SGM41523/SGM41523A/B/C
Compact Switch, 2.5A Standalone Single-Cell Battery Charger with Safe and Reliable Charging

GENERAL DESCRIPTION

The SGM41523/A/B/C is a compact switch standalone battery charger for single-cell Li-Ion or Li-polymer battery. It is featured with resistor programmable maximum charge current, ordering selections of preset end of charge current and pre-charge current and floating time out. Other safety features are provided in the SGM41523/A/B/C such as over-voltage and over-current protections, fold-back retaining, input under-voltage lockout, battery temperature monitoring and thermal shutdown. These features ensure safe and reliable operation, easy to design and offer comfortable user experience.

The SGM41523/A/B/C is available in a Green TDFN-3×3-12L package. It operates over an ambient temperature range of -40℃ to +85℃.

APPLICATIONS

Portable Audio Speaker
Mobile Phone
Wearables
EPOS

FEATURES

- **Maximum 2.5A Charging for 4.1V to 4.45V Battery**
- **1.3MHz Switch Frequency**
- **93% Charge Efficiency at 1.5A from 5V Input**
- **91% Charge Efficiency at 1.5A from 9V Input**
- **Charging Voltage and Current Programmable**
- **CC/CV Interface for Charge Current and Battery Voltage Settings**
- **4.2V Input Voltage Regulation**
- **Support 4.2V to 12V Input Voltage Range with 18V Absolute Maximum Input Voltage Rating**
- **13.5V Over-Voltage Protection with 100ns Turn-Off Timer**
- **Output Voltage Fold-Back Retaining**
- **Optional High or Low Charge Enable**
  - **Active Low (SGM41523/SGM41523A)**
  - **Active High (SGM41523B/SGM41523C)**
- **JEITA Guideline Compliance**
  - **T2 Threshold 10℃ (SGM41523/SGM41523B)**
  - **T2 Threshold 15℃ (SGM41523A/SGM41523C)**
- **-40℃ to +85℃ Operating Temperature Range**
- **Available in a Green TDFN-3×3-12L Package**

TYPICAL APPLICATION

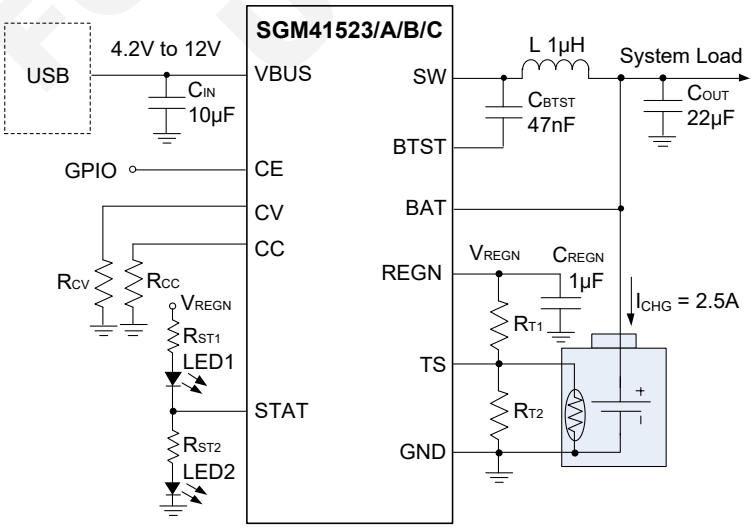


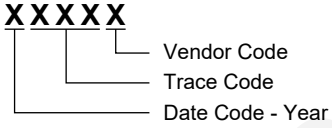
Figure 1. Typical Application Circuit

PACKAGE/ORDERING INFORMATION

MODEL	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM41523	TDFN-3×3-12L	-40℃ to +85℃	SGM41523YTDF12G/TR	SGM 41523DF XXXXX	Tape and Reel, 4000
SGM41523A	TDFN-3×3-12L	-40℃ to +85℃	SGM41523AYTDF12G/TR	SGM SGXDF XXXXX	Tape and Reel, 4000
SGM41523B	TDFN-3×3-12L	-40℃ to +85℃	SGM41523BYTDF12G/TR	SGM SGYDF XXXXX	Tape and Reel, 4000
SGM41523C	TDFN-3×3-12L	-40℃ to +85℃	SGM41523CYTDF12G/TR	SGM SGZDF XXXXX	Tape and Reel, 4000

MARKING INFORMATION

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



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.

