SGM41563
Li+/Polymer Battery Charger with Low I_Q Boost Operation

GENERAL DESCRIPTION

The SGM41563 is a linear charger for single-cell Li+/polymer battery plus an ultra-low standby current boost operation for generating a 5V output from the battery power. Its wide input range allows charging with loose regulated power like conducting coil, solar cells or thermal coupling piles. The boost quiescent current (0.68μA TYP) is affordable even for small cell always-on standby application.

The SGM41563 is available in a Green SOIC-8 (Exposed Pad) package.

FEATURES

- **Five Charge Voltage Options:**
  4.2V/4.25V/4.3V/4.35V/4.4V
- **5mA to 700mA Charger for Single-Cell Li+/ Polymer Battery**
- **Constant-Current/Constant-Voltage Charging**
- **Die Temperature Charge Current Regulation**
- **-4% Voltage Fold-Back Power Retaining**
- **+2% Path Resistive Loss Compensation**
- **Floating Charge Over-Time Termination**
- **Ultra-Low Quiescent Current**
- **Programmable Charge Current**
- **Power-Saving Charging Indication**
- **Internal Over-Temperature Protection**
- **Available in a Green SOIC-8 (Exposed Pad) Package**

APPLICATIONS

Rechargeable Battery Powered IoT Gadget
Self-Powered IoT Terminals

TYPICAL APPLICATION

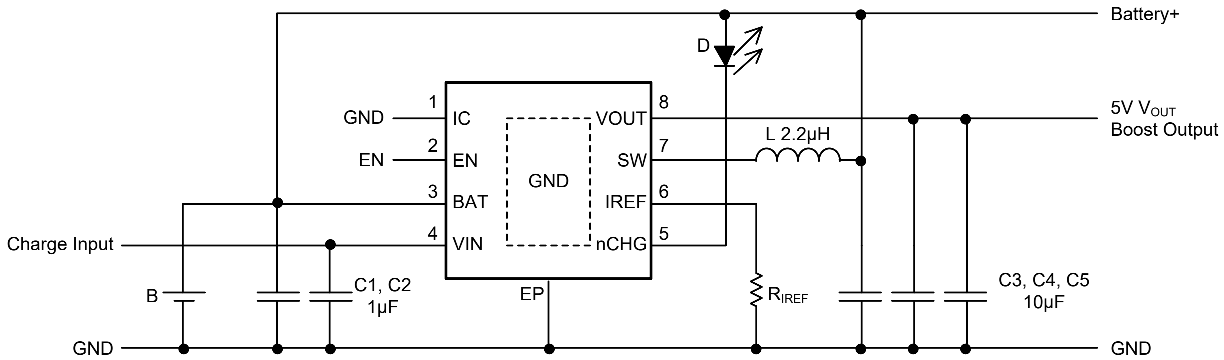


Figure 1. Typical Application Circuit

PACKAGE/ORDERING INFORMATION

MODEL	V_{CH} (V)	PACKAGE DESCRIPTION	SPECIFIED TEMPERATURE RANGE	ORDERING NUMBER	PACKAGE MARKING	PACKING OPTION
SGM41563	4.2	SOIC-8 (Exposed Pad)	-40℃ to +85℃	SGM41563-420YPS8G/TR	SGM CK9YPS8 XXXXX	Tape and Reel, 4000
	4.25	SOIC-8 (Exposed Pad)	-40℃ to +85℃	SGM41563-425YPS8G/TR	SGM CKAYPS8 XXXXX	Tape and Reel, 4000
	4.3	SOIC-8 (Exposed Pad)	-40℃ to +85℃	SGM41563-430YPS8G/TR	SGM CKBYPS8 XXXXX	Tape and Reel, 4000
	4.35	SOIC-8 (Exposed Pad)	-40℃ to +85℃	SGM41563-435YPS8G/TR	SGM CKCYPS8 XXXXX	Tape and Reel, 4000
	4.4	SOIC-8 (Exposed Pad)	-40℃ to +85℃	SGM41563-440YPS8G/TR	SGM CKDYPS8 XXXXX	Tape and Reel, 4000

MARKING INFORMATION

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

XXXXX
- 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.

ABSOLUTE MAXIMUM RATINGS

Voltage Range
- VIN to GND .... -0.3V to 10V
- EN, SW, VOUT, IREF to GND .... -0.3V to 6V
- BAT to GND .... -0.3V to 5.5V
- nCHG to GND .... -0.3V to 13.2V

Package Thermal Resistance

SOIC-8 (Exposed Pad), θ_{JA} .... 42℃/W

Junction Temperature .... +150℃

Storage Temperature Range .... -65℃ to +150℃

Lead Temperature (Soldering, 10s) .... +260℃

ESD Susceptibility

HBM 4000V

CDM 1000V

RECOMMENDED OPERATING CONDITIONS

Supply Voltage Range .... 2.7V to 7.5V

Operating Junction Temperature Range .... -40℃ to +125℃

Operating Ambient Temperature Ranges .... -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

