2A , 4.5V-22V Input , Multi-Cell Switching Charger

GENERAL DESCRIPTION

PW4203 is a 4.5-22V input, 2A multi-cell synchronous Buck Li-Ion battery charger, suitable for portable application. Select pin is convenient for multi-cell charging. 800 kHz synchronous buck regulator integrates of 22V rating FETs with ultra low on- resistance to achieve high efficiency and simple circuit design.
The PW4203 is available in an 8-pin SOP package, provides a very compact system solution and good thermal conductance.

FEATURES

- Wide Input Voltage Range: 4.5V to 22V
- High Efficiency Int. Synchronous Buck Regulator with Fixed 800kHz Switching Frequency
- Selectable for Multi-cell Charging
- Trickle Current / Constant Current / Constant Voltage Charge Mode
- Programmable (2A Max) Constant Charge Current
- Programmable Charging Timer
- Input Voltage UVLO and Battery OVP
- Over Temperature Protection
- Output Short Circuit Protection
- Automatic Shutdown Prevents Reverse Energy Flow
- Charge Status Indication
- Normal Synchronous Buck Operation when Battery Removed
- SOP-8 Exposed Pad Package

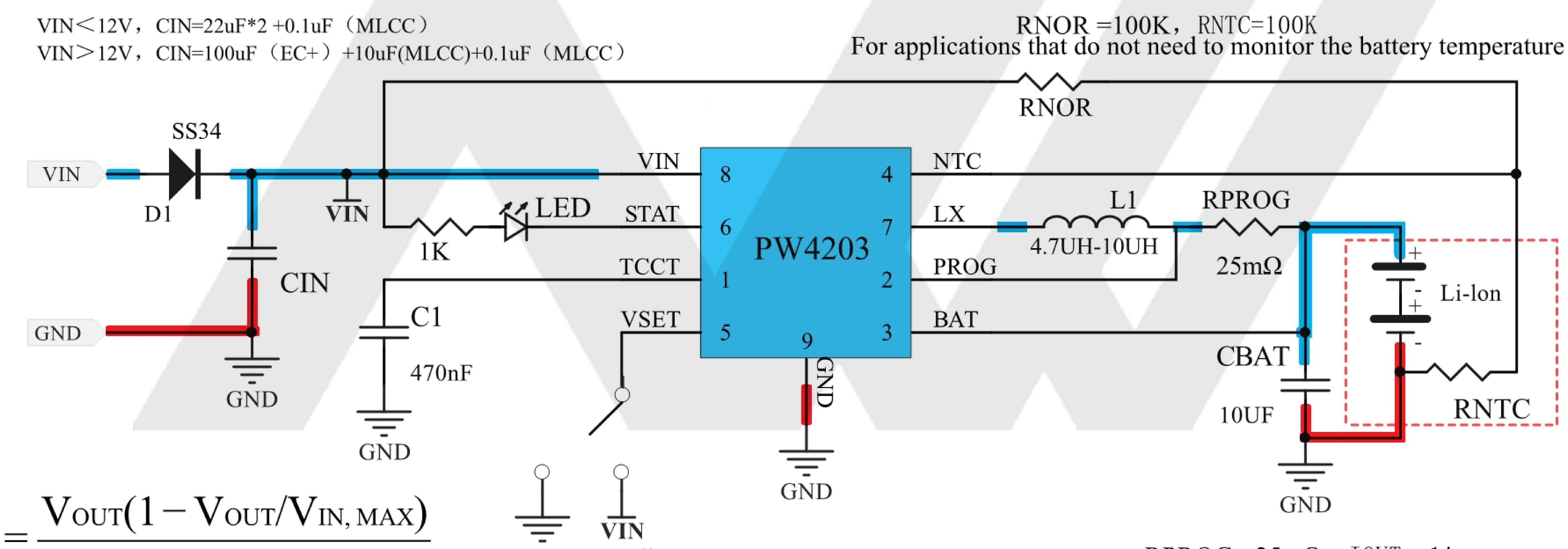
APPLICATIONS

- Cellular Telephones,
- PDA, MP3 Players, MP4 Players
- Digital Cameras
- Bluetooth Applications
- PSP Game Players, NDS Game Players

PCB Design Scheme

Products

TYPICAL APPLICATION CIRCUIT



$$L = \frac{V_{OUT}(1 - V_{OUT}/V_{IN,MAX})}{0.8 \times I_{OUT,MAX} \times 40\%}$$

GND VIN

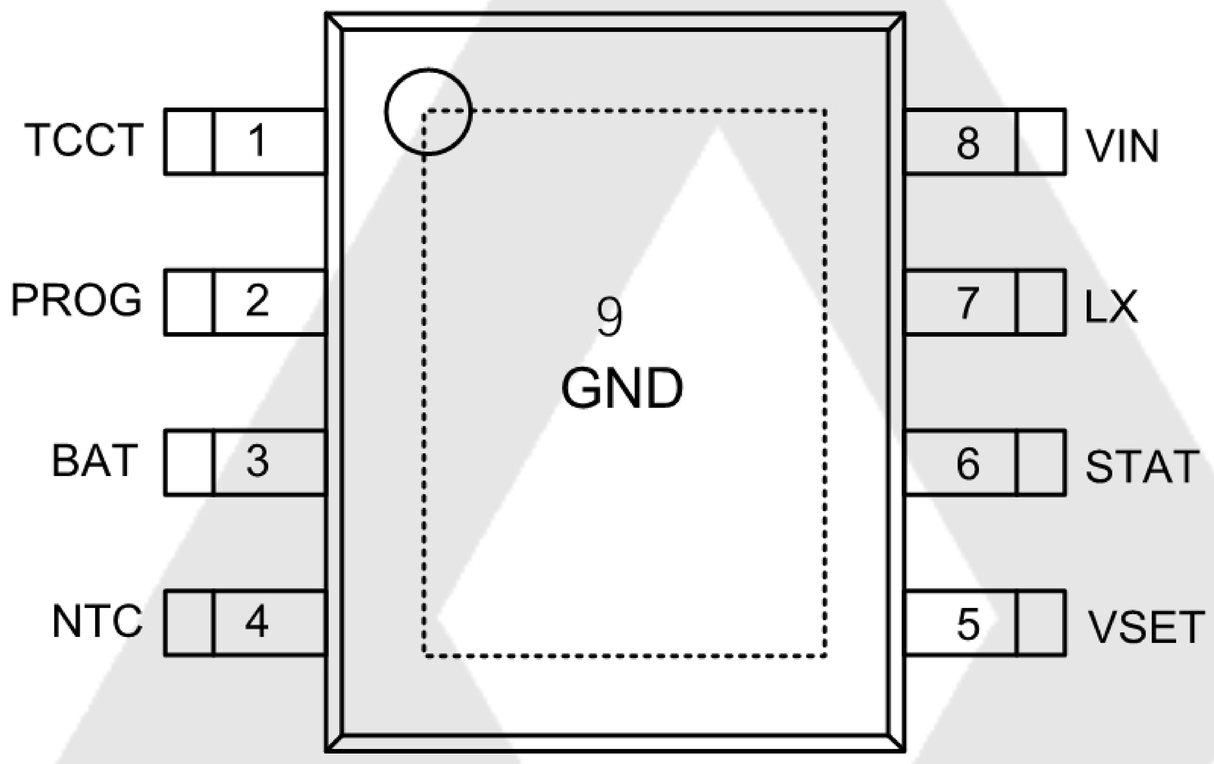
2 Cells：8.4V Charger Voltage (VOUT)