DEVICE COMPARISON TABLE

Part No.	Charge Enable (CE)	V_{T2} Threshold	Sample
SGM41523	Low	10℃	Available
SGM41523A	Low	15℃	Stockout
SGM41523B	High	10℃	Available
SGM41523C	High	15℃	Stockout

ABSOLUTE MAXIMUM RATINGS

Voltage Range (with Respect to GND)
VBUS (Converter Not Switching) ..... -2V to 18V
BTST (Converter Not Switching)..... -0.3V to 18V
SW, BAT ..... -2V to 14V
BTST to SW ..... -0.3V to 6V
REGN, TS, CE (Converter Not Switching)
..... -0.3V to 6V
CC, CV, STAT..... -0.3V to 6V
Output Sink Current
STAT.....6mA
Junction Temperature.....+150℃
Storage Temperature Range .....-65℃ to +150℃
Lead Temperature (Soldering, 10s).....+260℃

RECOMMENDED OPERATING CONDITIONS

Input Voltage Range, V_{VBUS} (1) .....4.2V to 12V
Input Current (VBUS), I_{IN} .....2.5A (MAX)
Output Current (SW), I_{SWOP}.....2.5A (MAX)
Battery Voltage, V_{BATOP}.....4.45V (MAX)
Fast Charge Current, I_{BATOP} .....2.5A (MAX)
Operating Temperature Range .....-40℃ to +85℃

NOTE:
1. The inherent switching noise voltage spikes should not exceed the absolute maximum rating on either the BTST or SW pins. A tight layout minimizes switching noise.

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

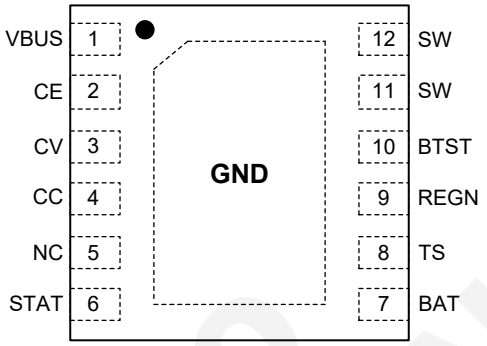
This integrated circuit can be damaged if ESD protections are not considered carefully. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance 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)



TDFN-3×3-12L

PIN DESCRIPTION

PIN	NAME	TYPE (1)	FUNCTION
1	VBUS	P	Charger Input and Voltage Sense. Place a 10μF ceramic capacitor from VBUS pin to GND close to device.
2	CE	DI	Charge Enable Pin. When this pin is driven low for SGM41523/A or driven high for SGM41523B/C, battery charging is enabled.
3	CV	AI	Charge Voltage Programming Input Pin. Connect a resistor between this pin and GND, for feeding different voltages to select 6 different charge voltages.
4	CC	AI	Charge Current Programming and Charging Inhibition Input. Connect a resistor between this pin and GND for programming the constant charge current by $I_{CHGREG} = K \cdot V_{REF}/R_{CC}$. Pull up this pin to a voltage higher than V_{REF} to stop charging.
5	NC	—	No Connection.
6	STAT	DO	Push-Pull Charge Status Output. Use a 10kΩ pull-up to the logic high rail (or an LED from a rail to this pin + a resistor + another LED from this pin to GND). The STAT pin acts as follows: During charge: low (LED ON). Charge completed or charger in sleep mode: high (LED OFF). Charge suspended (in response to a fault): 0.65Hz, 50% duty cycle pulses (LED BLINKS).
7	BAT	P	Battery Positive Terminal Pin. Use a 22μF capacitor between BAT and GND pins close to the device.
8	TS	AI	Temperature Qualification Voltage Input (Supports JEITA Profile). Connect to the battery NTC thermistor that is grounded on the other side. To program operating temperature window, it can be biased by a resistor divider between REGN and GND. Charge suspends if TS voltage goes out of the programmed range. It is recommended to use a 103AT-2 type thermistor. If NTC or TS pin function is not needed, use a 10kΩ/10kΩ pair for the resistor divider.
9	REGN	P	LDO Output that Powers LSFET Driver and Internal Circuits. Internally, the REGN pin is connected to the anode of the bootstrap diode. Connect a 1μF (10V rating) ceramic capacitor from REGN pin to GND. The capacitor should be placed close to the IC.
10	BTST	P	High-side Driver Positive Supply. It is internally connected to the bootstrap diode cathode. Use a 47nF ceramic capacitor from SW pin to BTST pin.
11,12	SW	P	Switching Node Output. Connect SW pin to the output inductor. Connect the 47nF bootstrap capacitor from SW pin to BTST pin.
Exposed Pad	GND	P	Thermal Pad and Ground Reference. It is the ground reference for the device and also the thermal pad to conduct heat from the device (not suitable for high current return). Tie externally to the PCB ground plane (GND). Thermal vias under the pad are needed to conduct the heat to the PCB ground planes.

NOTE:
1. AI = Analog Input, AO = Analog Output, AIO = Analog Input and Output, DI = Digital Input, DO = Digital Output, DIO = Digital Input and Output, P = Power.