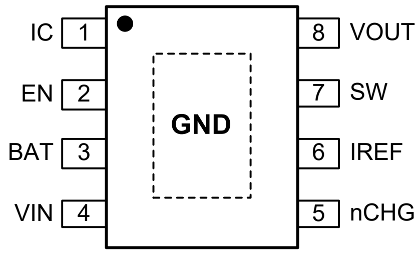
This integrated circuit can be damaged if ESD protections are not considered carefully. SGMICRO recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage. ESD damage can range from subtle performance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



SOIC-8 (Exposed Pad)

PIN DESCRIPTION

PIN	NAME	TYPE	FUNCTION
1	IC	IC	Internal Connection. Connect this pin to ground.
2	EN	I	Boost Enable Input. This is a logic input pin to disable or enable the boost converter. Drive to logic low to disable the boost. Drive to logic high to enable the boost. Do not leave it floating.
3	BAT	IO	Battery. Output to the battery and/or system load, for charging and/or powering the system. The boost circuit is internally connected to this node as its bias.
4	VIN	P	Power Input. For powering this device and feeding to the BAT output.
5	nCHG	O	Charging Indication. This pin blinks during charging and keeps on for about 52s when the end-of-charge (EOC) condition is qualified.
6	IREF	IO	Maximum Charge Current Programming and Charge Disable Input. Drive to logic high to disable the charger. Connect a resistor between this pin and GND to set the charge current limit determined by the following equations: I_{CHG} < 400mA, I_{CHG} (mA) = 24000/R_{IREF} (kΩ); I_{CHG} > 400mA, I_{CHG} (mA) = 20500/R_{IREF} (kΩ) + 58mA.
7	SW	IO	Chopping Output of the Boost. It is connected to the power inductor.
8	VOUT	O	Boost Converter Output. Place storage capacitor(s) close to this pin and clip between this pin and ground.
Exposed Pad	GND	G	Ground of the Circuit.

NOTE: I: Input, O: Output, IO: Input or Output, G: Ground, P: Power for the Circuit, IC: Internal Connection.

ELECTRICAL CHARACTERISTICS

(T_J = +25℃, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
No Load Operation Current	I_{NO_OP}	Test with the typical application circuit in Figure 1		70		μA
Charger Only (V_{VIN} = 5V, V_{BAT} = 3.6V, R_{IREF} = 120kΩ, nCHG floating.)						
Operation Input Range	V_{OP_RANGE}		2.7		7.5	V
Charge Current Range	I_{CH_RANGE}		5		700	mA
Retaining Current	$I_{RETAINING}$	Force the output voltage to 2V, R_{IREF} = 120kΩ		200		mA
VIN-BAT Current	I_{FB_RANGE}	V_{VIN} - V_{BAT} = 1V, R_{IREF} = 13kΩ		700		mA
No Operation Current	$I_{BAT\_REVERSE}$	V_{VIN} = 3V, V_{BAT} = 5.2V, the current into BAT		9	12	μA
	I_{BAT_LK}	V_{VIN} = floating, V_{BAT} = 5.2V, the current into BAT		0.08	1	μA
	I_{SHUT}	V_{VIN} = 6V, V_{IREF} = 5.5V, V_{EN} = 0V, the current into VIN		7.5	10	μA
	I_{NOT_CHG}	V_{VIN} = 5V, I_{BAT} = 0mA, the current into VIN		72	110	μA
Charge Voltage	V_{CH}	4.2V to 4.4V, 5 voltage options, in 50mV steps	4.2		4.4	V
Charge Voltage Error	V_{CH_ERR}	I_{BAT} = 20mA	-28		28	mV
Charge Start Voltage	V_{DH}	V_{VIN} - V_{BAT}, up-going		310		mV
Reverse Block Start Voltage	V_{DL}	V_{VIN} - V_{BAT}, down-going		25		mV
Charge Current at Specific R_{IREF} Setting	I_{CHG}	R_{IREF} = 120kΩ	173	200	227	mA
		R_{IREF} = 600kΩ	33.6	40	46.4	
Pre-condition Charge Voltage	V_{RPR}	Percentage to V_{CH}	56.5	60	64.5	%
Path Resistive Loss Compensation Voltage	V_{RDC}	Add percentage to V_{CH}	1.2	2	2.7	%
Drop Compensation Check Voltage	V_{DCC}	Drop percentage to V_{CH}	0.3	2.2	4	%
Fold-Back Voltage	V_{FB}	Drop percentage to V_{CH}	3.3	4	4.6	%
Floating and Recharge Voltage	V_{FLTING_RC}	Drop percentage to V_{CH} for floating time counting; drop percentage to V_{FB} for recharging		1.5	3	%
End of Charge Current	I_{EOC}	Percentage to I_{CHG}	15	20	25	%
Pre-Condition Charge Current	I_{PR}	Percentage to I_{CHG}	3	7.5	14.5	%
Floating Charge Time	t_{FLTING}			44		Min
System Load Pre-charge	t_{SYS_PRE}			21		ms
Charge-On Sinking Time	t_{ON}			160		ms
Charge-On Driving Cycle Time	t_C			1.28		s
End of Charge Sinking Time	t_{EOC}			51.2		s
Charge Current Regulated Temperature	T_{CUT}			130		℃
IO Characteristics for Indication Drive and Logic Control Input						
Charge Disable Voltage	V_{TIREF}				1.6	V
nCHG Low Sinking	I_{SNK}	Pull nCHG to 5V		3.6		mA
nCHG Leakage	I_{LKG}	Pull nCHG to 5V		0.01		μA

