16V 3A Multi-Cell Battery Switching Charger

General Description

The FP8207 is a 4.9V~16V input voltage, 3A multi cell synchronous step-down switching charger with few external components, FP8207 is well suited for a wide range of portable applications. Charging current can be programmed by an external current sensing resistor. With 500KHz switching frequency. The FP8207 employs a 2.4V float voltage feedback reference, so any desired battery float voltage up to 12.6V can be programmed with a resistor divider. Other features include UVLO, automatic recharge, charge status indicators and battery temperature monitor.

Features

- Wide Input Voltage Range: 4.9V to 16V
- Up to 3A Programmable Charge Current
- Resistor Programmable Battery Float Voltage Range: 4.1V to 12.6V
- Preset Charge Voltage with $\pm$1% Accuracy
- Automatic Recharge
- Fix 500KHz Switching Frequency
- Support 94% Duty Cycle
- Thermal Regulation
- Charge Status Indicators for No Battery and Charge Failure Display
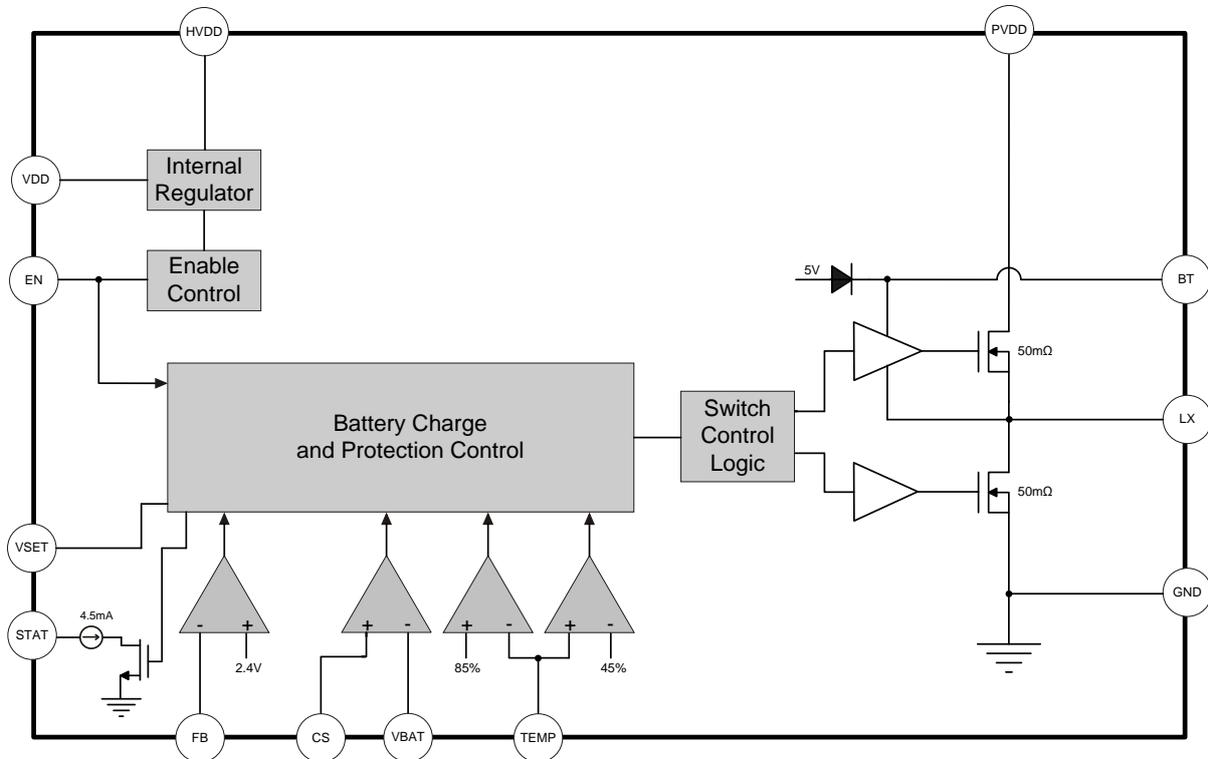- Available TSSOP-14L With Exposed PAD

Applications

- Portable Information Appliances
- Charging Docks & Cradles
- Solar Powered Applications
- Handheld Computers

Typical Application Circuit
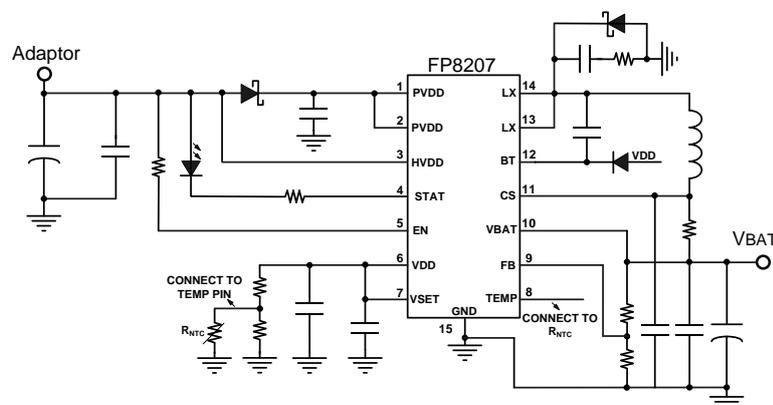
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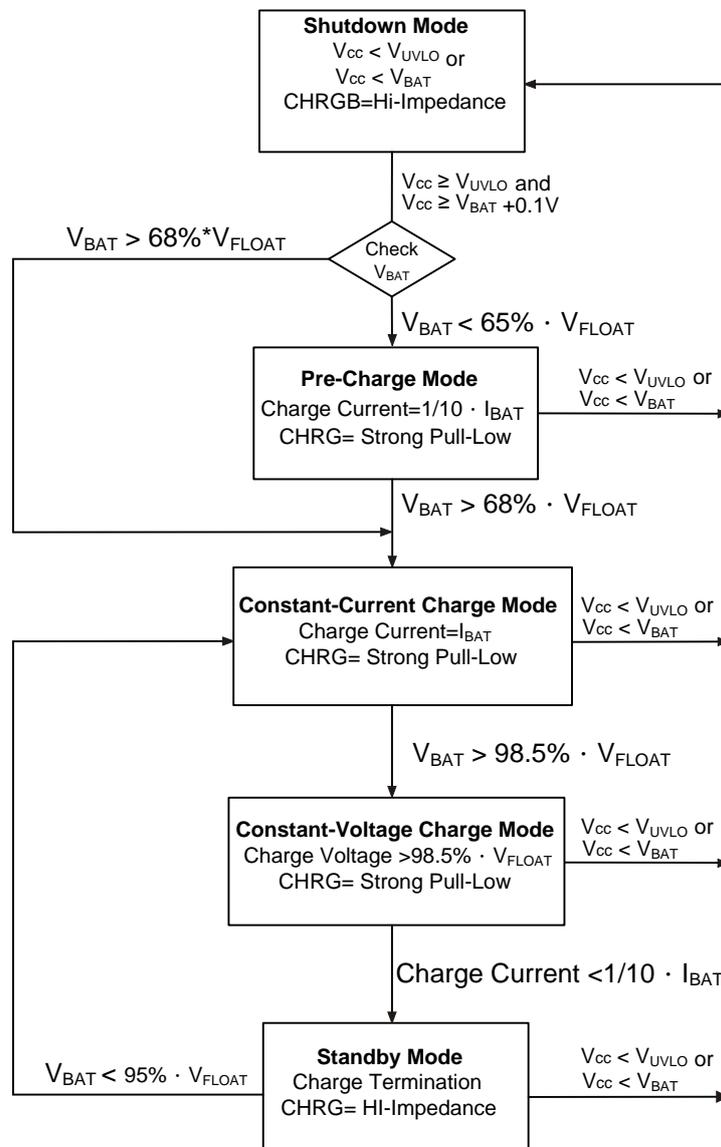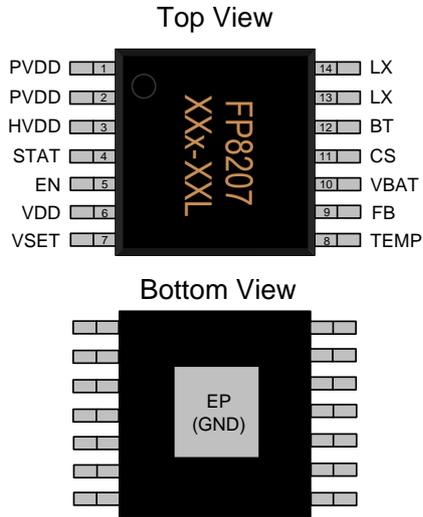
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Function Block Diagram