1 Cell： 4.2V Charger Voltage (VOUT)

RPROG= 25mΩ，IOUT= 1A

RPROG= 13mΩ，IOUT= 1.92A

PIN ASSIGNMENT/DESCRIPTION



SOP-8-EP

Pin Number	Pin Name	Function
1	TCCT	Charge time limit pin. Connect this pin with a capacitor to ground. Internal current source charge the capacitor for TC mode and CC mode's charge time limit. TC charge time limit is about 1/9 of CC charge time.
2	PROG	Charge current program pin. Connect a current sense resistor from PROG pin to BAT pin. Average charge current is detected for both TC mode and CC mode.
3	BAT	Battery positive pin
4	NTC	Thermal protection pin. UTP threshold is about 75%VIN and OTP threshold is about 30%VIN. Pull up to VIN can disable charge logic and make the IC operate as normal buck regulator. Pull down to ground can shutdown the IC.
5	VSET	Pull down for single-cell, pull high for 2 cells.
6	STAT	Charge status indication pin. It is open drain output pin and can be used to turn on a LED to indicate the charge in process. When the charge is done, LED is off.
7	LX	Switch node pin. This pin connects the drains of the integrated main and synchronous power MOSFET switches. Connect to external inductor.
8	VIN	Positive power supply input pin. VIN ranges from 4.5V to 22V for normal operation. It has UVLO function and must be 300Mv greater than the battery voltage to enable normal operation.
9	GND	Exposed Pad, Ground pin.

Absolute Maximum Ratings (note1)

Parameter		VALUE	Unit
VSET, NTC, STAT		-0.5-32	V
VIN, BAT, LX		-0.5- 25	V
TCCT		-0.5- 3.6	V
PROG		BAT-0.3~BAT+0.3	V
LX Pin current continuous		2	A
Power Dissipation, PD @ TA = 25°C		3.3	W
Package Thermal Resistance (Note 2)	θJA	30	°C/W
	θJC	20	°C/W
Junction Temperature Range		-40 to 125	°C
Lead Temperature (Soldering, 10 sec.)		260	°C
Storage Temperature Range		-65 to 125	°C

RECOMMANDED OPERATING Conditions (note3)

Parameter	VALUE
VSET, NTC, STAT	less than 32V
VIN, BAT, LX	less than 25V
TCCT	less than 3.6V
PROG	in the range of BAT-0.3~BAT+0.3LX
Pin current continuous	less than 2A
Junction Temperature Range	-20°C to 100°C
Ambient Temperature Range	-40°C to 85°C

Note 1: Stresses beyond the "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only. Functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

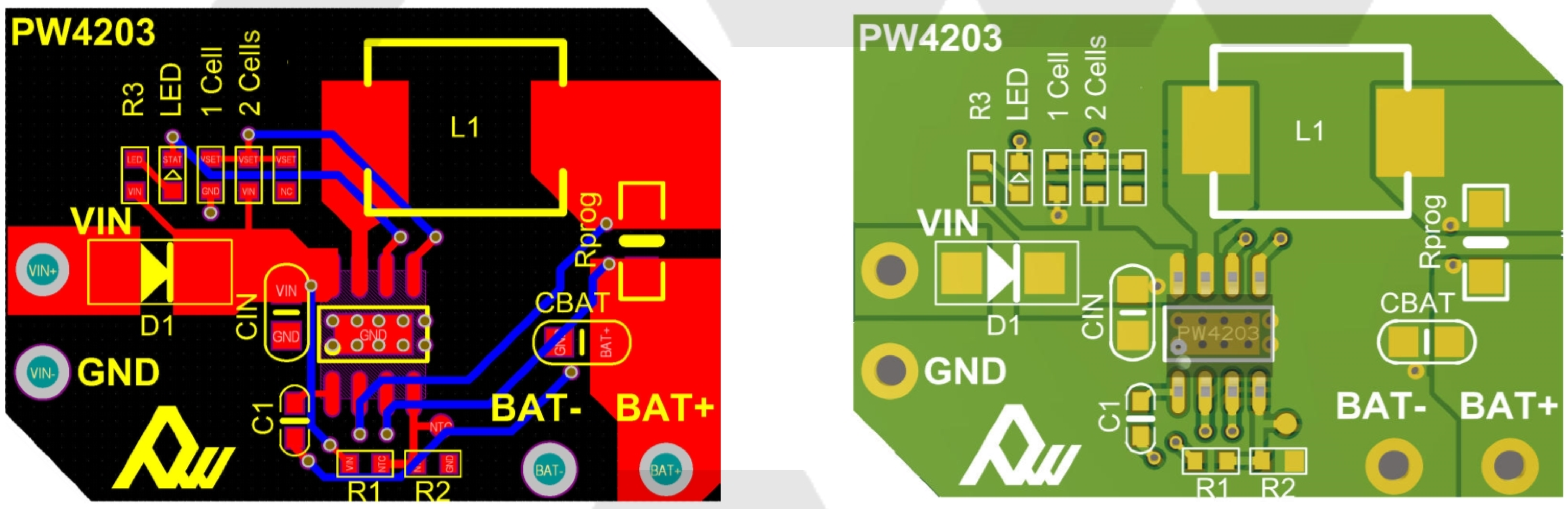
Note 2: θJA is measured in the natural convection at TA = 25°C on a low effective four -layer thermal conductivity test board of JEDEC 51-3 thermal measurement standard.

Note 3: The device is not guaranteed to function outside its operating conditions

Layout Considerations

The layout design of PW4203 regulator is relatively simple. For the best efficiency and minimum noise problems, we should place the following components close to the IC: CIN, L, R1 and R2.

1. It is desirable to maximize the PCB copper area connecting to GND pin to achieve the best thermal and noise performance. If the board space allowed, a ground plane is highly desirable.
2. CIN must be close to Pins VIN and GND. The loop area formed by CIN and GND must be minimized.
3. The PCB copper area associated with LX pin must be minimized to avoid the potential noise problem.
4. The capacitor C1 and the trace connecting to the TCCT pin must NOT be adjacent to the LX net on the PCB layout to avoid the noise problem. It should be better to ground C1 to the output Capacitor's ground