ELECTRICAL CHARACTERISTICS

(V_{VBUS_UVLOZ} < V_{VBUS} < V_{VBUS_OV} and V_{VBUS} > V_{BAT} + V_{SLEEP}, T_J = -40℃ to +85℃, typical values are at T_J = +25℃, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Quiescent Currents						
Battery Discharge Current (BAT)	I_{BAT}	V_{BAT} = 4.5V, V_{VBUS} < $V_{VBUS-UVLOZ}$ or no VBUS		0.1		μA
		V_{BAT} = 4.5V, V_{VBUS} = 5V, fold-back mode		4.7		
Input Supply Current (VBUS)	I_{VBUS}	V_{VBUS} = 12V, V_{VBUS} > V_{BAT}, converter not switching		1.8		mA
		V_{VBUS} = 5V, V_{VBUS} > V_{BAT}, converter not switching		1.5		
		V_{BAT} = 3.8V, V_{VBUS} > V_{BAT}, V_{VBUS} > V_{VBUS_UVLOZ}, converter switching		TBD		
BAT Pin and VBUS Pin Power-Up						
VBUS Operating Range	V_{VBUS_OP}	V_{VBUS} rising	4.2		13.2	V
VBUS for Device Active, No Battery Sense VBUS Pin Voltage	V_{VBUS_UVLOZ}	V_{VBUS} rising		3.33		V
Device Active Hysteresis	$V_{VBUS\_UVLOZ\_HYS}$	V_{VBUS} falling from above V_{VBUS_UVLOZ}		60		mV
Sleep Mode Falling Threshold	V_{SLEEP}	(V_{VBUS} - V_{BAT}), $V_{VBUSMIN}$ ≤ V_{BAT} ≤ V_{REGN}, V_{VBUS} falling		70		mV
Sleep Mode Rising Threshold	V_{SLEEPZ}	(V_{VBUS} - V_{BAT}), $V_{VBUSMIN}$ ≤ V_{BAT} ≤ V_{REGN}, V_{VBUS} rising		175		mV
VBUS 13V Over-Voltage Rising Threshold	$V_{VBUS\_OV\_RISE}$	V_{VBUS} rising		13.2		V
VBUS 13V Over-Voltage Hysteresis	$V_{VBUS\_OV\_HYS}$	V_{VBUS} falling		360		mV
Bad Adapter Detection Falling Threshold	$V_{VBUSMIN}$	V_{VBUS} falling		3.9		V
Bad Adapter Detection Hysteresis	$V_{VBUSMIN\_HYS}$			250		mV
Bad Adapter Detection Current Source	I_{BAD_SRC}	Sink current from VBUS to GND		25		mA
Power Path Management						
Total High-side MOSFET On-Resistance - (Q1 + Q2)	R_{ON_HSFET}	V_{REGN} = 5V		150		mΩ
Low-side Switching MOSFET On-Resistance - Q3	R_{ON_LSFET}	V_{REGN} = 5V		116		mΩ
Battery Charger						
Charge Voltage Program Range	V_{BATREG_RANGE}		4.1		4.45	V
Charge Voltage Step	V_{BATREG_STEP}			50		mV
Charge Voltage Setting	V_{BATREG}	R_{CV} = 0Ω or floating (4.2V)		4.2		V
		R_{CV} = 22.1kΩ (4.35V)		4.35		
Charge Voltage Setting Accuracy	V_{BATREG_ACC}	V_{BATREG} = 4.2V or V_{BATREG} = 4.35V		0.3		%
Charge Current Regulation Range	I_{CHGREG_RANGE}		0		2500	mA
Charge Current Regulation Setting	I_{CHGREG}	I_{CHGREG} = 500mA, V_{BAT} = 3.1V or V_{BAT} = 3.8V		0.504		A
Charge Current Regulation Accuracy	I_{CHGREG_ACC}		TBD		TBD	%
Charge Current Regulation Setting	I_{CHGREG}	I_{CHGREG} = 1.2A, V_{BAT} = 3.1V or V_{BAT} = 3.8V		1.19		A
Charge Current Regulation Accuracy	I_{CHGREG_ACC}		TBD		TBD	%
Pre-Charge Current Regulation Setting	I_{PRECHG}	I_{CHGREG} = 1.2A, V_{BAT} = 3.1V or V_{BAT} = 3.8V I_{PRECHG} is 10% of I_{CHGREG}		125		mA
Pre-Charge Current Regulation Accuracy	I_{PRECHG_ACC}		TBD		TBD	%
Pre-Charge Current Regulation Setting	I_{PRECHG}	I_{CHGREG} = 0.5A, V_{BAT} = 3.1V or V_{BAT} = 3.8V I_{PRECHG} is 10% of I I_{CHGREG}		53		mA
Pre-Charge Current Regulation Accuracy	I_{PRECHG_ACC}		TBD		TBD	%

ELECTRICAL CHARACTERISTICS (continued)