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State Diagram

Shutdown Mode
$V_{CC} < V_{UVLO}$ or
$V_{CC} < V_{BAT}$
CHRGB=Hi-Impedance

$V_{CC} \geq V_{UVLO}$ and
$V_{CC} \geq V_{BAT} +0.1V$

$V_{BAT} > 68\% * V_{FLOAT}$

Check V_{BAT}

$V_{BAT} < 65\% \cdot V_{FLOAT}$

Pre-Charge Mode
Charge Current=$1/10 \cdot I_{BAT}$
CHRG= Strong Pull-Low

$V_{CC} < V_{UVLO}$ or
$V_{CC} < V_{BAT}$

$V_{BAT} > 68\% \cdot V_{FLOAT}$

Constant-Current Charge Mode
Charge Current=I_{BAT}
CHRG= Strong Pull-Low

$V_{CC} < V_{UVLO}$ or
$V_{CC} < V_{BAT}$

$V_{BAT} > 98.5\% \cdot V_{FLOAT}$

Constant-Voltage Charge Mode
Charge Voltage $>98.5\% \cdot V_{FLOAT}$
CHRG= Strong Pull-Low

$V_{CC} < V_{UVLO}$ or
$V_{CC} < V_{BAT}$

Charge Current $<1/10 \cdot I_{BAT}$

$V_{BAT} < 95\% \cdot V_{FLOAT}$

Standby Mode
Charge Termination
CHRG= HI-Impedance

$V_{CC} < V_{UVLO}$ or
$V_{CC} < V_{BAT}$

Battery Charging Status Indicators

Charge Status	STAT (Red Light)
In Charging	ON
Charge Termination	OFF

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Pin Descriptions

TSSOP-14L(EP)

Top View

Pin		
PVDD	1	14 LX
PVDD	2	13 LX
HVDD	3	12 BT
STAT	4	11 CS
EN	5	10 VBAT
VDD	6	9 FB
VSET	7	8 TEMP

FP8207
XXx-XXL

Bottom View

EP
(GND)

Name	No.	I / O	Description
PVDD	1	I	Adaptor Input Voltage
PVDD	2	I	Adaptor Input Voltage
HVDD	3	P	Adaptor Input Voltage for IC Control
STAT	4	O	Charge State Indicator, 4.5mA LED current
EN	5	I	Chip Enable Control
VDD	6	O	5V LDO output(V_{IN} >7V), drive up to 1mA
VSET	7	I	Charge current regulation
TEMP	8	I	Battery Temperature Detector
FB	9	I	Battery Float Voltage Feedback Reference
VBAT	10	P	Battery Voltage
CS	11	I	Charge current-sense input
BT	12	O	Bootstrap
LX	13	O	Switch node and inductor connection pin
LX	14	O	Switch node and inductor connection pin
EP	15	P	IC Ground . Exposed PAD-Must connect to Ground

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Marking Information

TSSOP-14L(EP)
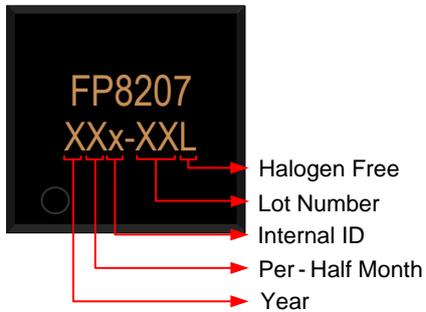
Halogen Free: Halogen free product indicator

Lot Number: Wafer lot number's last two digits

<div align="center">

For Example → Lot : 123456 → XXx-56L

</div>

Internal ID: Internal Identification Code

Per-Half Month: Production period indicator in half month time unit

<div align="center">

For Example : A → First Half Month of January

B → Second Half Month of January

C → First Half Month of February

D → Second Half Month of February

</div>

Year: Production year's last digit

Ordering Information

Part Number	Operating Temperature	Package	MOQ	Description
FP8207mR-G1	-25°C ~ +85°C	TSSOP-14L(EP)	2500EA	Tape & Reel

Absolute Maximum Ratings

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Supply Voltage	V_{IN}		-0.3		18	V
LX、STAT PIN Voltage			-0.3		18	V
Bootstrap Voltage	V_{BS}		V_{LX}		$V_{LX}+6$	V
BAT Voltage	V_{BAT}		-0.3		14	V
CS Voltage	V_{CS}		$V_{BAT}-0.5$		$V_{BAT}+0.5$	
All Other Pins			-0.3		6	V
BAT pin Current	I_{BAT}				4.5	A
Junction Temperature	T_J				+150	°C
Storage Temperature	T_S		-65		+150	°C
Thermal Resistance (Junction to Ambient)	$θ_{JA}$	TSSOP-14L(EP)			75	°C / W
Thermal Resistance (Junction to Case)	$θ_{JC}$	TSSOP-14L(EP)			13	°C / W
Operating Temperature			-25		+85	°C
Lead Temperature (soldering, 10 sec)					+260	°C