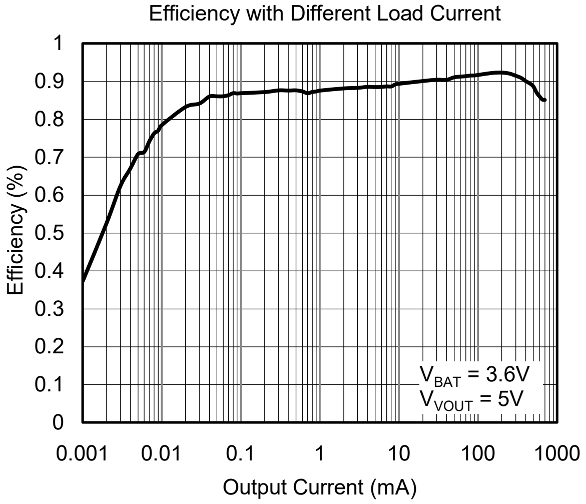
ELECTRICAL CHARACTERISTICS (continued)

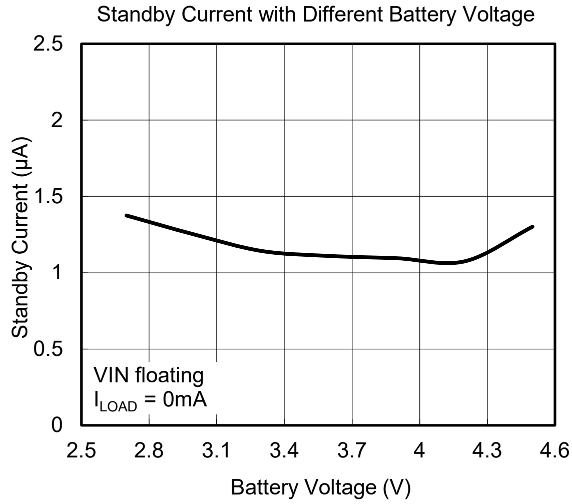
(T_J = +25℃, unless otherwise noted.)

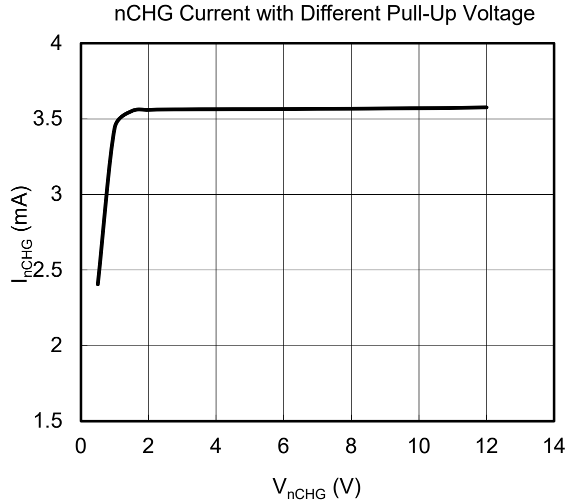
PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Boost Only (V_{BAT} = 2.7V to 5.2V, C_{BAT} = 10μF, C_{VOUT} = 20μF, typical values are at V_{BAT} = 3.7V.)						
Output Voltage	V_{OUT_PWM}	V_{BAT} < V_{VOUT}, in PWM mode operation	4.84	5.00	5.09	V
	V_{OUT_PFM}	V_{BAT} < V_{VOUT}, in PFM mode operation		5.04		
Output Current	I_{OUT_RANGE}			500		mA
Quiescent Current into BAT Pin	I_Q	No load, not switching		0.08	0.6	μA
Quiescent Current into VOUT Pin		No load, not switching, boost or down mode		0.6	1	μA
Peak Current Limit	I_{LIM}	boost operation	0.89	1.3	1.62	A
Switch Frequency	f_{SW}	V_{BAT} = 3.7V	0.98	1.2	1.35	MHz
Low-side Switch On-Resistance	R_{ON_L}			300	420	mΩ
High-side Switch On-Resistance	R_{ON_H}			320	410	mΩ
Boost Stop Temperature	T_{OT}	The temperature boost stops		150		℃
Resuming Temperature	T_{HYS}	Temperature drop for boost resuming operation		25		℃
Control Logic						
EN High Threshold	V_{IH}		1.20			V
EN Low Threshold	V_{IL}				0.40	V
EN Input Leakage	I_{EN_LKG}	V_{BAT} = V_{EN} = 5V			0.3	μA

