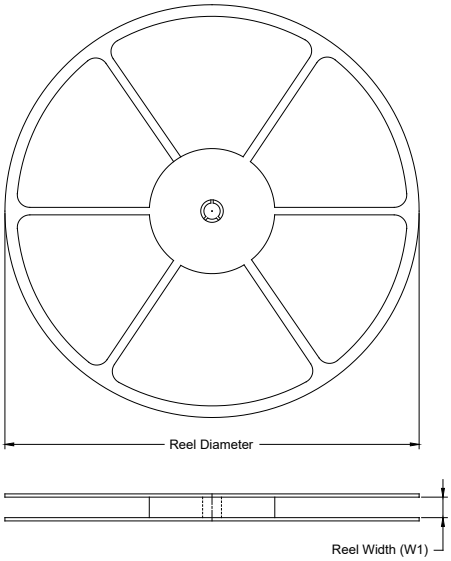
RECOMMENDED LAND PATTERN (Unit: mm)

Symbol	Dimensions In Millimeters		
	MIN	MOD	MAX
A	0.340	0.370	0.400
A1	0.000	0.020	0.050
A2		0.100 REF	
b	0.170	-	0.300
b1		0.068 REF	
D	0.950	1.000	1.050
E	0.950	1.000	1.050
D1	0.430	0.480	0.530
E1	0.430	0.480	0.530
L	0.200	0.250	0.300
L1		0.093 REF	
L2	0.200	-	0.370
e		0.650 BSC	
k	0.150	-	-
eee	-	0.050	-

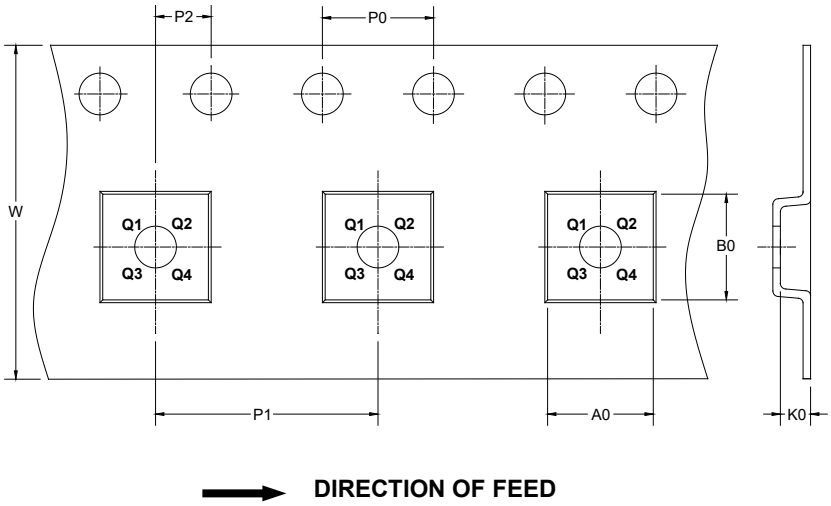
NOTE: This drawing is subject to change without notice.

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



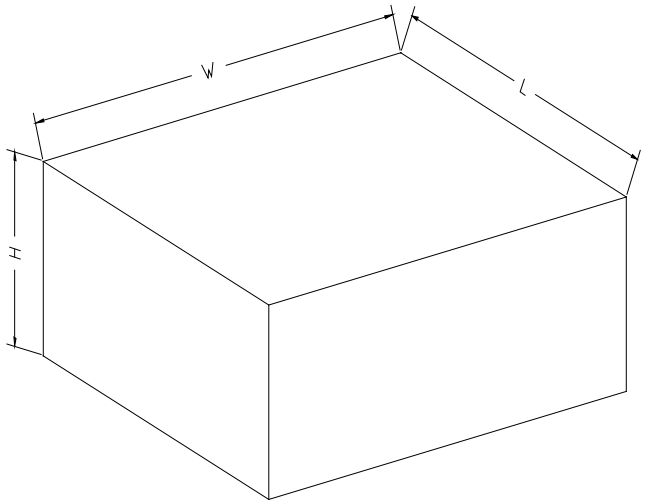
NOTE: The picture is only for reference. Please make the object as the standard.

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
XTDFN-1×1-4L	7″	9.5	1.16	1.16	0.50	4.0	2.0	2.0	8.0	Q1

DD0001

CARTON BOX DIMENSIONS



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

KEY PARAMETER LIST OF CARTON BOX

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

DD0002