Suggested Layou

ELECTRICAL CHARACTERISTICS

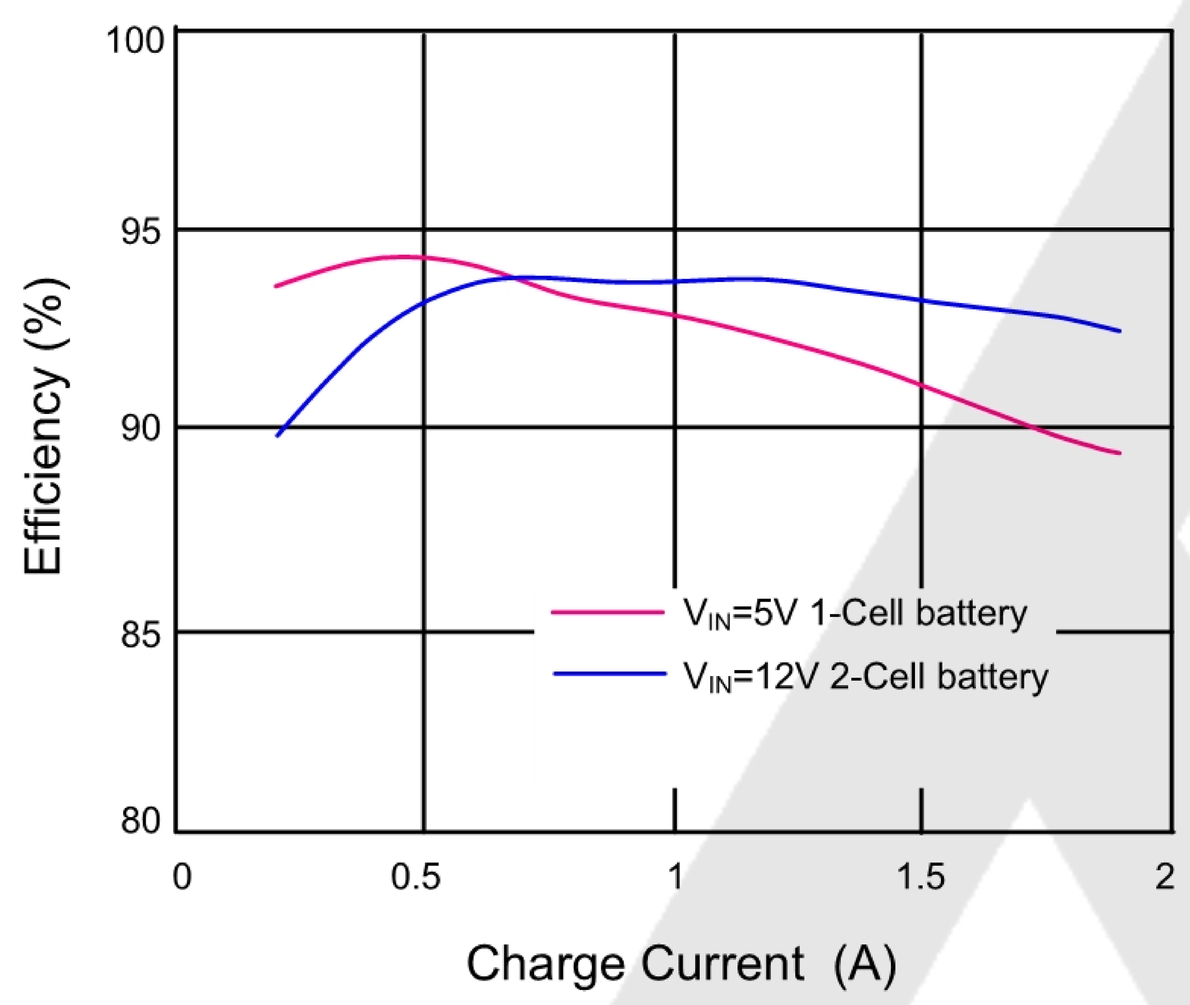
(TA=25°C, VIN=15V, GND=0V, CIN=10uF, L1=2.2uH, RPROG=25mΩ, C1=470nF, unless otherwise specified.)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
VIN	Supply voltage		4.5		22	V
VUVLO	VIN under voltage lockout threshold	VIN rising and measured from VIN to GND			3.9	V
ΔVUVLO	VIN under voltage lockout hysteresis	Measured from VIN to GND		190.		mV
VOVP	Input overvoltage protection	VIN rising and measured from VIN to GND			24	V
ΔVOVP	Input overvoltage protection hysteresis	Measured from VIN to GND		750		mV

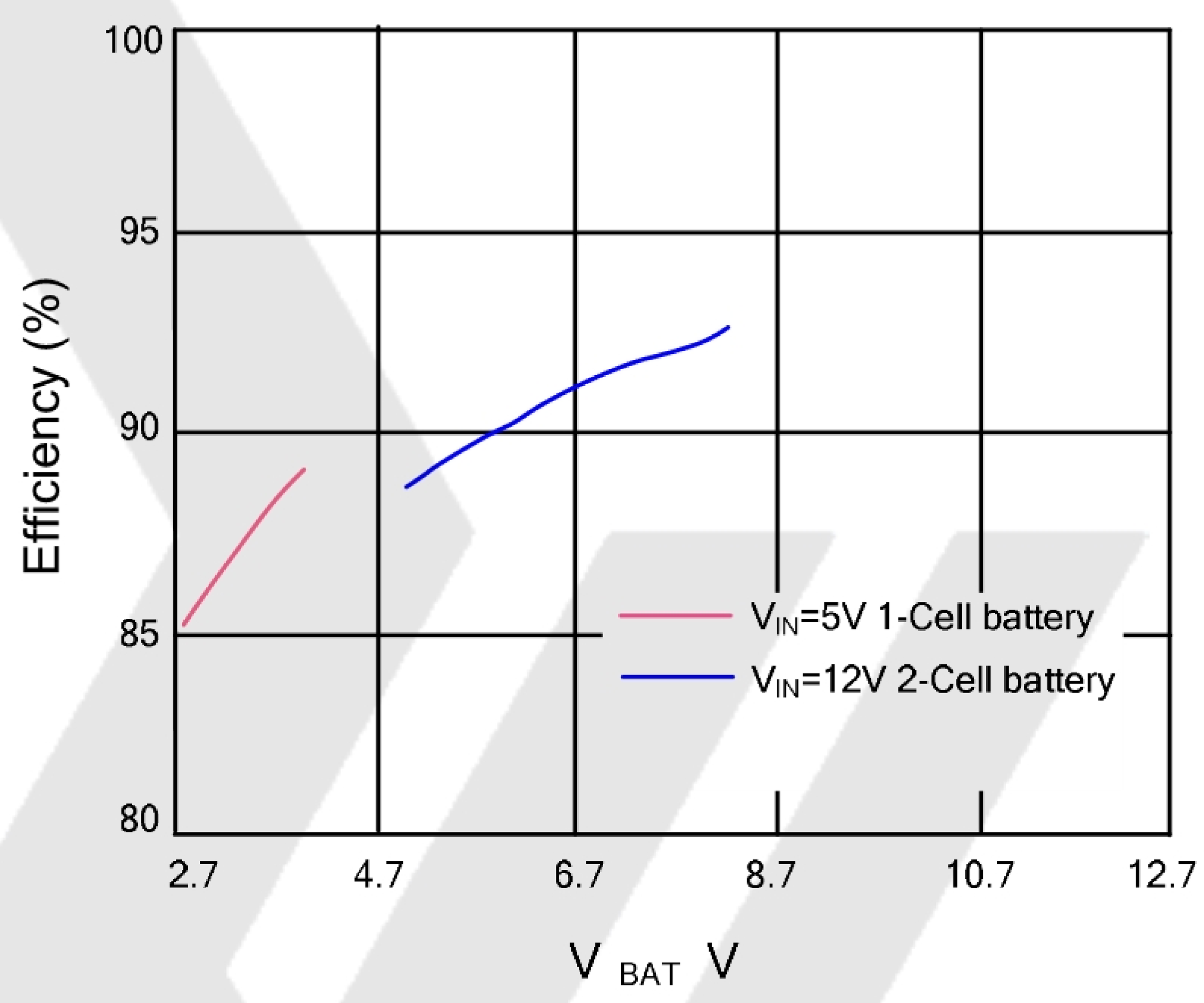
Symbol	Parameter	Conditions	Min	Typ	Max	Unit
IBAT	Battery discharge current	NTC pull down to GND			25	uA
IIN	Input quiescent current	Disable Charge			2.0	mA
fOSC	Oscillator frequency		640	800	960	kHz
D	PFET duty cycle				100	%
RNFET	RDS(ON) of N-FET			150		mΩ
RPFET	RDS(ON) of P-FET			160		mΩ
Vcv	Single-cell CV charge mode	0°C <=TA<=70°C	4.16	4.20	4.24	V
	2-cell CV charge mode		8.32	8.40	8.48	V
ΔVRCH	Single-cell Voltage threshold for Recharge	0°C <=TA<=70°C	50	100	150	mV
	2-cell Voltage threshold for Recharge		100	200	300	mV
VTRK	Single-cell TC charge mode voltage threshold	0°C <=TA<=70°C	2.2	2.5	2.8	V
	2-cell TC charge mode voltage threshold		4.4	5.0	5.6	V
VDET	Detect voltage threshold	VSHOT< VBAT< VRCH	80%		90%	VIN
tDET	Detect delay time	VSHOT< VBAT< VRCH		30		mS
	Internal charge current accuracy for Constant Current Mode	ICC=25mV/Rprog	-10		10	%
	Internal charge current accuracy for Trickle Current Mode	ITC=2.5mV/Rprog	-50		50	%
VOVP	Output voltage OVP threshold		108%	113%	118%	VCV
VSHOT	Output short protection threshold	VBAT falling edge	1.70	2.00	2.30	V
fFBK	Frequency fold back	VBAT<2V		12.5%		fOSC
ILM	Power FET current limit			4.0		A
TTC	Trickle current charge timeout	C1=330nF	0.23	0.5	0.67	hour
TCC	Constant current charge timeout	C1=330nF	3.0	4.5	6.0	hour
TMC	Charge mode change delay time			30		ms
TTERM	Termination delay time			30		ms
TRCHG	Recharge time delay			30		ms
UTP	Under temperature protection		70%	75%	80%	VIN
	Under temperature protection hysteresis	Falling edge		5%		VIN
OTP	Over temperature protection		28%	30%	32%	VIN
	Over temperature protection hysteresis	Rising edge		2%		VIN
ΔVASD	ASD voltage threshold hysteresis	Measured from VIN to VBAT	140	280	420	mV