(V_{VBUS_UVLOZ} < V_{VBUS} < V_{VBUS_OV} and V_{VBUS} > V_{BAT} + V_{SLEEP}, T_J = -40℃ to +85℃, typical values are at T_J = +25℃, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Battery Charger						
Battery LOW Falling Threshold	V_{BATLOW_FALL}	I_{CHGREG} = 200mA		2.82		V
Battery LOW Rising Threshold	V_{BATLOW_RISE}	Pre-charge to fast charge		3		V
Termination Current Regulation Setting	I_{TERM}	I_{CHGREG} = 1.2A, V_{BAT} = 3.1V or V_{BAT} = 3.8V I_{TERM} is 10% of I_{CHGREG}		120		mA
Termination Current Regulation Accuracy	I_{TERM_ACC}		TBD		TBD	%
Termination Current Regulation Setting	I_{TERM}	I_{CHGREG} = 0.5A, V_{BAT} = 3.1V or V_{BAT} = 3.8V I_{TERM} is 10% of I_{CHGREG}		42		mA
Termination Current Regulation Accuracy	I_{TERM_ACC}		TBD		TBD	%
Battery Short Voltage	V_{SHORT}	V_{BAT} falling		2.15		V
	V_{SHORTZ}	V_{BAT} rising		2.2		
Battery Short Current	I_{SHORT}	V_{BAT} < V_{SHORTZ}		38		mA
Fold-Back Mode Threshold below V_{BATREG}	$V_{FOLDBACK}$	V_{BAT} falling		80		mV
Recharge Threshold below V_{BATREG}	V_{RECHG}	V_{BAT} falling		130		mV
Charge Current Amplification Ratio	K			10000		
Constant Current Control Reference Voltage	V_{REF}			1		V
Input Voltage and Current Regulation						
Input Voltage Regulation Limit	V_{INDPM}	LVDPM version		4.2		V
Input Voltage Regulation Accuracy	V_{INDPM_ACC}		TBD		TBD	%
BAT Pin Over-Voltage Protection						
Battery Over-Voltage Threshold	V_{BATOVP_RISE}	As percentage of V_{BATREG}, V_{BAT} rising		104		%
	V_{BATOVP_FALL}	As percentage of V_{BATREG}, V_{BAT} falling		102		
Thermal Regulation and Thermal Shutdown						
Junction Temperature Regulation Threshold	$T_{JUNCTION\_REG}$	Temperature increasing		110		℃
Thermal Shutdown Rising Temperature	T_{SHUT}	Temperature increasing		150		℃
Thermal Shutdown Hysteresis	T_{SHUT_HYS}			40		℃
JEITA Thermistor Comparator						
T1 (0℃) Threshold	V_{T1}	Charge suspended T1 below this temperature, as percentage of V_{REGN}		73.2		%
Falling		As percentage of V_{REGN}		71.2		%
T2 (10℃) Threshold	V_{T2}	Charge back to I_{CHGREG}/10 and V_{BATREG} - 100mV below this temperature, as percentage of V_{REGN} (SGM41523/SGM41523B)		68.1		%
Falling		As percentage of V_{REGN} (SGM41523/SGM41523B)		66.8		%
T2 (15℃) Threshold	V_{T2}	Charge back to I_{CHGREG}/10 and V_{BATREG} - 100mV below this temperature, as percentage of V_{REGN} (SGM41523A/SGM41523C)		65.3		%
Falling		As percentage of V_{REGN} (SGM41523A/SGM41523C)		63.8		%
T3 (45℃) Threshold	V_{T3}	Charge back to I_{CHGREG}/10 and V_{BATREG} - 100mV above this temperature, as percentage of V_{REGN}		44.2		%
Falling		As percentage of V_{REGN}		46.0		%
T4 (60℃) Threshold	V_{T4}	Charge suspended above this temperature, as percentage of V_{REGN}		34.7		%
Falling		As percentage of V_{REGN}		35.9		%

ELECTRICAL CHARACTERISTICS (continued)

(V_{VBUS_UVLOZ} < V_{VBUS} < V_{VBUS_OV} and V_{VBUS} > V_{BAT} + V_{SLEEP}, T_J = -40℃ to +85℃, typical values are at T_J = +25℃, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Charge Over-Current Comparator (Cycle-by-Cycle)						
HSFET Cycle-by-Cycle Over-Current Threshold	I_{HSFET_OCP}			4		A
Charge Under-Current Comparator (Cycle-by-Cycle)						
LSFET Under-Current Falling Threshold	V_{LSFET_UCP}	From sync mode to non-sync mode		160		mA
PWM						
PWM Switching Frequency	f_{SW}	Oscillator frequency, buck mode		1300		kHz
Maximum PWM Duty Cycle	D_{MAX}			98		%
REGN LDO						
REGN LDO Output Voltage	V_{REGN}	V_{VBUS} = 9V, I_{REGN} = 40mA		5		V
		V_{VBUS} = 5V, I_{REGN} = 20mA		4.65		
REGN LDO Maximum Output Current	I_{REGN_MAX}	V_{VBUS} = 5V		TBD		mA
Logic I/O Pin Characteristics (nCE)						
Input Low Threshold	V_{IL}				0.5	V
Input High Threshold	V_{IH}		0.6			V
High-Level Leakage Current	I_{BIAS}	Pull up rail 1.8V		0.1		μA
Logic I/O Pin Characteristics (STAT)						
High-Level Output Voltage	V_{OH}			2.8		V
Low-Level Output Voltage	V_{OL}				0.2	V
Output or Sink Current Ability	I_{STAT}			3.8		mA

TIMING REQUIREMENTS

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
V_{VBUS}/V_{BAT} Power-Up						
VBUS OVP Reaction Time	t_{ACOV}	V_{VBUS} rising above ACOV threshold to turn off Q2		100		ns
Wait Window for Bad Adapter Detection	t_{BADSRC}			30		ms
Battery Charger						
Deglitch Time for Charge Termination	t_{TERM_DGL}			250		ms
Deglitch Time for Recharge	t_{RECHG_DGL}			250		ms
Battery Over-Voltage Deglitch Time to Disable Charge	t_{BATOVP}			1		μs