Suggested IR Re-flow Soldering Curve
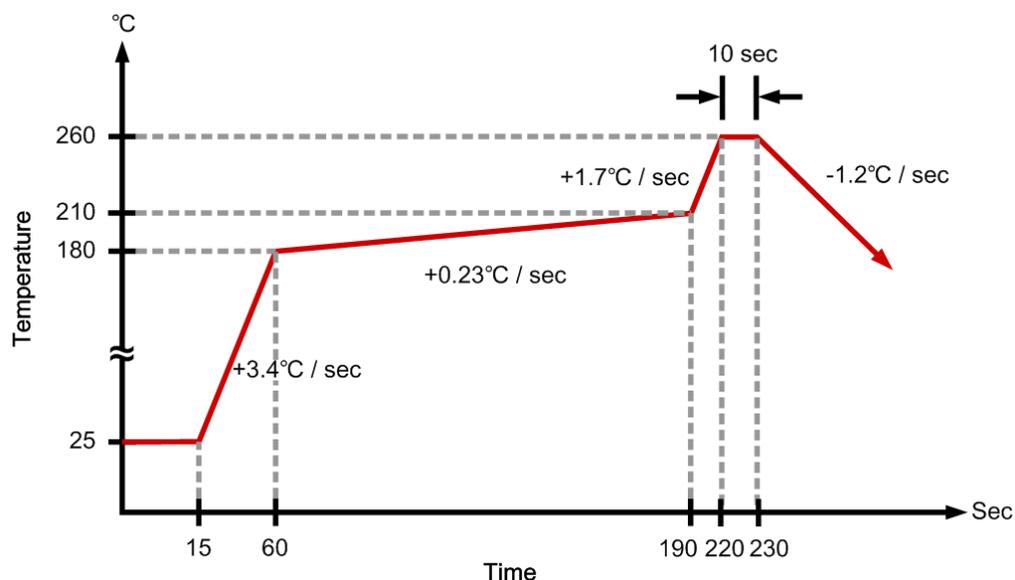
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Recommended Operating Conditions

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Supply Voltage	VIN		4.9		16	V
Operating Temperature		Ambient Temperature	-25		85	°C

DC Electrical Characteristics (V_{IN}=12V, V_{BAT}=3.3V, T_A= 25°C, unless otherwise noted)

Parameter	Symbol	Test Conditions	Min.	Typ.	Max.	Unit
V_{IN} UVLO Threshold	$V_{IN,UV}$	V_{IN} Rising		4		V
V_{IN} UVLO Threshold Hysteresis	$V_{UV,HYS}$			300		mV
V_{IN}-V_{BAT} Lockout Threshold	V_{ASD}	V_{IN} Rising, V_{BAT}=4V		400		mV
		V_{IN} Falling, V_{BAT}=4V (enter sleep)		385		mV
		V_{IN} Rising, V_{BAT}=8V		620		mV
		V_{IN} Falling, V_{BAT}=8V (enter sleep)		480		mV
		V_{IN} Rising, V_{BAT}=12V		940		mV
		V_{IN} Falling, V_{BAT}=12V (enter sleep)		560		mV
V_{BAT} OVP	V_{OVP}	V_{BAT} Rising Edge		105%		V_{FB}
V_{BAT} Short Protect	$V_{SHORT-R}$	V_{BAT} Rising Edge		44%		V_{FB}
	$V_{SHORT-F}$	V_{BAT} Falling Edge		38%		V_{FB}
Standby Current	I_{SB}	Charge Termination		800		µA
Shutdown Supply Current	I_{SHDN}	V_{IN}< V_{BAT} , V_{IN}< $V_{IN,UV}$			700	µA
		V_{EN} = 0V			10	µA
V_{BAT} pin Current	I_{BAT}	Standby-Mode, V_{BAT}=4.2V		25	40	µA
		Shutdown-Mode,		13	20	µA
		Sleep-Mode, NO V_{IN} V_{BAT}=4V		13	20	µA
Input Voltage Regulation reference	$V_{EN/REG}$		2.34	2.4	2.46	V
BAT Float Voltage reference	V_{FB}		2.376	2.4	2.424	V
Charge Sense Voltage (CC)		V_{CS} - V_{BAT}	47.5	50	52.5	mV
Trickle Charge Current	I_{TRIKL}			C/10		
Trickle Charge Threshold Voltage	V_{TRIKL}			68%		V_{FLOAT}
Trickle Charge Hysteresis Voltage	V_{TRKHYS}			200		mV
Termination Current Threshold	I_{TERM}			C/10		
Battery Recharge Threshold Voltage	V_{RECHRG}			95%		V_{FLOAT}
High side Power MOS	R_{HS}			50		mΩ
Low side Power MOS	R_{LS}			50		mΩ
LDO output	V_{DD}	V_{IN} >7V, $I_{DD(ext)}$=0 ※$I_{DD(ext)}$ up to 1mA	4.75	5	5.25	V
Power MOS Current Limit	I_{CL}			4.2		A