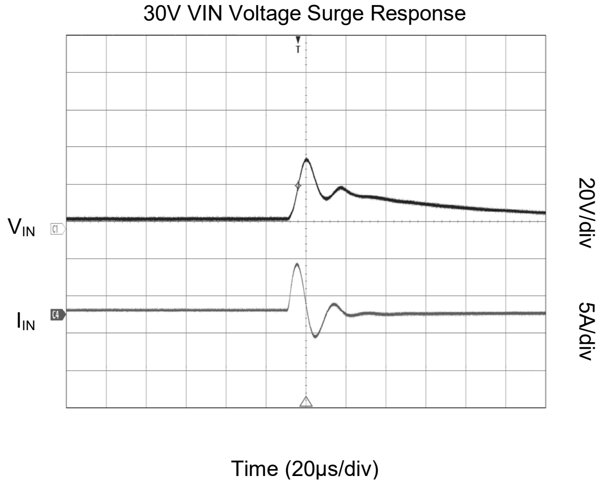
TYPICAL PERFORMANCE CHARACTERISTICS

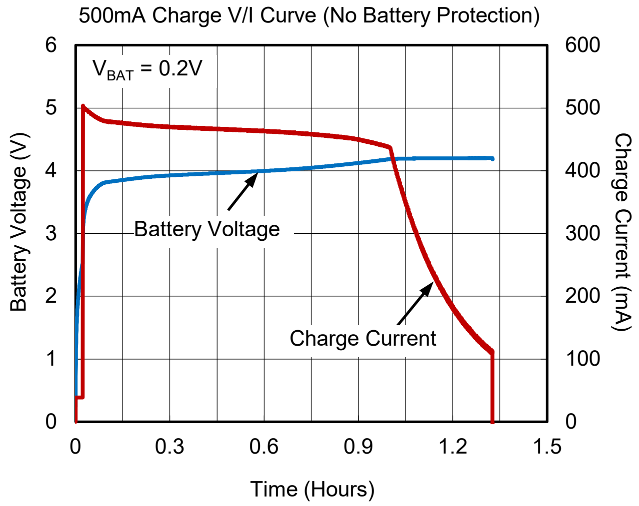
T_J = +25℃, V_{VIN} = 5V, EN = V_{BAT}, V_{BAT} = 3.6V, unless otherwise noted.

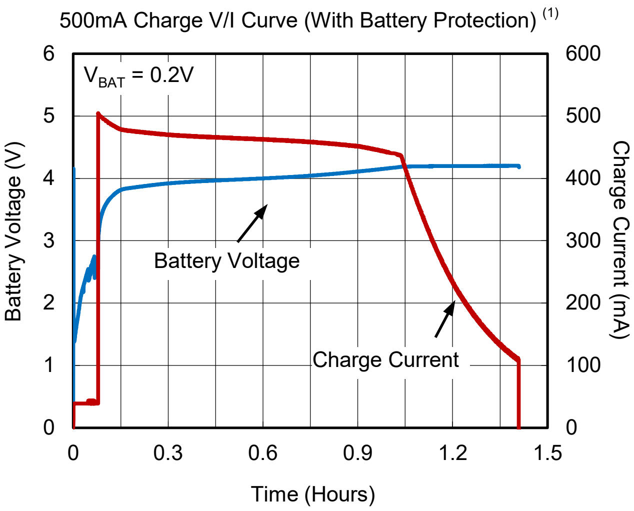






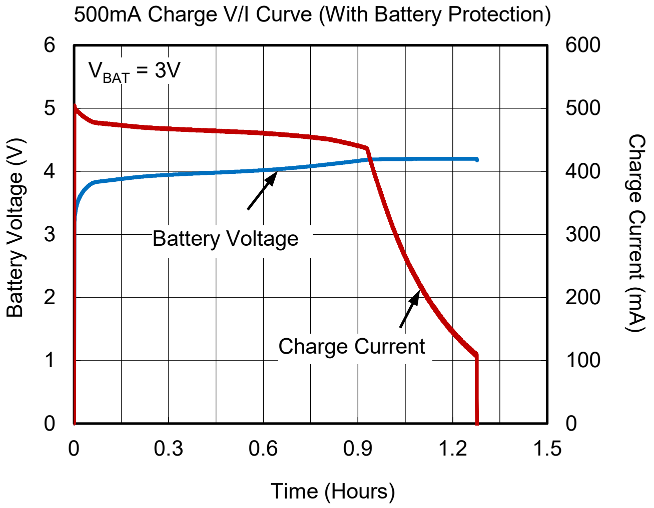






TYPICAL PERFORMANCE CHARACTERISTICS (continued)

T_J = +25℃, V_{VIN} = 5V, EN = V_{BAT}, V_{BAT} = 3.6V, unless otherwise noted.



NOTE:

1. The plot is acquired in test with a battery pack with the SGM41100 series battery protector. Voltage profile in range < 2.5V reflects the protector behavior, and the current profile droop is path resistance dependent.