FUNCTIONAL BLOCK DIAGRAM

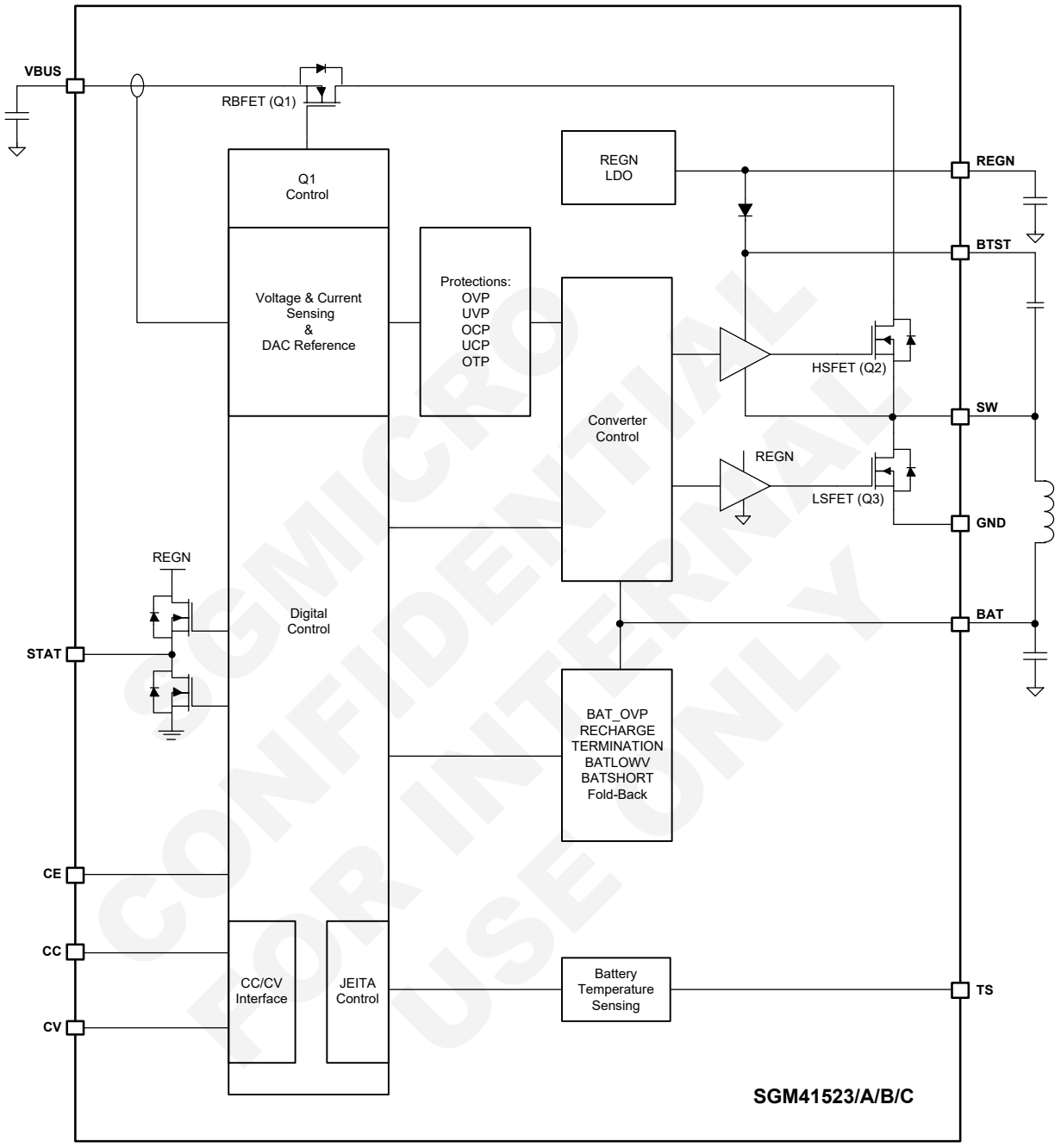


Figure 2. Block Diagram

DETAILED DESCRIPTION

Overview

The SGM41523/A/B/C is a highly-integrated 2.5A switch-mode stand-alone battery charge management device for single-cell Li-Ion and Li-polymer battery with high input voltage support for a wide range of smart phones, tablets and portable devices. The low impedance power path optimizes switch-mode operation efficiency, reduces battery charging time and extends battery life during discharging phase. The CC/CV interface for charging settings makes the device a truly flexible solution. Its input voltage and current regulations deliver maximum charging power to battery. The solution is highly integrated with input reverse blocking FET (RBFET, Q1), high-side switching FET (HSFET, Q2), and low-side switching FET (LSFET, Q3). It also integrates the bootstrap diode for the high-side gate drive for simplified system design.

Starting and termination of a charging cycle can be accomplished without software control. The sensed battery voltage is used to decide for starting phase of charge in one of the three phases of charge cycle: pre-conditioning, constant current or constant voltage. When the charge current falls below a preset limit and the battery voltage is above recharge threshold, the charger function will automatically terminate and end the charging cycle. If the voltage of a charged battery falls below the recharge threshold, the charger starts another charging cycle.