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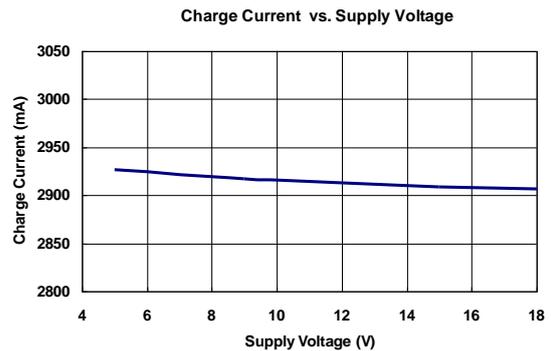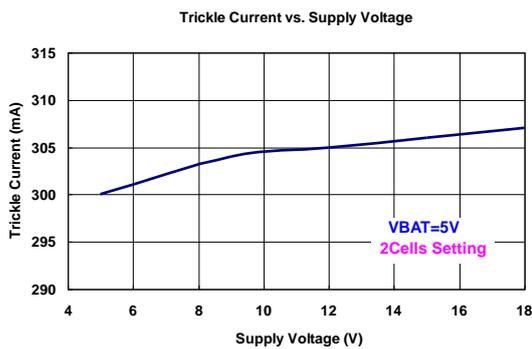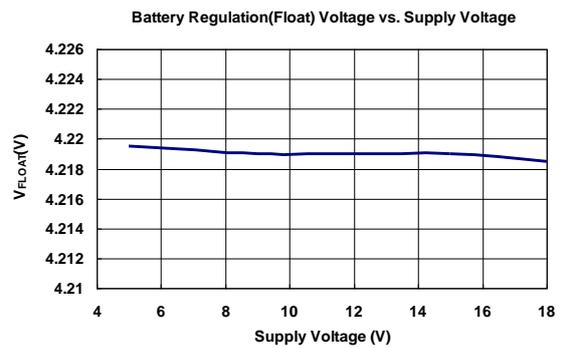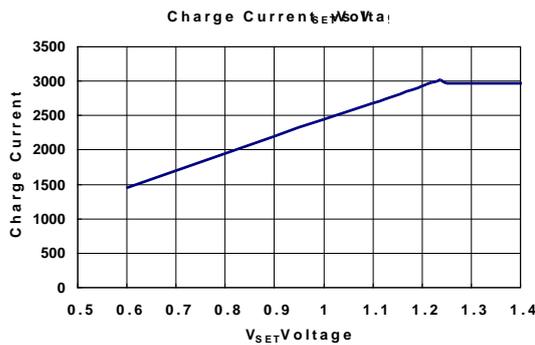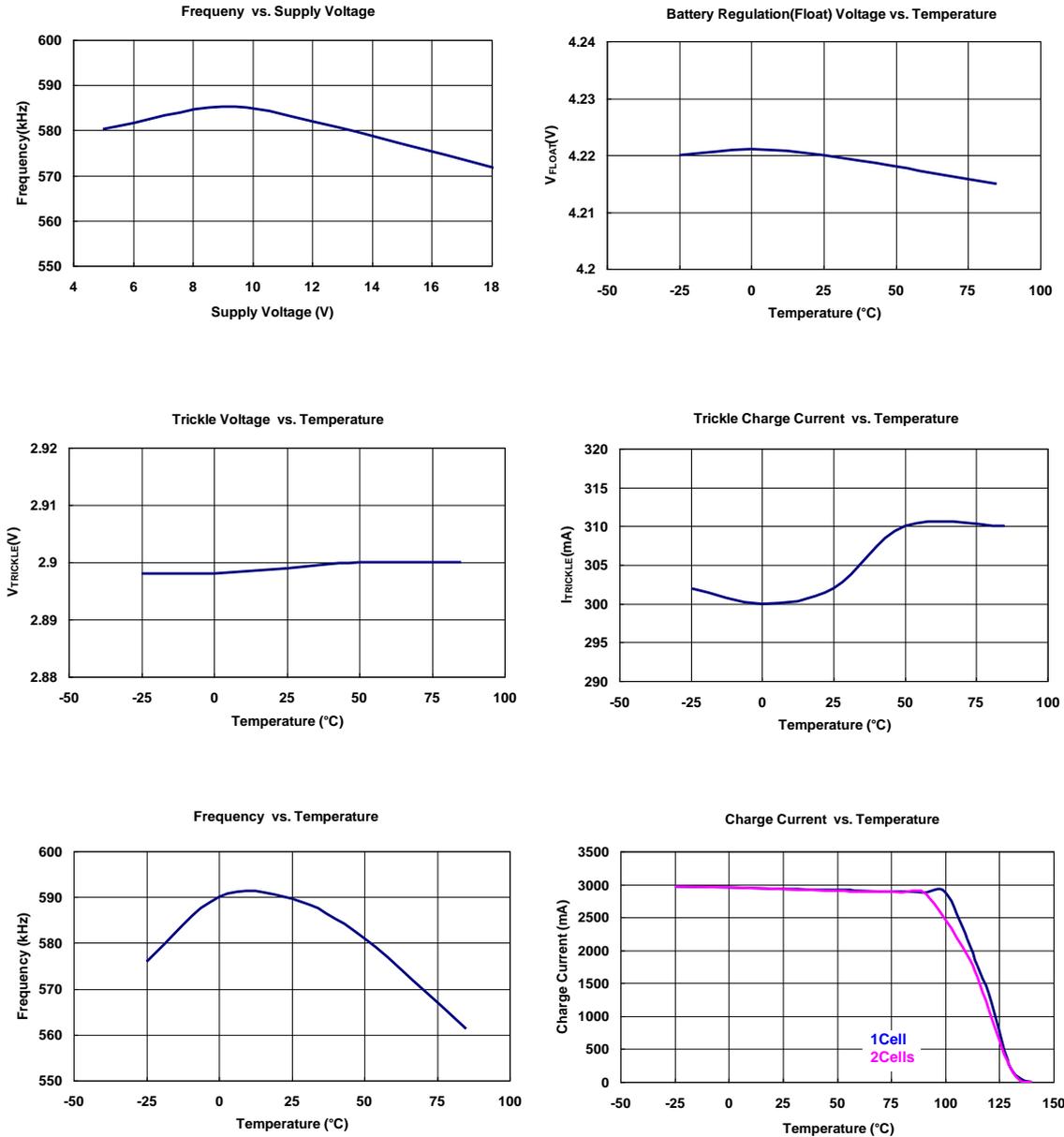
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Parameter	Symbol	Test Conditions	Min.	Typ.	Max.	Unit
LED Pin Output Sink Current	I_{LED}			4.5		mA
Switching Frequency	F_{LX}		400	500	600	KHz
Min.Duty	D_{MIN}			15		%
Max.Duty	D_{MAX}			94		%
Thermal Shutdown	T_{LIM}			150		°C
Thermal Shutdown Hysteresis				25		°C
TEMP pin High Threshold Voltage	V_{TEMP-H}	Compare with VDD	77	80	83	%
TEMP pin Low Threshold Voltage	V_{TEMP-L}	Compare with VDD	42	45	48	%
Enable Threshold voltage	V_{EN-H}		1.1	1.2	1.3	V
Enable Threshold voltage Hysteresis				80		mV

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Typical Operating Characteristics

(V_{IN}=12V, Charge Current=3A, 1Cell=3.7V, T_A= 25°C, unless otherwise noted)

**Charge Current vs.Battery Voltage**

VIN=12V
2Cells Setting

Charge Current vs. Battery Voltage

VIN=12V
2Cells Setting

Charge Current vs. V_{SET} Voltage

Battery Regulation(Float) Voltage vs. Supply Voltage

Trickle Current vs. Supply Voltage

VBAT=5V
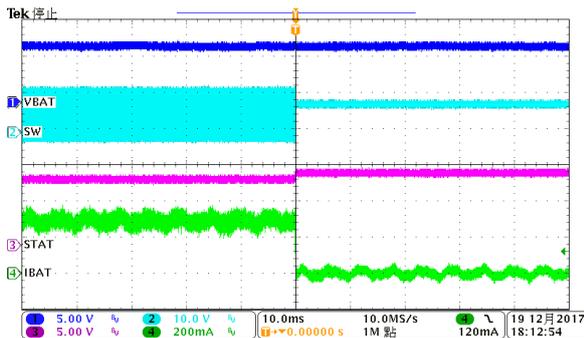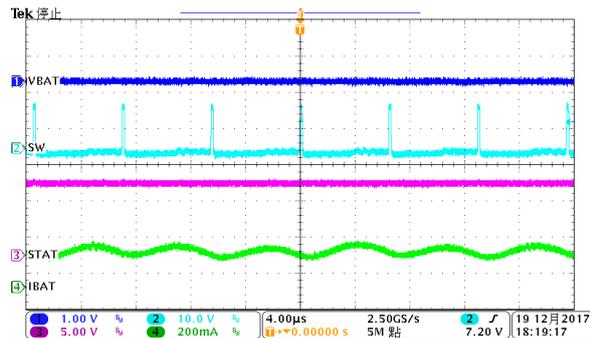2Cells Setting