FUNCTIONAL BLOCK DIAGRAM

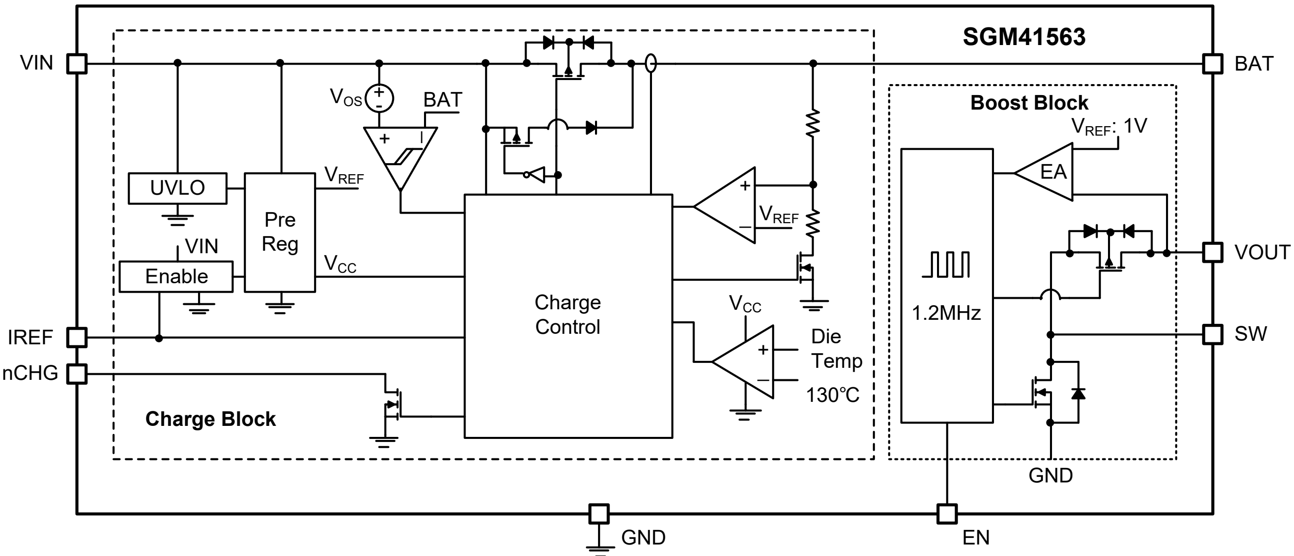


Figure 2. Block Diagram

ESSENTIAL SEQUENCE

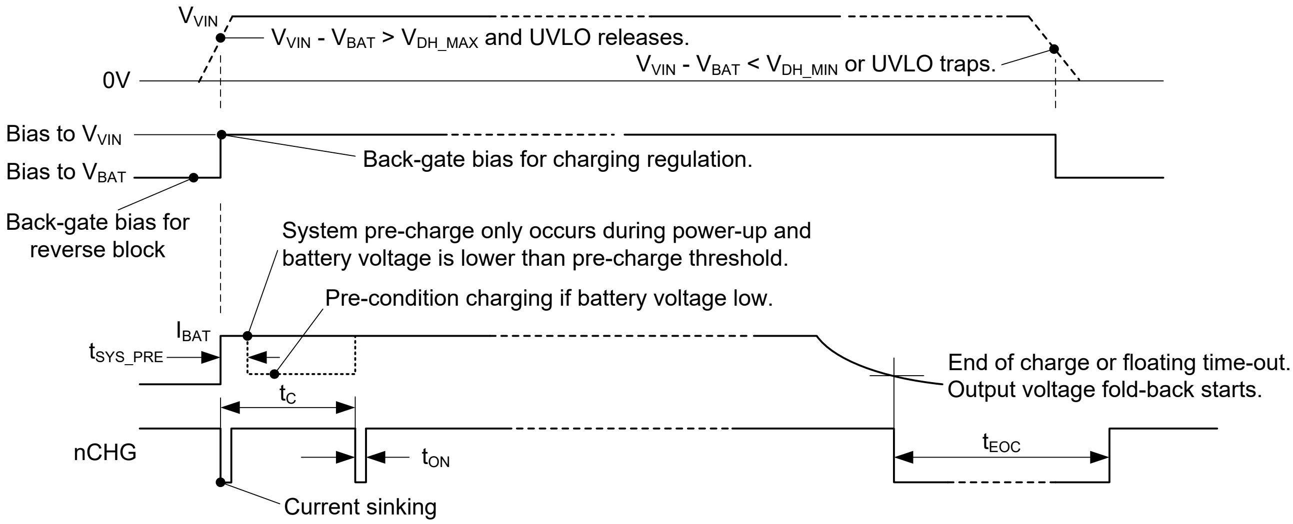


Figure 3. Essential On/Off Timing

DETAILED DESCRIPTION

The SGM41563 has a linear battery charger block with low I_Q boost operation which is biased from the BAT pin. It only consumes ultra-low quiescent current less than 1μA, which is designed for the always-on standby applications.

The Linear Charger

The charger block uses a CC/CV charge profile, plus the following added features for improving safety, suitability and availability:

System Load Pre-charge: When power up in the situation that the battery terminal voltage is below the pre-condition voltage threshold, the output with maximum current limit for t_{SYS_PRE} to provide enough current for the system to start up with no battery or with a battery in under-voltage protection state.

Wide Available Input Range: Charging is kept when the input voltage is high or when the supply could not maintain enough voltage and current. The charge current is regulated for no over-heating the device or maintains minimum drop-out for no reverse leakage, even the current could not be maintained continuously.

Voltage Fold-Back Power Retaining: When EOC condition is qualified, lower the output to a safe voltage while release the current limit to the maximum, retain powering the load system. The fold-back does not sink charge back out of the battery and avoids discharging and recharging cycling in continuous plugged-in situation.