Typical Performance Characteristics

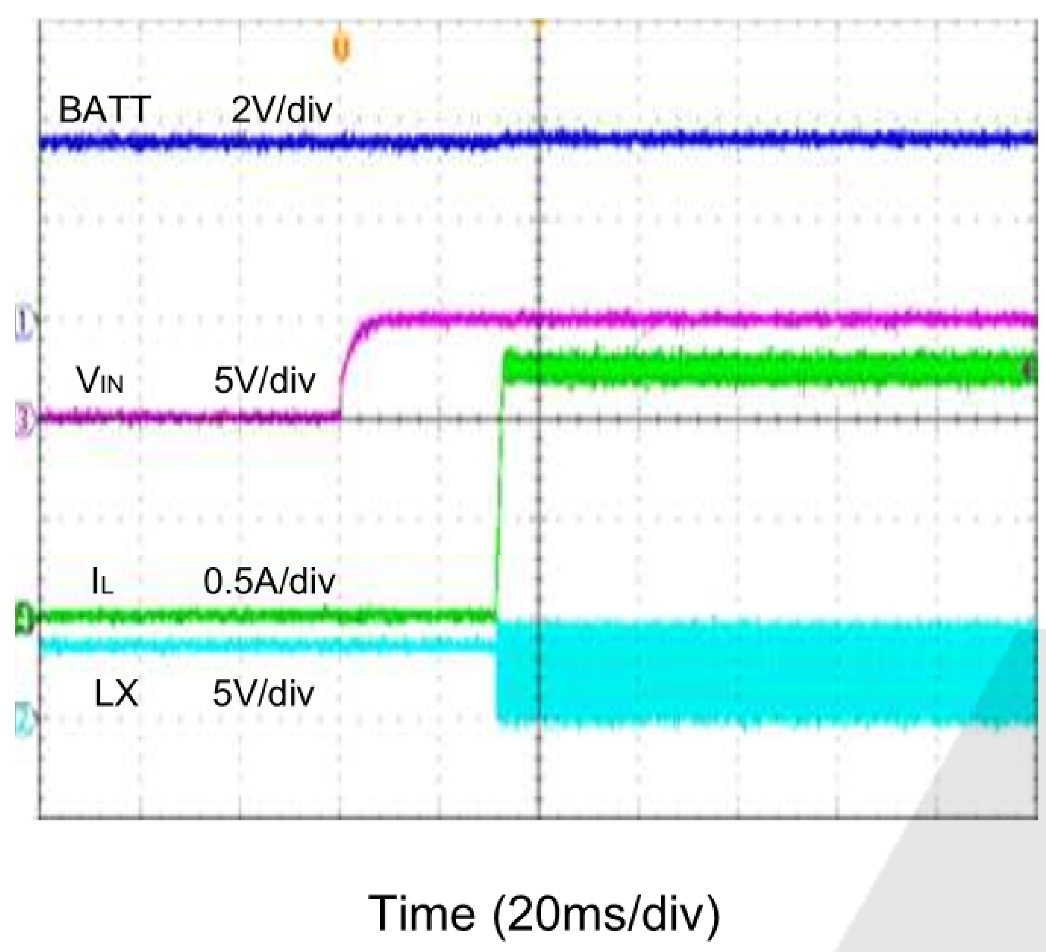
(TA=25°C, VIN=5V, RPROG=20mΩ, 1 cell battery, unless otherwise specified)



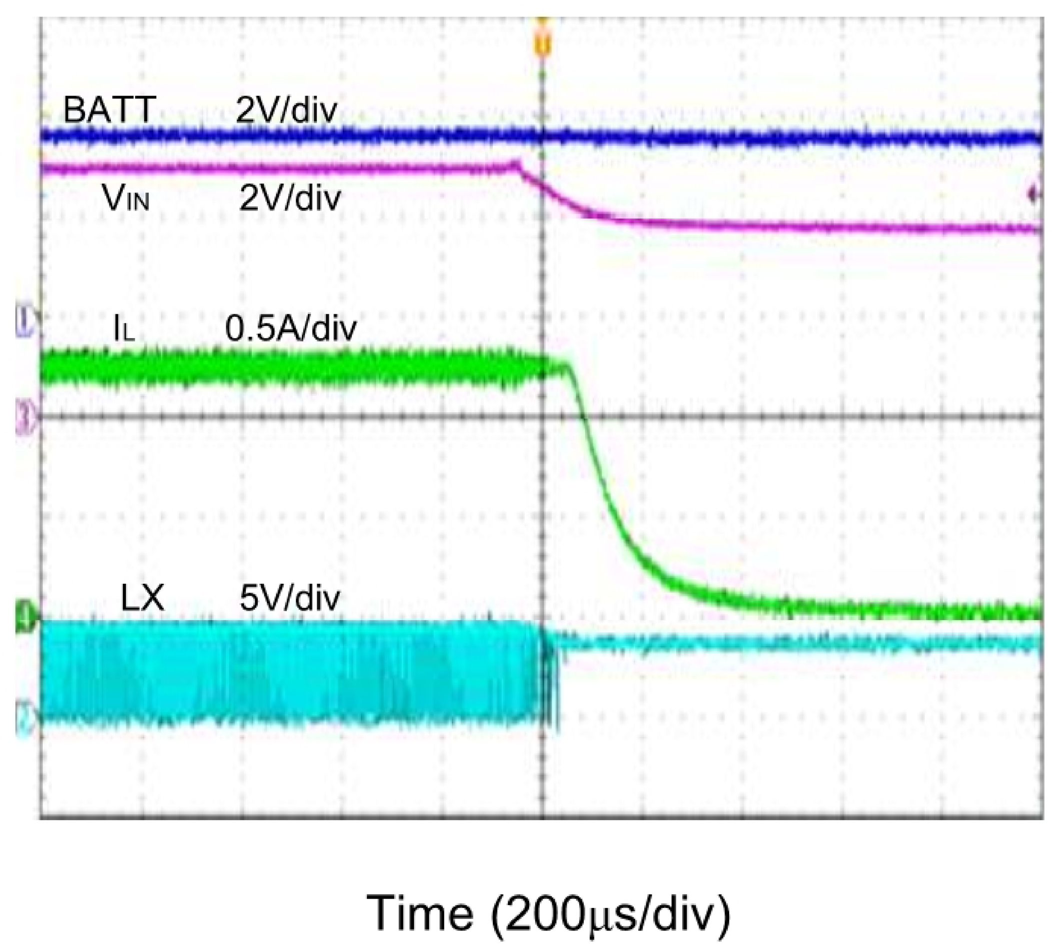
Efficiency vs. Charge Current (CV mode)