Charge Current vs. Supply Voltage

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(V_{IN}=12V, Charge Current=3A, 1Cell=3.7V, T_A= 25°C, unless otherwise noted)

Frequeny vs. Supply Voltage

Battery Regulation(Float) Voltage vs. Temperature

Trickle Voltage vs. Temperature

Trickle Charge Current vs. Temperature

Frequency vs. Temperature

Charge Current vs. Temperature

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Power ON Test
(V_{IN}=12V，V_{BAT}=7V，I_{BAT}=3A)

Power OFF Test
(V_{IN}=12V，V_{BAT}=7V，I_{BAT}=3A)
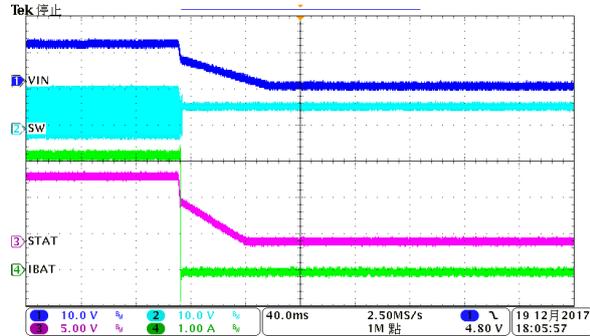
EN ON Test
(V_{IN}=12V，V_{BAT}=7V，I_{BAT}=3A)
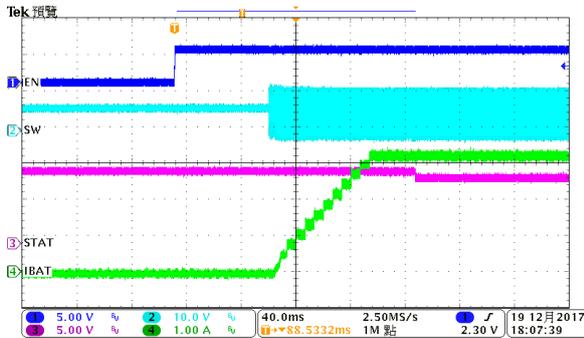
EN OFF Test
(V_{IN}=12V，V_{BAT}=7V，I_{BAT}=3A)
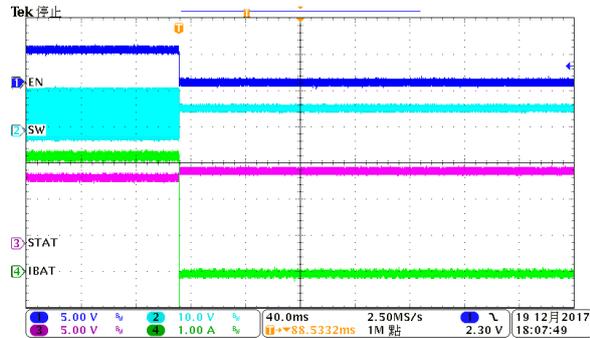
The Charge Cycle End
(V_{IN}=12V，I_{BAT}=3A)

Battery Short
(V_{IN}=12V，I_{BAT}=3A)

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Function Description

Operation

The FP8207 is a switch-mode battery charger designed primarily for charging multi cell lithium-ion batteries.The charger uses a constant-current/constant-voltage charge algorithm with programmable current. Charging current can be programmed externally with a single current sensing resistor between the CS pin and the BAT pin.

Normal Charge Cycle

A charge cycle begins when the voltage at the H_{VDD} pin rises above the UVLO threshold. If the BAT pin voltage is smaller than 68% · V_{FLOAT}, the charger enter trickle charge mode. In this mode, the FP8207 supplies approximately 1/10 the programmed charging current to bring the battery voltage up to a safe level for full current charging. When the BAT pin voltage rises over than 68% · V_{FLOAT}, the charger enters constant-current mode, where the full programmed charge current is supplied to the battery. When the BAT pin voltage approaches 98.5% · V_{FLOAT}, the FP8207 enters the constant-voltage mode and the charge current begins to decrease. When the charge current drops to 1/10 of the programmed value, the charge cycle ends.

Setting Charge Current

When the battery voltage exceeds the trickle charge threshold, the charger goes into the full scale constant current charge mode. In constant current mode, the charge current is set by the external sense resistor Rcs and an internal 50mV reference, The required resistor value can be calculated from the charge current with following equation:

$$Rcs = \frac{50mV}{I_{CHG}}$$

Charge Termination

A charge cycle is terminated when the charge current falls to 1/10 the programmed value after the final float voltage is reached. This condition is detected by using an internal filtered comparator to monitor the sense voltage. When the voltage between the CS pin and the BAT pin falls below 5mV for longer than T_{TERM} (1.8ms), charging is terminated. The charge current is latched of and the FP8207 enters standby mode, where the input supply current drops to 200uA. The FP8207 draws very few current from the battery in standby mode. This feature reduces the charge and discharge cycles on the battery, further prolonging the battery life.

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Thermal Protection and Thermal Fold-back Protection

The thermal fold-back protection will reduces the charge current if the IC junction temperature is higher than 125°C.

The over temperature protection will shut down the charger when the IC junction temperature is higher than 150°C.

Programming Battery Float Voltage

The output battery float voltage is programmed by connecting a resistor divider from the BAT pin to FB pin. The battery float voltage can be programmed up to 12.6V. The battery float voltage value can be calculated by following equation:

$$V_{FLOAT} = 2.4 \times \frac{R_1 + R_2}{R_2}$$

	R1	R2
One Cell	270kΩ	360 kΩ
Two Cells	750kΩ	300kΩ
Three Cells	680kΩ	160kΩ
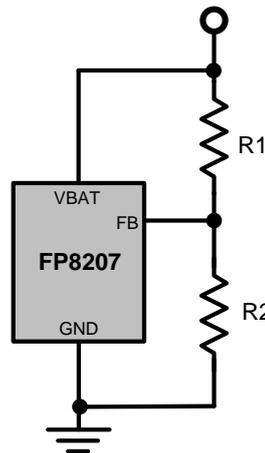
Battery Temperature Fault Monitoring

In the event of a battery over-temperature condition, the charging control will turn off the internal pass device and report a battery temperature fault on the TEMP pin. Inside the FP8207, two internal voltage references V_{TEMP-H} and V_{TEMP-L} are fixed at 80% $\times V_{DD}$ and 45% $\times V_{DD}$ respectively. As the TEMP pin voltage rises above V_{TEMP-H} or falls below V_{TEMP-L}, the FP8207 stops charging and indicates a fault condition. After the system recovers from a temperature fault, the device will resume charging operation. For applications that do not need to monitor the battery temperature, short the TEMP pin to the GND.