Floating Charge Time-Out: When charging with high system load that sinks more than the end of charge residual current, charging stops when the battery voltage stays higher than floating charge voltage for over t_{FLTING} and turns in the end of charge fold-back power retaining.

Over-Temperature Charge Regulation: The device senses temperature with its on-die sensing circuit. When the die temperature reaches T_{CUT}, the charge current is reduced for maintaining the temperature.

Path Resistive Loss Compensation and Charge Termination Current: Once the end of charge condition is detected the first time, the charge is turned to output V_{FB} while the V_{BAT} is checked; a drop is seen as the current in the charge path falls. If the drop is significant, more than V_{DCC}, the output voltage is then increased to V_{RDC} to compensate as the excessive loss drop detected. This allows using relative high residual current level for charge termination detection while the bigger portion of charge current goes into load instead of into current.

Charging Procedure, Start, End of Charge, Power Retaining and Restart: There are two kinds of charge procedure, charging a battery cell without any battery protector and with a battery protector. The devices' native charging procedure is recorded with a battery without any protector, in which the system pre-charge, battery pre-charge, floating, end of charge and safe fold-back power retaining are included. When charging a battery with a protector, the start-end curve is affected by the protector's behavior and the residual battery voltage is kept by the protector, in which the BAT voltage raises too fast that no much difference to chargers with a battery FET.

The charge procedure is provided as a constant current and constant voltage, with a system pre-charge at power up and a pre-condition charging if the battery voltage is lower than the fast charging threshold. The end of charge is qualified when the charge current falls to the termination current in the floating charge period or floating timer runs out of time, once or after the path resistive loss compensated. Charge procedure parameters are illustrated in Figure 3 as well, in which timing is not scaled for showing details in short time intervals.

Charge Current Programming: The current passing through the VIN to BAT path is sampled and the current is proportional to the path current that is fed out of the IREF pin. The proportional current goes through the R_{IREF} and makes a voltage drop over the R_{IREF} proportional to the path current. The current regulation loop controls the path resistance to make the drop equal to an internal reference voltage unless the voltage regulation loop takes control. The current sample ratio, R_{IREF} and the internal reference voltage decide the path current when the current loop takes control. The relationship between the R_{IREF} and the path current is represented as:

$$I_{CHG} = 24000/R_{IREF}\ (k\Omega) \text{ for } I_{CHG} < 400mA$$
$$I_{CHG} = 58(mA) + 20500/R_{IREF}\ (k\Omega) \text{ for } I_{CHG} > 400mA$$

DETAILED DESCRIPTION (continued)

The Boost Converter

The boost block operates in peak-current PWM mode in normal load condition, and turns into power-saving skip mode in light load condition. The power input to load is disconnected when it is disabled by pulling EN low.

In addition to the normal regulation, both the peak inductor current and the output voltage are monitored for over-current protection and short circuit protection. Whenever the peak current reaches I_{LIM}, the low-side switch is turned off. Whenever the output voltage falls below 2.2V, the output is pre-charged through the high-side switch that has a current limit for about 200mA. The switching operation stops whenever the output voltage is higher than the over-voltage protection threshold (V_{OV}), or the die temperature is higher than the over-temperature threshold (T_{OT}).

Careful Handling to In-Rush and Out-Rush: In-rush voltage surge or out-rush voltage surge might occur and damage the low voltage pins BAT and VOUT during the battery attaching or the supply applying in production test in the always-on circuit showed in Figure 4.

It is recommended to place TVS diodes clipping to the BAT pin and VOUT pin for surge absorption. However, if you decide not to use TVS diodes, the R1 and C6 are alternatives in the always-on application, which inserts a short delay to EN enabling after battery attaching or test supply contact, to avoid the boost starting during the voltage surge. The larger capacitances of C4 and C5, as shown in Figure 4, are recommended to lowering the out-rush voltage surge caused by load contact bouncing, which is usual situation in frequent load assertion applications like TWS case, where the load contact capacitance should be less than 1/10 of the total capacitances of the C4 and C5 practically.