Several safety features are provided in the SGM41523/A/B/C such as over-voltage and over-current protections, battery temperature monitoring, and thermal shutdown and input UVLO. TS pin is connected to an NTC thermistor for battery temperature monitoring and protection in both charge and boost modes according to JEITA profile. This device also features thermal regulation in which the charge current is reduced if the junction temperature exceeds 110℃. The STAT output reports the charging status and any fault conditions.

Power-On-Reset (POR)

The internal circuit of the device is powered from the greater voltage between V_{VBUS} and V_{BAT}. When the voltage of the selected source goes above its UVLO level (V_{VBUS} > V_{VBUS_UVLOZ} or V_{BAT} > V_{BAT_UVLOZ}) a POR happens and activates the sleep comparator and battery depletion comparator. Upon activation, the CC/CV interface will also be ready for charge current and voltage settings.

Battery Charging Profile

The SGM41523/A/B/C features a full battery charging profile with five phases. In the beginning of the cycle the battery voltage (V_{BAT}) is tested and appropriate current and voltage regulation levels are selected as shown in Table 1. Depending on the detected status of the battery, the proper phase is selected to start or for continuation of the charging cycle. The phases are: battery short (battery voltage too low), pre-conditioning, constant current, constant voltage and fold-back mode.

Table 1. Charge Current Setting Based on V_{BAT}

V_{BAT}	Charge Current
< 2.2V	I_{SHORT}
2.2V to 3V	I_{PRECHG}
> 3V	I_{CHGREG}

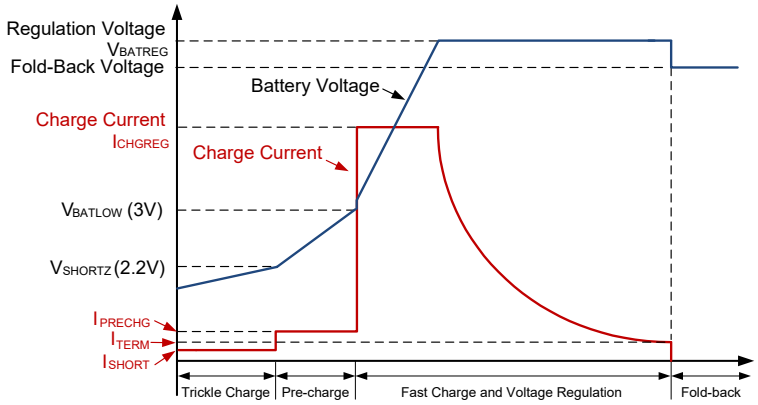


Figure 3. Battery Charging Profile

DETAILED DESCRIPTION (continued)

Charging Termination

A charging cycle is terminated when the battery voltage is above the recharge threshold and the current falls below the programmed termination current. After the charging cycle is completed, the converter enters fold-back mode.

The SGM41523/A/B/C has no battery switch but provides an alternative way for battery safe and for extending battery life, which is the voltage fold-back mode when a battery is fully charged while the input power is kept. This alternative has less energy loss as no switch in the discharge loop. The only penalty is that it could not support instant start if the battery voltage is excessive low, in which condition it takes few minutes more for the load system to be ready for start. When the device operates in FBM, the output voltage is $V_{FOLDBACK}$ lower than V_{BATREG}, and the output current limit is I_{CHGREG}.

Compliance with JEITA Guideline

JEITA guideline (April 20, 2007 release) is implemented in the device for safe charging of the Li-Ion battery. JEITA highlights the considerations and limits that should to be considered for charging at cold or hot battery temperatures. High charge current and voltage must be avoided outside normal operating temperatures (typically 0℃ and 60℃). This functionality can be disabled if not needed. Four temperatures levels are defined by JEITA from T1 (minimum) to T4 (maximum). Outside this range charging should be stopped. The corresponding voltages sensed by NTC are named V_{T1} to V_{T4}. Due to the sensor negative resistance, a higher temperature results in a lower voltage on TS pin. The battery cool range is between T1 - T2 and the warm range is between T3 - T4. Charge must be limited in the cool and warm ranges.

One of the conditions for starting a charge cycle is having the TS voltage within V_{T1} to V_{T4} window limits. If during the charge, battery gets too cold or too hot and TS voltage exceeds the T1 - T4 limits, charging is suspended (zero charge current) and the controller waits for the battery temperature to come back within the T1 to T4 window.

At cool temperature (T1 - T2) or at warm temperature (T3 - T4), the charge current reduces to 10% of the charge current, and the charge voltage decreases by about 100mV automatically.