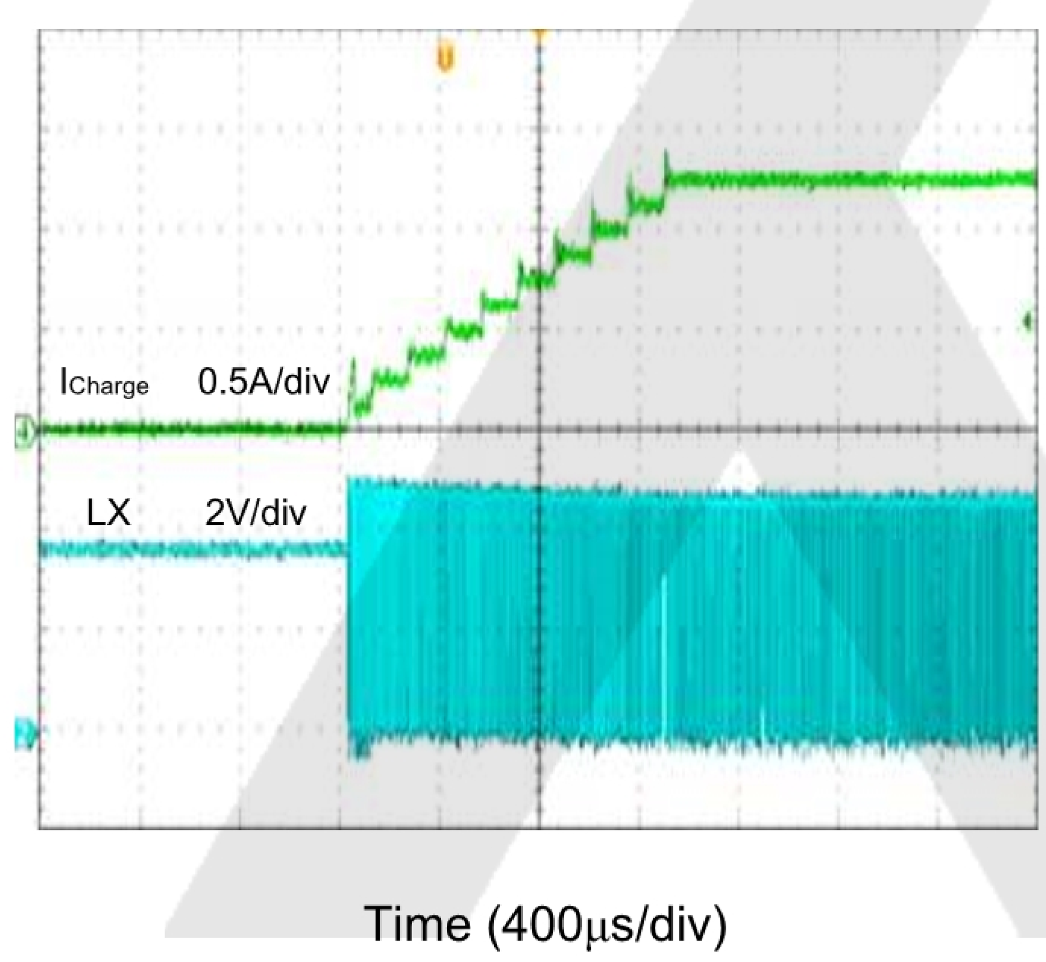
Efficiency vs. Charge Current (CC mode)