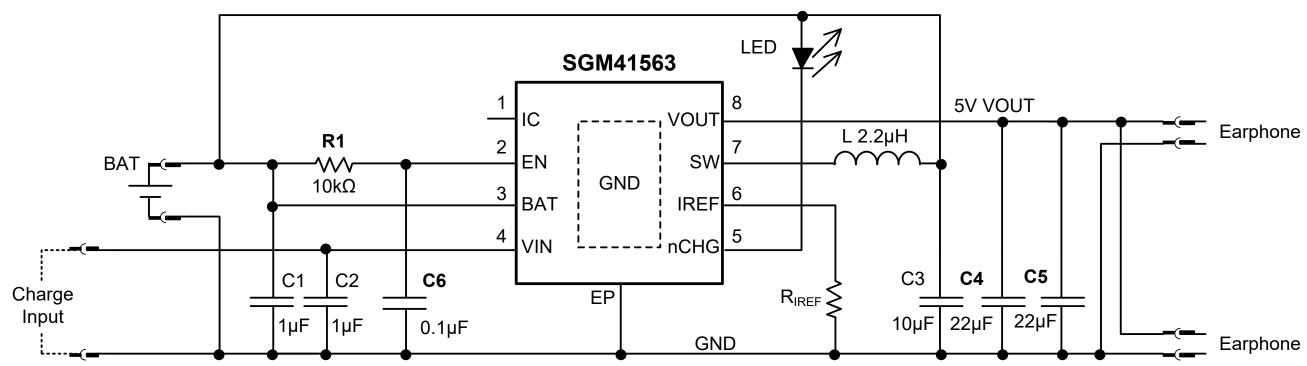


Figure 4. Typical Application Circuit for Always-on Boost in TWS Charger Case

APPLICATION INFORMATION

The typical application circuit with the recommended component parameters is shown in Figure 1. The boost keeps stable if reducing the input decoupling capacitance and the output storage capacitance to half value if not care about the increasing of the output voltage ripple amplitude and the input current ripple amplitude.

Inductor Selection: The low DCR inductor of 2.2μH with the saturation current and the thermal limited current > 1.4A is recommended.

Layout Consideration: The inductor current alternates between the ground EP and the output storage capacitors C4 - C5, while the input decoupling capacitor C3 makes the return loop of the inductor current ripple. Refer to Figure 5; it makes the ripple current loop as small as possible for stable and low loss operation.

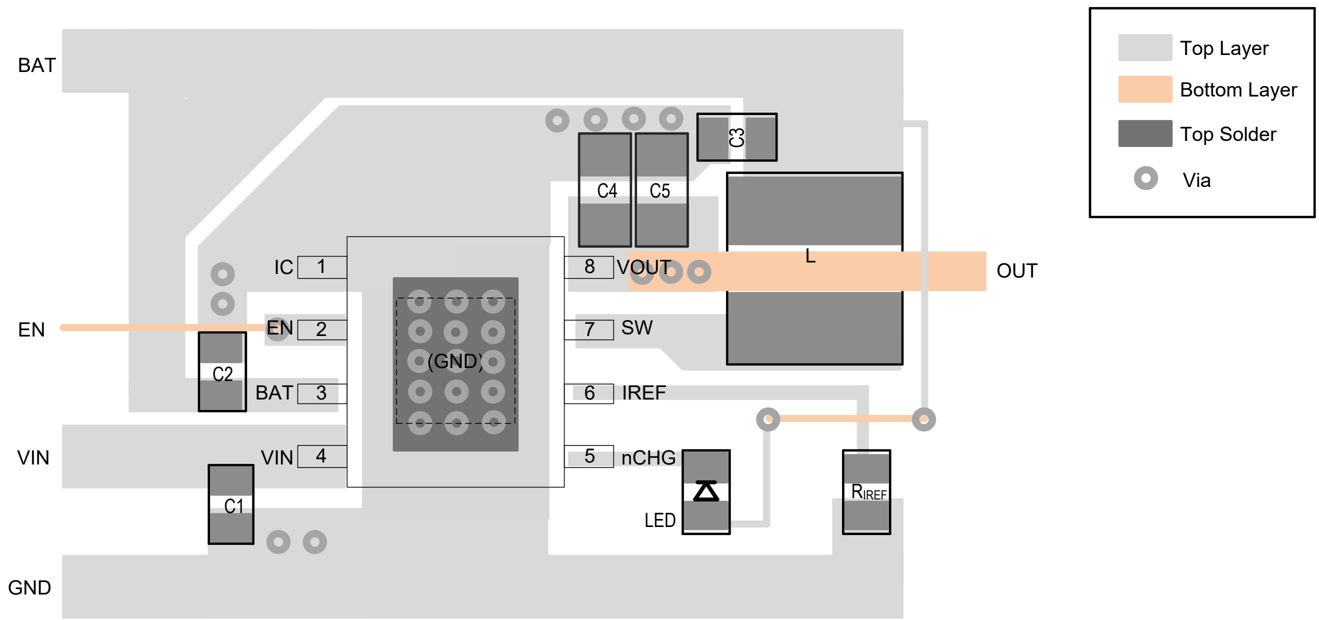


Figure 5. Layout Recommendation

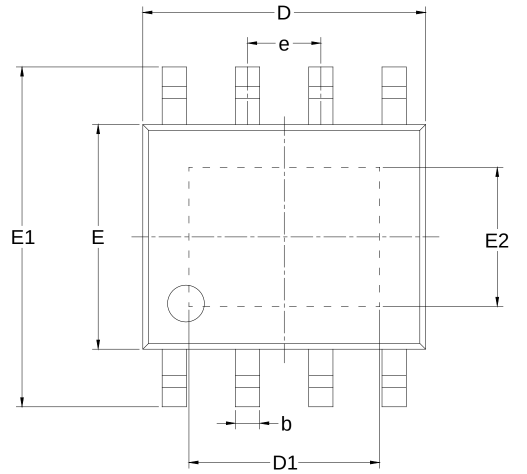
REVISION HISTORY

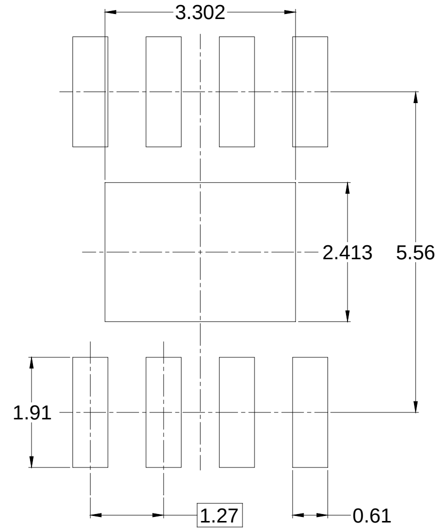
NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Original (MARCH 2020) to REV.A	Page
Changed from product preview to production data	All