The values of R1 and R2 are set according to the battery temperature range and the value of thermal sensitive resistor. If the battery is equipped with NTC(Negative Temperature Coefficient) thermistor and the temperature monitor range is $T_L \sim T_H(T_L < T_H)$, then R_T, the thermistor resistance,

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decreases as temperature increases from T_L to T_H, means $R_{TL} > R_{TH}$.

The TEMP pin voltage can be calculated as:

$$V_{TEMP} = \frac{R2 // R_T}{R1 + R2 // R_T} \times Vcc$$

Thus, this V_{TEMP} decreases as the temperature increase from T_L to T_H.

To set proper R1 and R2 value for temperature protection, we set:

$$0.8 \times V_{DD} = V_{TEMPH} = \frac{R2 // R_{TL}}{R1 + R2 // R_{TL}} \times Vcc \quad \text{at } T_L$$

$$0.45 \times V_{DD} = V_{TEMPL} = \frac{R2 // R_{TH}}{R1 + R2 // R_{TH}} \times Vcc \quad \text{at } T_H$$

Where R_{TL} and R_{TH} are the thermistor resistances at T_L and T_H respectively.

So R1 and R2 can be derived as following:

$$R1 = \frac{R_{TL} R_{TH} (K_2 - K_1)}{(R_{TL} - R_{TH}) K_1 K_2} = \frac{R_{TL} R_{TH} \times 35}{(R_{TL} - R_{TH}) \times 36}$$

$$R2 = \frac{R_{TL} R_{TH} (K_2 - K_1)}{R_{TL}(K_1 - K_1 K_2) - R_{TH}(K_2 - K_1 K_2)} = \frac{R_{TL} R_{TH} \times 35}{R_{TL} \times 9 - R_{TH} \times 44}$$

where $K_1 = 0.45$ and $K_2 = 0.8$
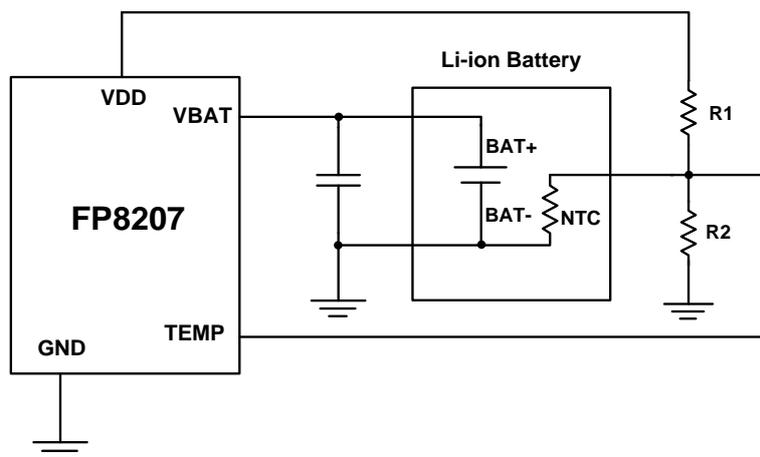
Input Supply Voltage Regulation

The FP8207 contains a voltage monitor pin that enables programming a minimum operational voltage. Connecting a resistor divider from IN pin to the EN_{REG} pin enables programming of minimum input supply voltage, typically used to program the peak power voltage for a solar panel. Maximum charge current is reduced when the EN_{REG} pin is below the regulation threshold of 2.4V. If an input supply cannot provide enough power to satisfy the requirements of an FP8207 charger, the supply voltage will collapse. A minimum operating supply voltage can thus be programmed by monitoring the supply through a resistor divider, such that the desired minimum vlotage corresponds to 2.4V at the EN_{REG} pin. The FP8207 servos the maximum output charge current to maintain the voltage on EN_{REG} at or above 2.4V.
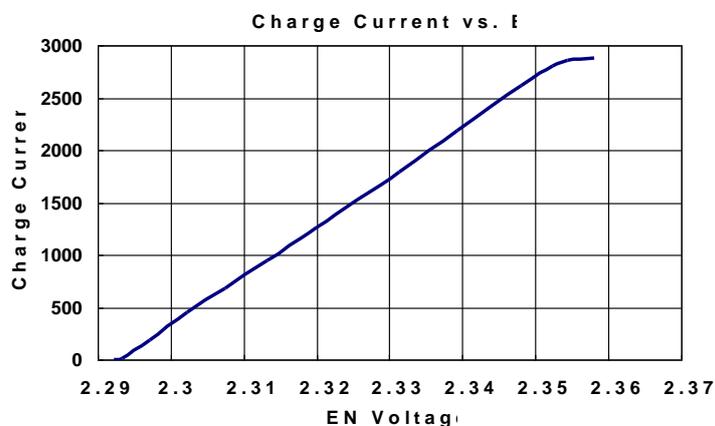
Programming of the desired minimum voltage is accomplished by connecting a resistor divider It can be calculated by following equation:

$$\frac{R1}{R2} = \frac{VIN(min)}{2.4} - 1$$

(EN Pin Vlotage must be under 5.5V)
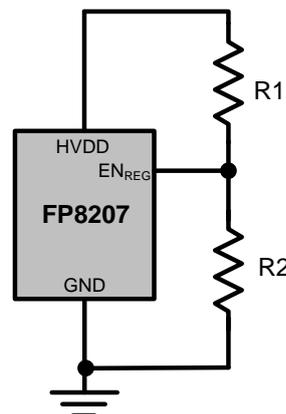
If the voltage regulation feature is not used, connect a resistor 300kΩ bwtween EN_{REG} pin and VIN.

Charge Current vs. E

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Charge Current Regulation

The full-scale differential voltage between CS and VBAT pins is 50mV. Battery charge current is sensed by resistor R_{sense} connected between CS and VBAT. VSET pins could be used of charge current regulation and the equation is as following:

$$I_{CHG} = \frac{50mV}{Rcs} \times \frac{VSET}{1.2V} \quad (0.6V \leq VSET \leq 1.2V)$$

※ It is recommended to use this function in Constant-Current Charge Mode.

$$I_{CHG} = \frac{50mV}{Rcs} \quad (VSET \geq 1.2V)$$

If VSET under 0.2V, the charge cycle ends.

Manual Shutdown

At any point in the charge cycle, the FP8207 can be put into shutdown mode when put the EN pin to the low-level voltage. This reduces the battery drain current to about to 13uA and the supply current to less than 10uA.

Under Voltage Lockout (UVLO)

An internal under voltage lockout circuit monitors the input voltage and keeps the charger in shutdown mode until V_{IN} rises above the under voltage lockout threshold. The UVLO circuit has a built-in hysteresis of 200mV. Furthermore, to protect against reverse current in the power MOSFET, the UVLO circuit keeps the charge in shutdown mode if V_{IN} falls to within 70mV of the battery voltage, If the UVLO comparator is tripped, the charger will not come out of shutdown mode until V_{IN} rises 200mV above the battery voltage.