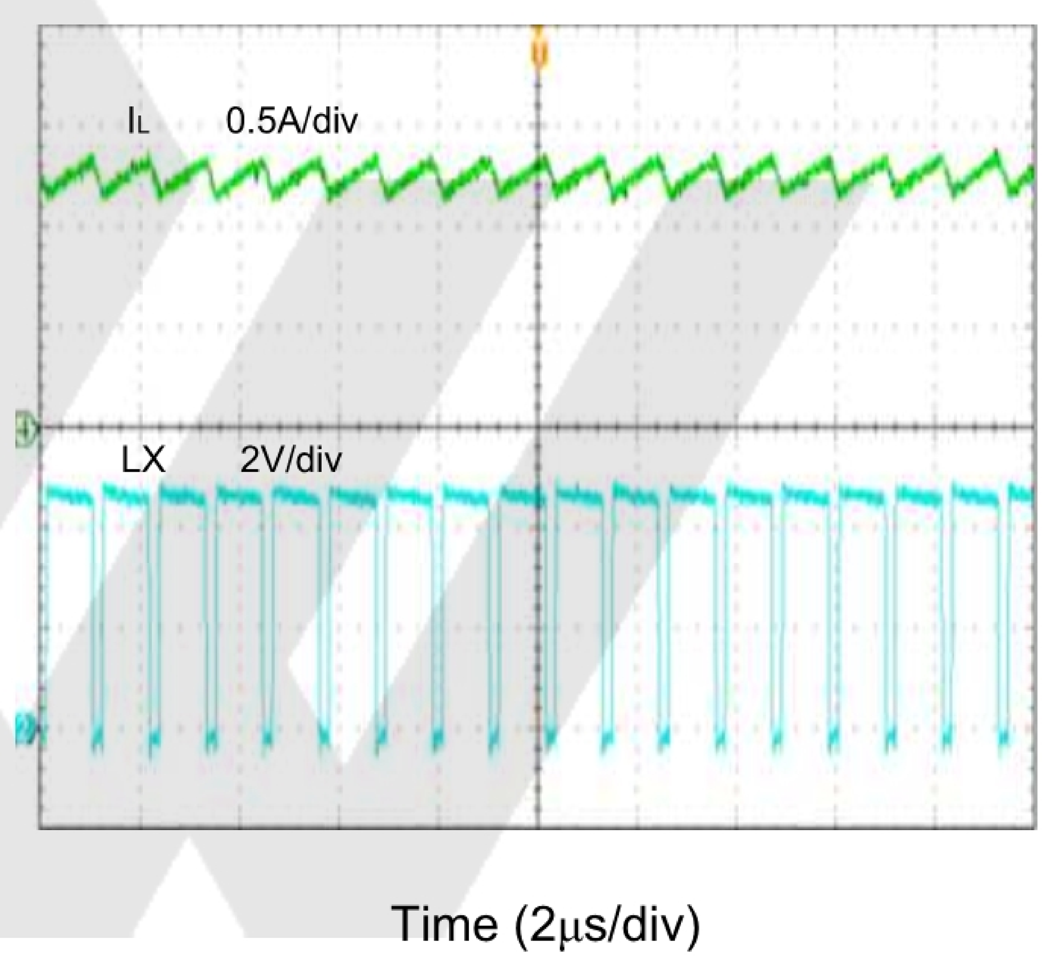
Power On



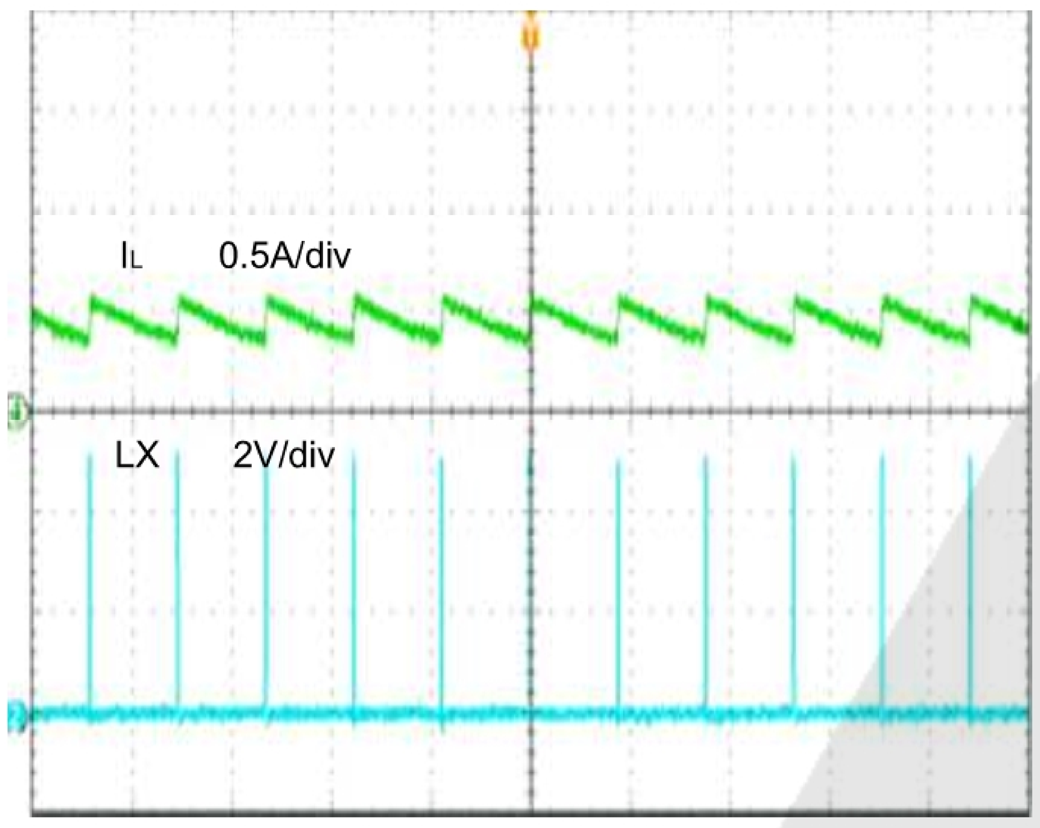
Power Off



Charge Current Soft Start

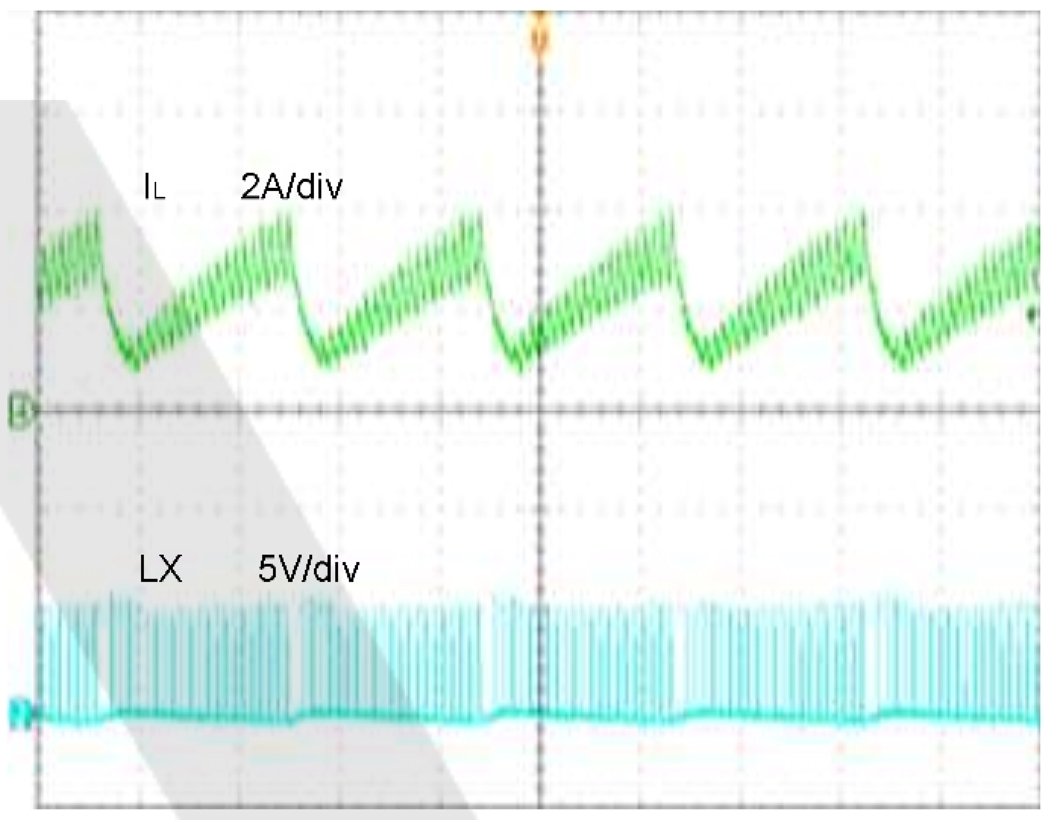


Constant Current Charge State



Time (10µs/div)