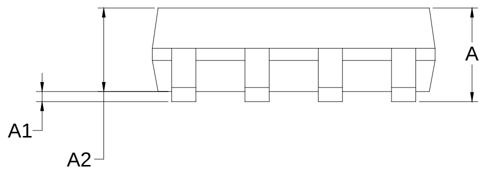
PACKAGE OUTLINE DIMENSIONS

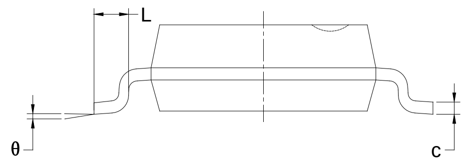
SOIC-8 (Exposed Pad)





RECOMMENDED LAND PATTERN (Unit: mm)

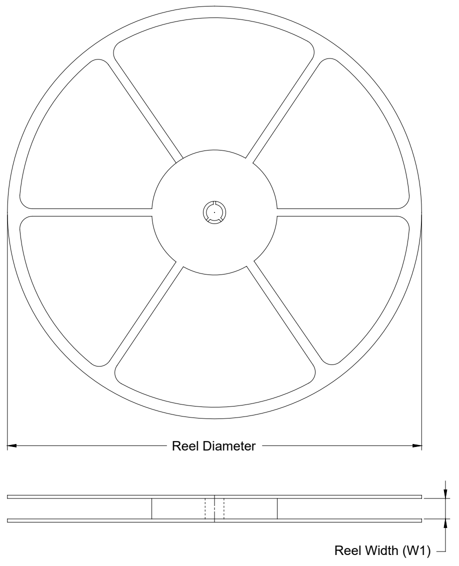




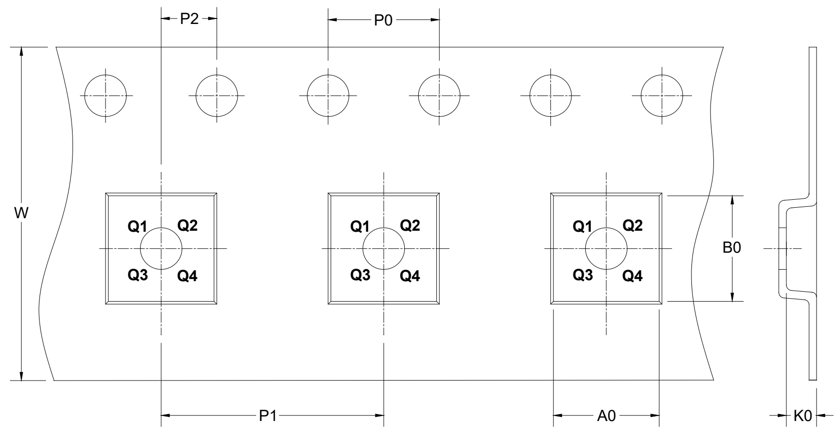
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A		1.700		0.067
A1	0.000	0.100	0.000	0.004
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.007	0.010
D	4.700	5.100	0.185	0.201
D1	3.202	3.402	0.126	0.134
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
E2	2.313	2.513	0.091	0.099
e	1.27 BSC		0.050 BSC	
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



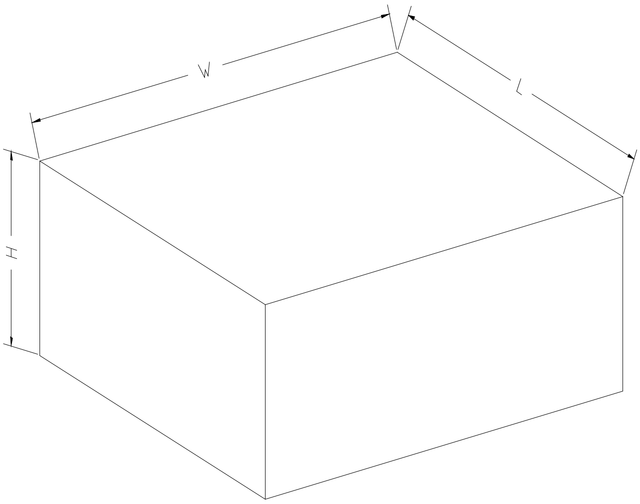
NOTE: The picture is only for reference. Please make the object as the standard.

KEY PARAMETER LIST OF TAPE AND REEL

Package Type	Reel Diameter	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	P1 (mm)	P2 (mm)	W (mm)	Pin1 Quadrant
SOIC-8 (Exposed Pad)	13″	12.4	6.40	5.40	2.10	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