Automatic Recharge

Once the charge cycle is terminated, the FP8207 continuously monitors the voltage on the BAT pin using a comparator with a 1.8ms filter time ($T_{RECHARGE}$). A charge cycle restarts when the battery voltage falls below 95% · V_{FLOAT} (which corresponds to approximately 80% to 90% battery capacity).This ensures that the battery is kept at or near a fully charged condition and eliminated the need for periodic charge cycle initiations.STAT output enters a strong pull-down state during recharge cycles.

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Application Information

Board Layout Considerations

It is very important to apply a good thermal conduction PC board layout to maximize the available charge current. The thermal path for the heat generated by the IC is from the die through the package leads(especially the ground lead) to the PC board copper. The PC board copper is the heat sink. The copper pads footprint should be as large as possible and expand out to large copper areas to spread and dissipate the heat to the surrounding ambient. Feed-through vias to inner or backside copper layers are also useful in improving the overall thermal performance of the charger. Other heat source on the board, not related to the charger, must also be consider when designing a PC board layout because they will affect overall temperature rise and the maximum charge current.

Inductor Selection

Inductance value is decided based on different condition. 3.3uH to 4.7µH inductance value is recommended for general application circuit. There are three important inductor specifications, DC resistance, saturation current and core loss. Low DC resistance has better power efficiency.

Capacitor Selection

Use Low ESR electrolytic capacitor is preferred to reduce the input inrush voltage, the other ceramic capacitors of X5R and X7R are recommended, which have low equivalent series resistance (ESR) and wider operation temperature range.

Layout Considerations

1. The power traces, consisting of the GND trace, the LX trace and the battery trace should be kept short,direct and wide.
2. Layout switching node LX, BT and inductor connection traces wide and short to reduce EMI.
3. Place input capacitor C1, C2, C8, C9 nearby Power pin as closely as possible to maintain Input voltage steady and filter out the pulsing input current.
4. The GND of the C_{IN} should be connected close together and directly to a ground plane.
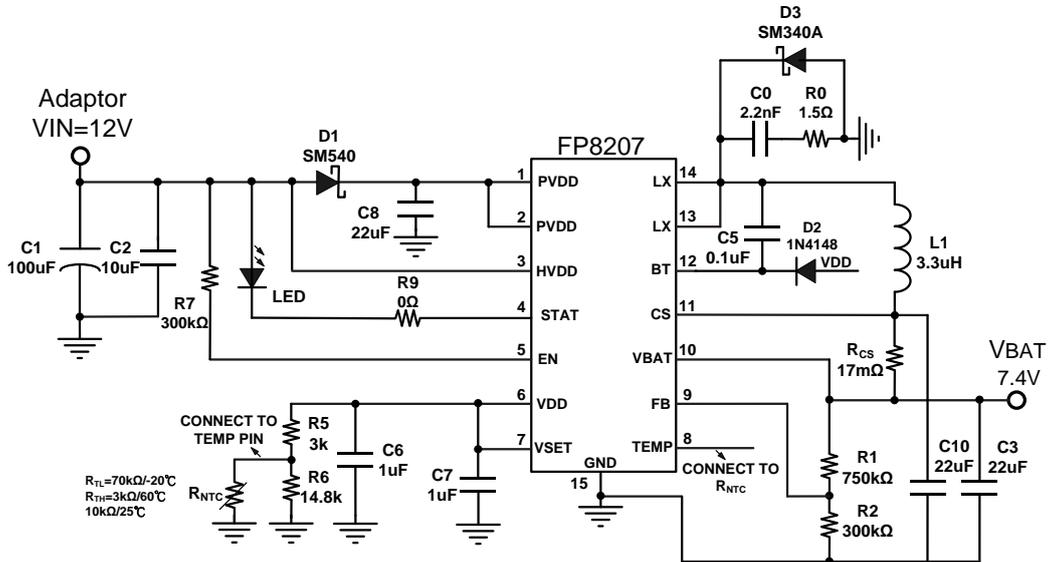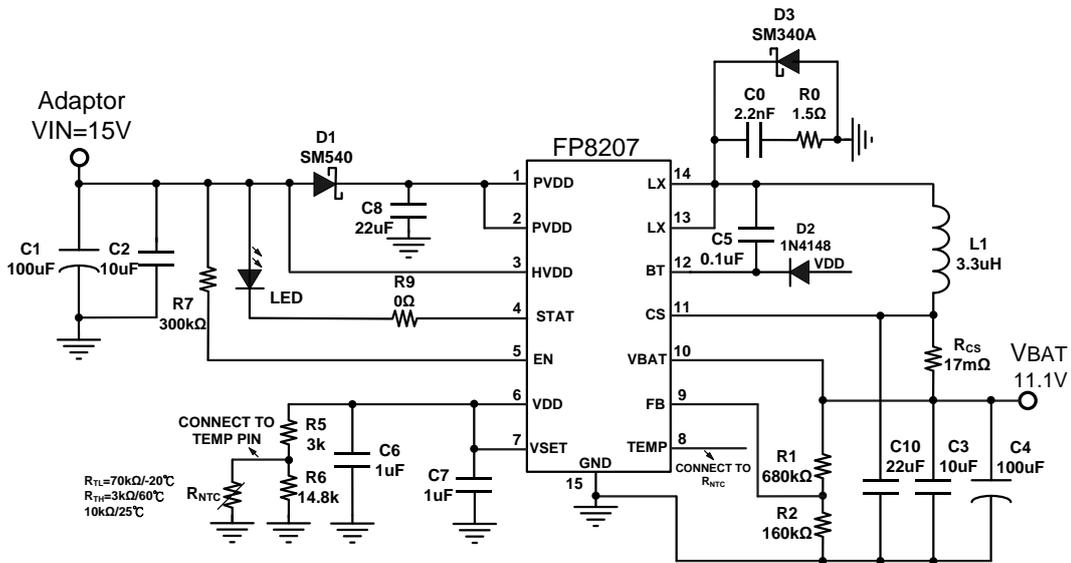5. Place R_{CS} nearby BAT pin and CS pin.
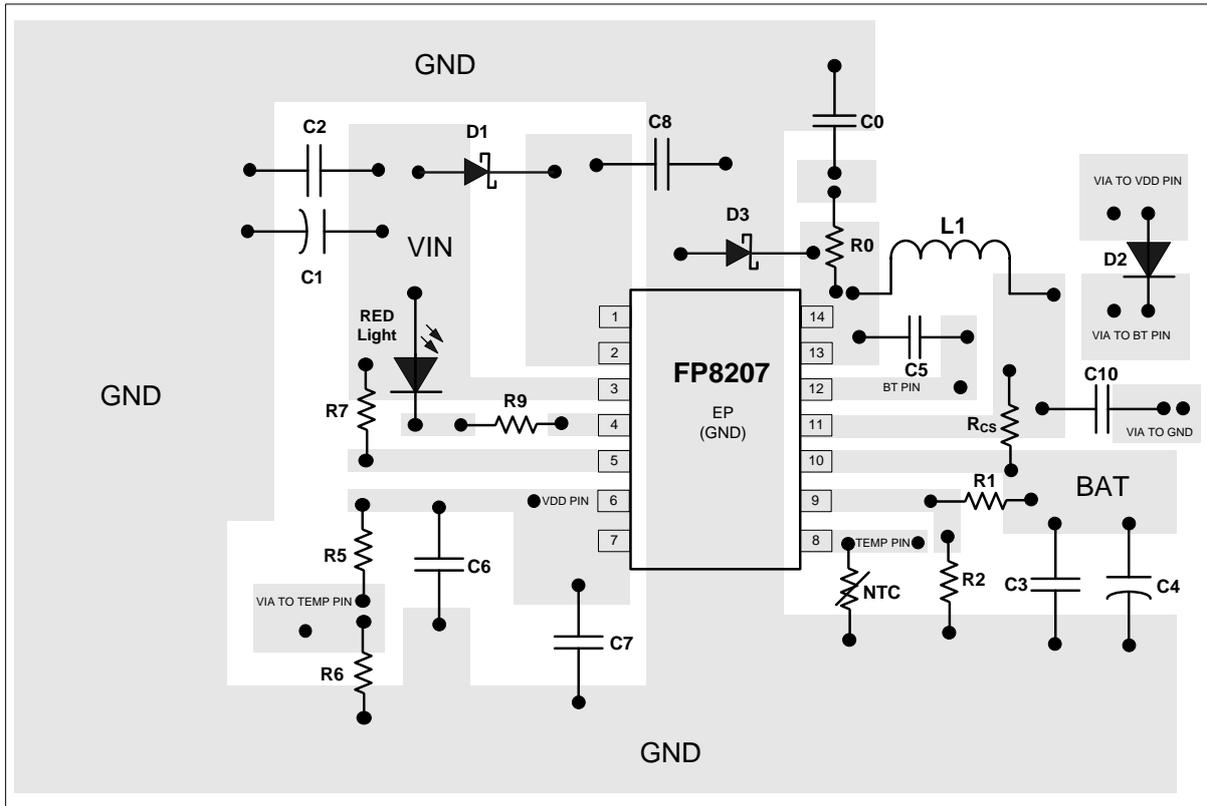
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Suggested Layout