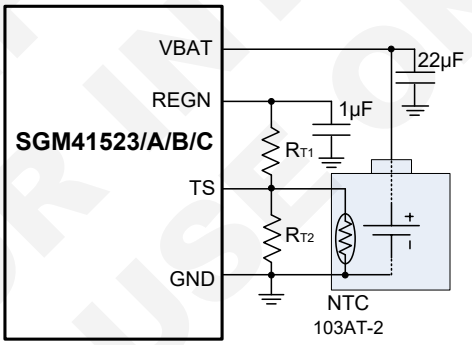


Figure 4. TS Resistor Network

The resistor bias network (Figure 4) can be calculated based on the following equations:

$$R_{T2} = \frac{V_{REGN} \times R_{THCOLD} \times R_{THHOT} \times \left(\frac{1}{V_{T1}} - \frac{1}{V_{T4}}\right)}{R_{THHOT} \times \left(\frac{V_{REGN}}{V_{T4}} - 1\right) - R_{THCOLD} \times \left(\frac{V_{REGN}}{V_{T1}} - 1\right)} \quad (1)$$

$$R_{T1} = \frac{\left(\left(\frac{V_{REGN}}{V_{T1}}\right) - 1\right)}{\left(\frac{1}{R_{T2}}\right) + \left(\frac{1}{R_{THCOLD}}\right)} \quad (2)$$

DETAILED DESCRIPTION (continued)

Table 2. Temperature Related Charging Control

Temperature Range	Charge Current	Charge Voltage
Lower than T1	/	/
T1 ~ T2	I_{CHGREG} × 10%	V_{BATREG} - 100mV
T2 ~ T3	I_{CHGREG}	V_{BATREG}
T3 ~ T4	I_{CHGREG} × 10%	V_{BATREG} - 100mV
Higher than T4	/	/

Select 0℃ to 60℃ range for Li-Ion or Li-polymer battery. With a 103AT-2 type thermistor we have:

- R_{THCOLD} = 27.28kΩ
- R_{THHOT} = 3.02kΩ
- R_{T1} = 5.23kΩ
- R_{T2} = 30.1kΩ

Charging Status (STAT Pin)

Charging state is indicated with the push-pull STAT pin as explained in Table 3. This pin is able to drive an LED (see Figure 1).

Table 3. STAT Pin Function

Charging State	STAT Indicator
Charging battery (or recharge)	Low (LED ON)
Charging completed	High (LED OFF)
Charging is disabled or in sleep mode	High (LED OFF)
Charge is suspended due to input over-voltage, TS fault, timer faults or system over-voltage or boost mode is suspended (TS fault).	0.65Hz Blinking

Protections

Input Over-Voltage

If VBUS voltage exceeds V_{VBUS_OV}, switching will stop immediately. The device will automatically resume normal operation once the input voltage drops back below the OVP threshold.

Thermal Regulation and Thermal Shutdown

The SGM41523/A/B/C monitors the internal junction temperature T_J to avoid overheating the chip and limits the IC surface temperature at 110℃ in buck mode. When the internal junction temperature exceeds thermal regulation limit (110℃), the device lowers down the charge current. During thermal regulation, the actual charge current is usually below the programmed battery charge current.

Additionally, the device has thermal shutdown to turn off the converter when IC surface temperature exceeds T_{SHUT} (150℃). The converter is enabled to recover when IC temperature is T_{SHUT_HYS} (40℃) below T_{SHUT} (150℃).

Battery Over-Voltage Protection

The battery over-voltage limit is 4% above the battery regulation voltage. Charging will immediately disable if a battery over-voltage occurs.

Battery Over-Discharge Protection

To recover from over-discharge, an input source is required at VBUS pin. The battery is charged with I_{SHORT} (38mA TYP) or the lower one of I_{SHORT} and I_{PRECHG} current when the V_{BAT} < V_{SHORTZ}, or pre-charge current when the battery voltage is between V_{SHORTZ} and $V_{BATLOWV}$.

DETAILED DESCRIPTION (continued)

Charging Voltage Programming

Forcing a voltage on the CV pin, or grounding it with a resistor that presents a similar voltage against the constant current sourcing from the pin during charging selects 1 of 6 charging voltages, as shown in Table 4.

Table 4. Conditions for Selecting a Charging Voltage

Charging Voltage (V)	Forcing Voltage (V)	Separation Thresholds (V)	Recommended Grounding Resistance (kΩ)
4.1	0.45	0.3 ~ 0.6	9.09
4.2	Grounding or Open	< 0.3 or > 2.0	Grounding or Floating
4.3	0.75	0.6 ~ 0.9	15
4.35	1.05	0.9 ~ 1.2	21
4.4	1.4	1.2 ~ 1.6	28
4.45	1.8	1.6 ~ 2.0	35.7

NOTE: Sourcing current out of the CV is typically 50μA.

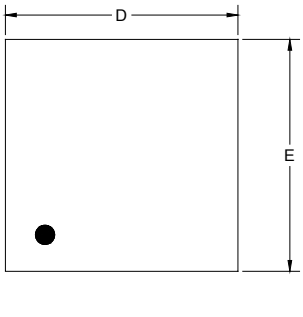
Charge Current Programming and Turn-Off

Charge current is programmed by using different R_{CC} resistance or by providing voltage difference on the R_{CC} by forcing a voltage at the other end, which could be generated by a DAC or by a PWM output.

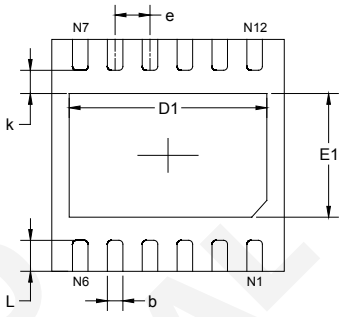
Forcing the CC to a voltage higher than V_{REF} turns the device off.