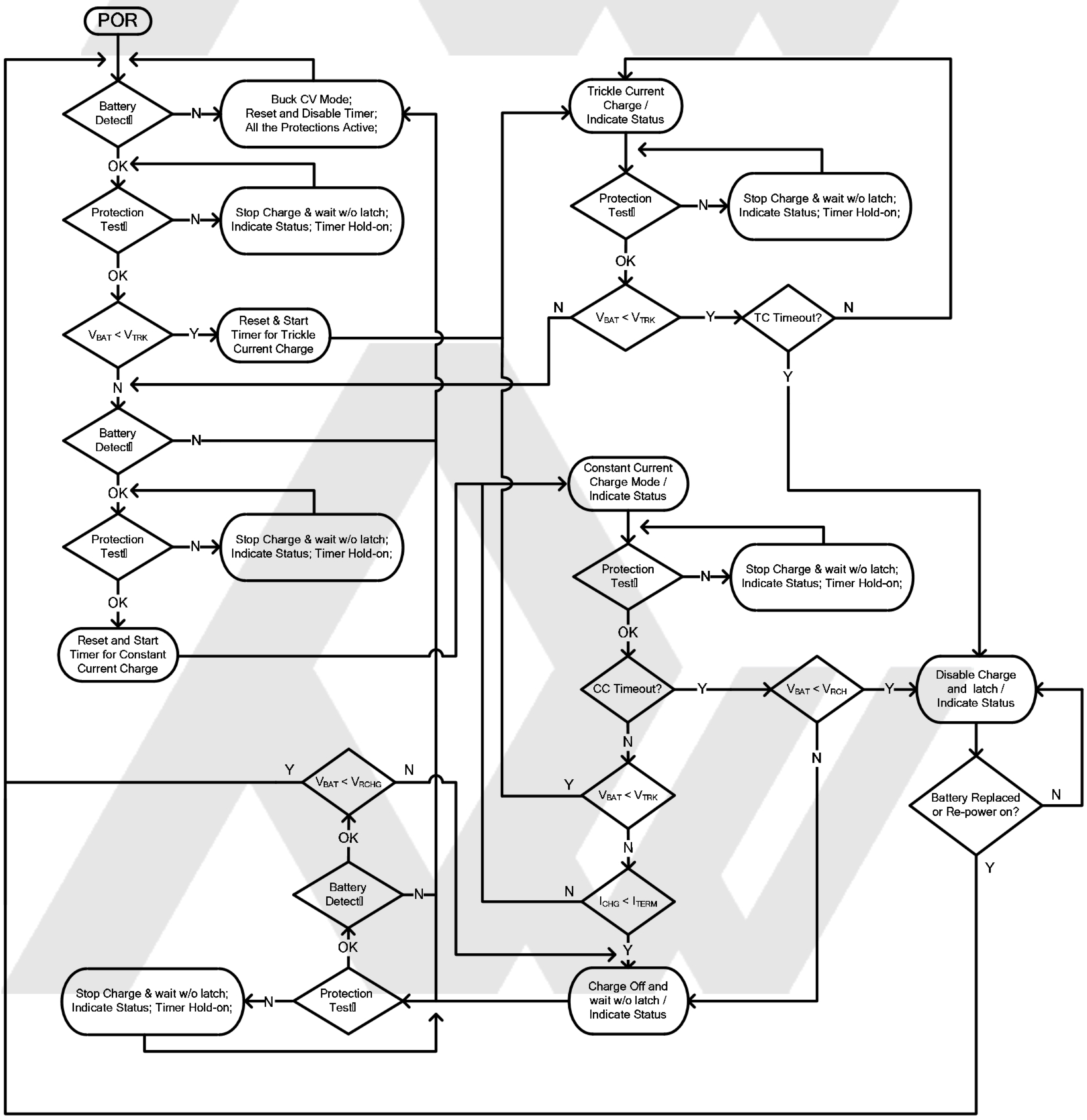
Battery Short



Time (100µs/div)

Buck Mode:Output Short

Basic Li-Ion Battery Charge Operation Flow Chart



Function Description

PW4203 is a 4.5V-22V input, 2A multi-cell synchronous buck Li-Ion battery charger, suitable for portable application. Select pin is convenient for multi-cell charging. Integrated 800 kHz synchronous buck regulator consists of 22V rating FETs with extremely low on-resistance to achieve high charge efficiency and simple circuit design.

Charging Status Indication Description

Charge-In-Process	Pulls and keeps STAT pin to Low
Charge Done	Pulls and keeps STAT pin to High
Fault Mode	Outputs high and low voltage alternatively with 0.5Hz frequency

Connects a LED from VIN to STAT pin, LED ON indicates Charge-in-Process, LED OFF indicates Charge Done, LED Flash indicates Fault Mode.

Buck Regulator Operation Description

If the Li-Ion battery is removed suddenly, the voltage on NTC pin increases higher than 90% Vin. Then, it operates as a normal peak current mode controlled synchronous buck converter and the output voltage on BAT pin is regulated at VCV. In this operation mode, the constant output current loop is still active, however the charge timeout and the trickle current charge are disabled.

Thermal Protection

Thermal shutdown is active for both battery and IC. IC resumes normal work when the temperature backs in normal range again.

Short Circuit Protection

When VBAT voltage is lower than the short circuit protection threshold, short circuit protection is active. In charger operation mode, the switching frequency is folded back to 12.5% of the default value and VC is folded back to 20% of the maximum value. The trickle charge timer is still active and would timeout the IC finally. In Buck operation mode, the switching frequency is folded back to 12.5% of the default value, and the VC initiates softstart periodically.

Over Current Protection

The internal current loop with different constant current capability is always active no matter in Buck mode or Battery Charging mode for the over current protection.

Over Voltage Protection

When VBAT voltage is higher than the over voltage protection threshold no matter with or without battery connecting, IC shuts down and recovers to normal work when VBAT backs to normal level. Input voltage has UVLO and OVP, which would make IC shutdown and recover to normal work when the VIN backs to normal range.

Timeout Protection

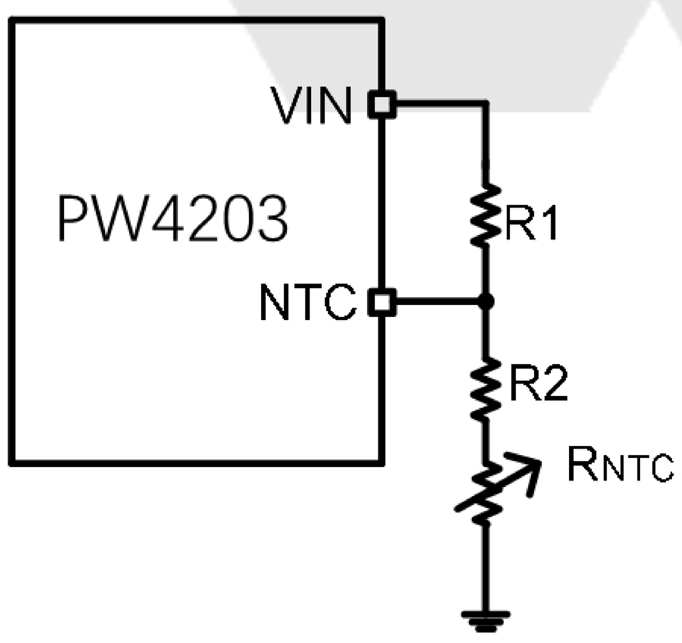
Programmable timeout protection is for both Trickle Current Charge Mode and Constant Current Charge Mode. Once timeout is active, IC stops the charge operation and latches off. Only power or battery re-plug in can get the latch logic reset and the IC restarted.

Application Information

Because of the high integration of PW4203, the application circuit based on this regulator IC is rather simple. Only input capacitor CIN, output capacitor COUT, inductor L, NTC resistors R1,R2 ,charge current sense resistor R_{PROG} and timer capacitor C1 need to be selected for the targeted applications specifications.

NTC resistor:

PW4203 monitors battery temperature by measuring the input voltage and NTC voltage. The controller triggers the UTP or OTP when the rate K (K=VNTC/VIN) reaches the threshold of UTP (KUT) or OTP (KOT). The temperature sensing network is showed as below.
Choose R1 and R2 to program the proper UTP and OTP points.



The calculation steps are:

1. Define KUT, KUT =70~80%
2. Define KOT, KOT =28~32%
3. Assume the resistance of the battery NTC thermistor is RUT at UTP threshold and ROT at OTP threshold.
4. Calculate R2

$$R2 = \frac{K_{OT}(1-K_{UT})R_{UT} - K_{UT}(1-K_{OT})R_{OT}}{K_{UT} - K_{OT}}$$

5. Calculate R1

$$R1 = (1/K_{OT} - 1)(R2 + R_{OT})$$

If choose the typical values KUT =75% and KOT=30%, then:

$$R2 = 0.17R_{UT} - 1.17R_{OT} \qquad R1 = 2.3(R2 + R_{OT})$$

Charge current sense resistor R_{PROG}

The charge current sense resistor R_{PROG} is calculated as below:

$R_{PROG}=25/I_{CHG}$, Unit: mohm

While the ICHG is the battery constant charge current.