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Rev. 0.64

Application Information
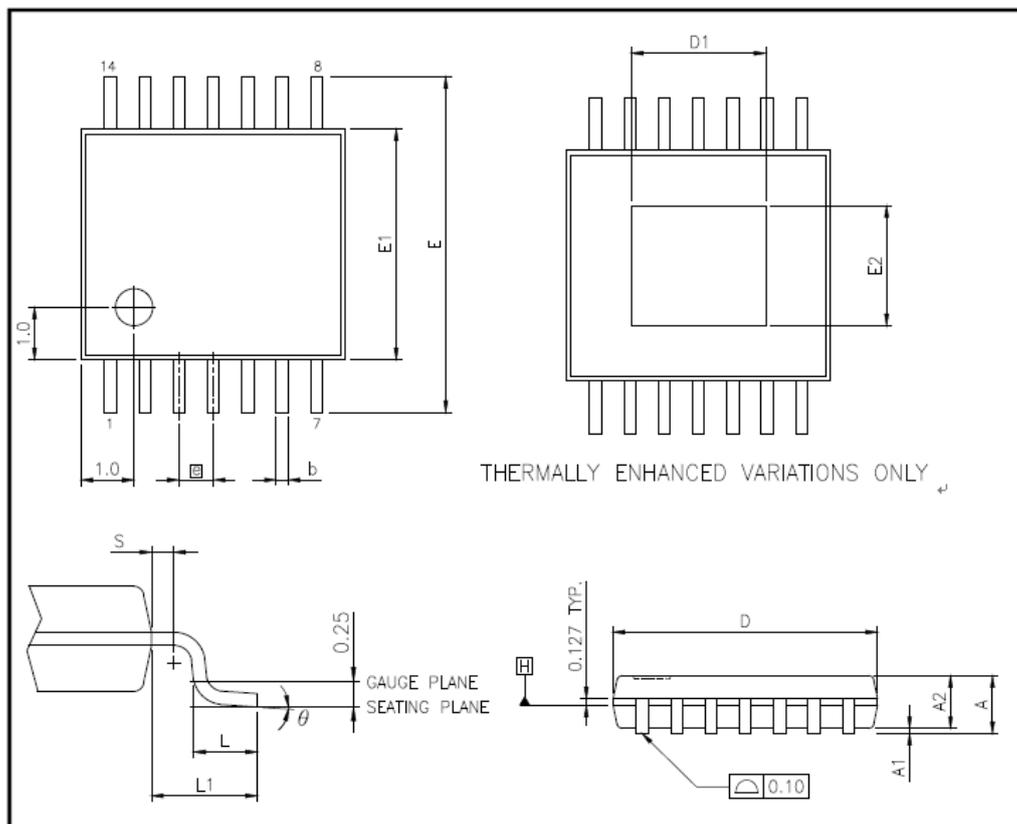

2Cells Setting

3Cells Setting

Note:

1.   Use ceramic capacitor of X5R or X7R for C2 and C3.

2.   R0 and C0 must be connected to LX and Ground.

3.   D3 must be connected to LX and Ground.

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Package Outline

TSSOP-14L(EP)

UNIT: mm

Symbols	Min. (mm)	Nom.(mm)	Max. (mm)
A	-	-	1.20
A1	0.00	-	0.15
A2	0.80	1.00	1.05
b	0.19	-	0.30
D	4.90	5.00	5.10
E1	4.30	4.40	4.50
E	6.40 BSC		
e	0.65 BSC		
L1	1.00 REF		
L	0.50	0.60	0.75
S	0.20	-	-
θ	0°	-	8°

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Exposed PAD Dimensions:

Symbols	Min. (mm)	Max. (mm)
E2	2.55	3.15
D1	2.64	3.25

Note:

1. All dimensions are in millimeters.

2. Dimension "D" does not include mold flash, protrusions or gate burrs. Mold flash,protrusions or gate burrs shall not exceed 0.15 pre side.

3. Dimension "E1" does not include interlead flash or protrusion. Interlead flash or protrusion shall not exceed 0.25 pre side.

4. Dimension "b" does not include interlead dambar protrusion. Allowable dambar protrusion shall be 0.08mm total in excess of the "b" dimension at maximum material condition. Dambar cannot be located on the lower radius of the foot. Minimum space between protrusion and adjacent lead is 0.07mm.

5. Dimension "D" and "E1" to be determined at datum plane.

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