PACKAGE OUTLINE DIMENSIONS

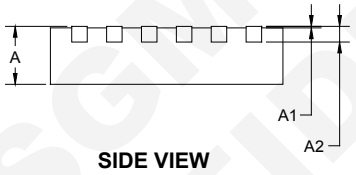
TDFN-3×3-12L



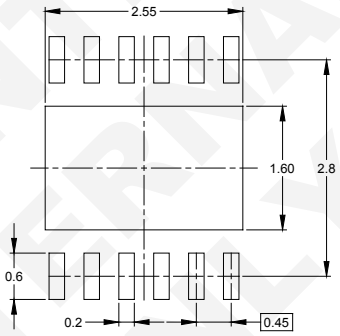
TOP VIEW



BOTTOM VIEW



SIDE VIEW

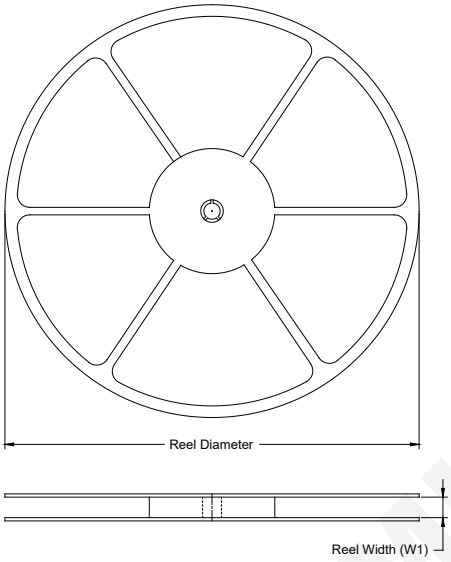


RECOMMENDED LAND PATTERN (Unit: mm)

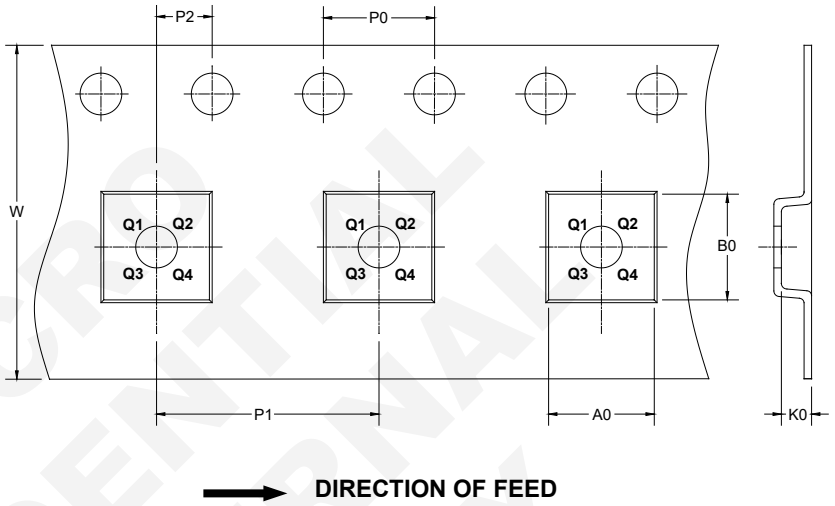
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.700	0.800	0.028	0.031
A1	0.000	0.050	0.000	0.002
A2	0.203 REF		0.008 REF	
D	2.924	3.076	0.115	0.121
D1	2.450	2.650	0.096	0.104
E	2.924	3.076	0.115	0.121
E1	1.500	1.700	0.059	0.067
k	0.200 MIN		0.008 MIN	
b	0.150	0.250	0.006	0.010
e	0.450 TYP		0.018 TYP	
L	0.324	0.476	0.013	0.019

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



DIRECTION OF FEED

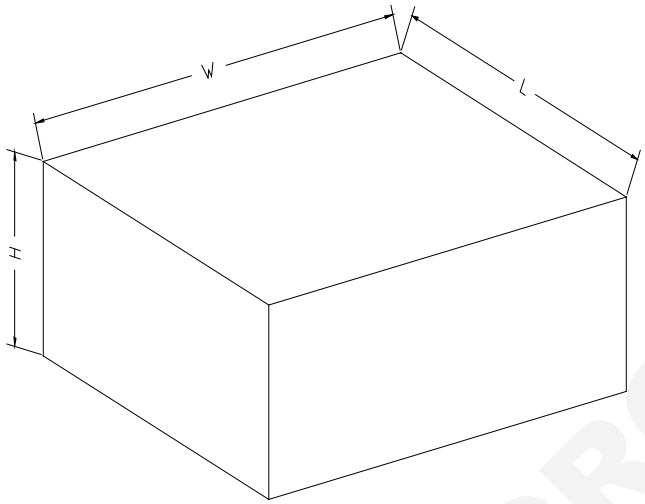
NOTE: The picture is only for reference. Please make the object as the standard.

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
TDFN-3×3-12L	13″	12.4	3.30	3.30	1.10	4.0	8.0	2.0	12.0	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
13″	386	280	370	5

DD0002