Timer capacitor C1

The charger also provides a programmable charge timer. The charge time is programmed by the capacitor connected between the TCCT pin and GND. The capacitance is given by the formula:

$$C_1 = 2*10^{-11} T_{CC} \qquad \text{Unit: F}$$

TCC is the target constant charge time

Input capacitor CIN:

The ripple current through input capacitor is greater,than:

$$I_{CIN\_MIN} = I_{CHG}\sqrt{D(1-D)}$$

To minimize the potential noise problem, place a typical X7R or better grade ceramic capacitor really close to the VIN and GND pins. Care should be taken to minimize the loop area formed by CIN, and VIN/GND pins.

Output capacitor COUT:

The output capacitor is selected to handle the output ripple noise requirements. Both steady state ripple and transient requirements must be taken into consideration when selecting this capacitor. For the best performance, it is recommended to use X7R or better grade ceramic capacitor with 10Uf capacitance.

Output inductor L:

There are several considerations in choosing this inductor.

1、 Choose the inductance to provide the desired ripple current. It is suggested to choose the ripple current to be about 40% of the average input current. The inductance is calculated as:

$$L = \frac{V_{OUT}(1 - V_{OUT}/V_{IN,MAX})}{F_{SW} \times I_{OUT,MAX} \times 40\%}$$

Where F_{SW} is the switching frequency and $I_{OUT,MAX}$ is the maximum load current.

The PW4203 regulator IC is quite tolerant of different ripple current amplitude. Consequently, the final choice of inductance can be slightly off the calculation value without significantly impacting the performance.

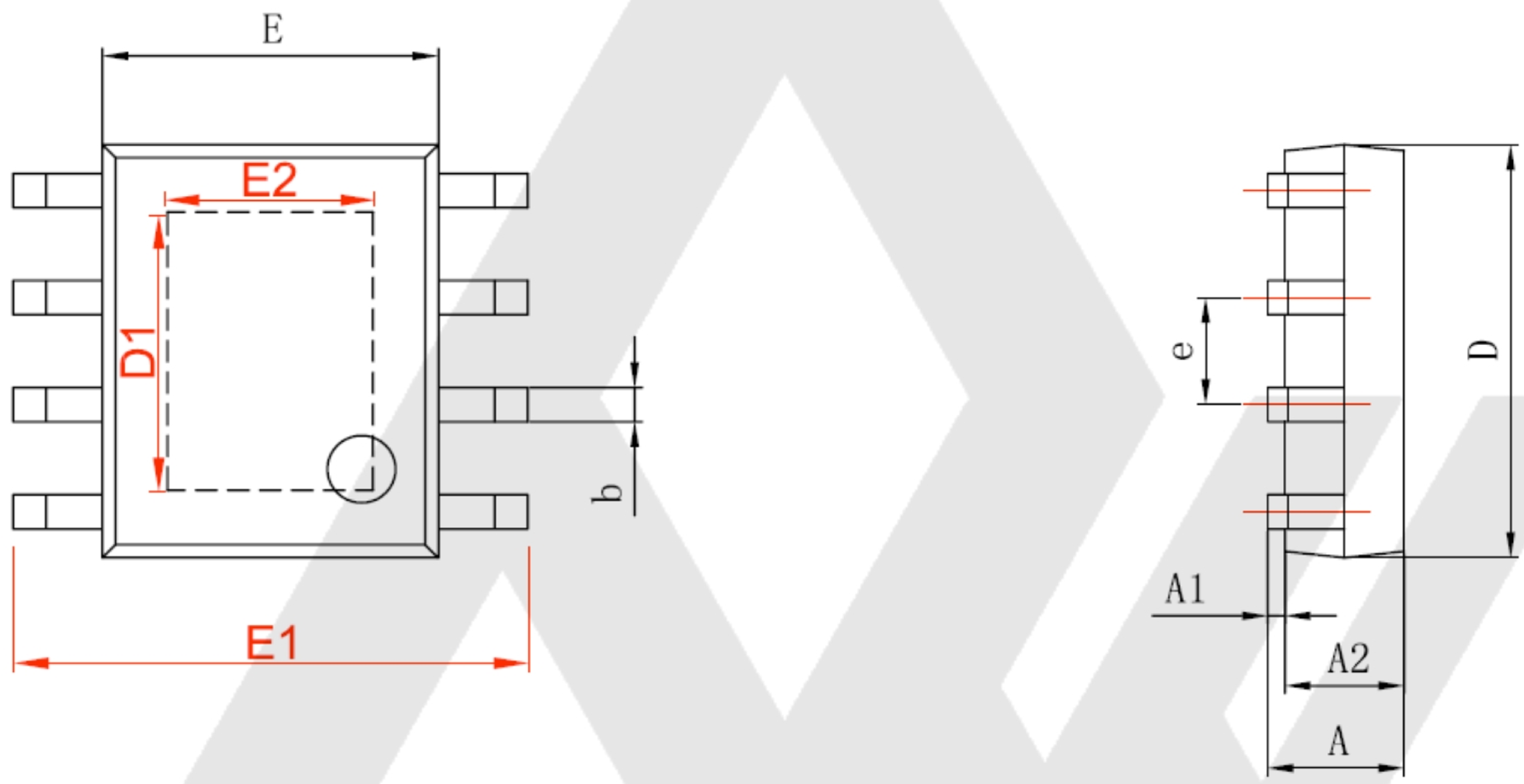
2、The saturation current rating of the inductor must be selected to be greater than the peak inductor current under full load conditions.

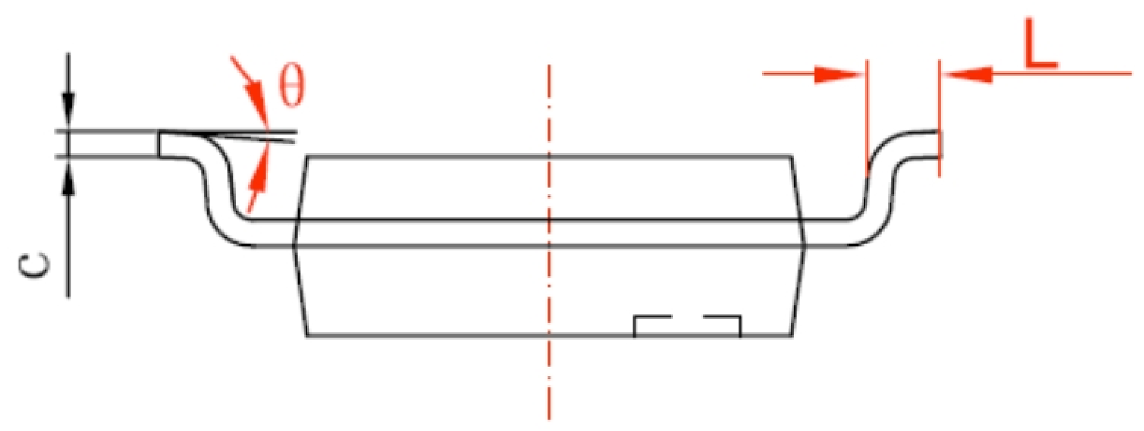
$$I_{SAT,MIN} > I_{OUT,MAX} + \frac{V_{OUT}(1 - V_{OUT}/V_{IN,MAX})}{2 \times F_{SW} \times L}$$

3、 The DCR of the inductor and the core loss at the switching frequency must be low enough to achieve the desired efficiency requirement. It is desirable to choose an inductor with DCR<10mohm to achieve a good overall efficiency.

PACKAGE DESCRIPTION

SOP8-EP





字符	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.350	1.750	0.053	0.069
A1	0.050	0.150	0.002	0.006
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	0.200
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	1.270(BSC)		0.050(BSC)	
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°

NOTE:

Preliminary and all contents are subject to change without prior notice.

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