Power Bank IC with 1A Linear Charger and 2A Synchronous Boost Converter

Halogen Free

General Description

The FP6807 is a highly integrated Power Bank IC with a Linear Li-Ion Charger up to 1A charge current and 2A output current Synchronous Boost Converter. With few external components, the FP6807 could enable Charger and Booster simultaneously and is well suited for portable power bank applications. In shutdown mode, reverse battery current I_{BAT} will be reduced to below 10uA. Other features include UVLO, automatic recharge, LED status indicators and booster output over-current / over-voltage protection.

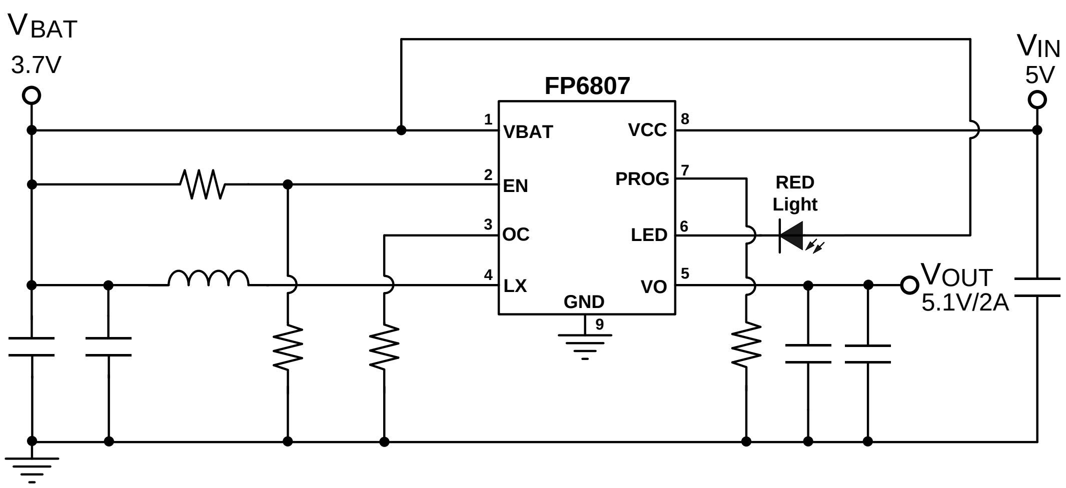
Features

- Up to 1A Programmable Battery Charging Current
- Low Stanby current: 120uA
- Preset Charge Voltage with ±1% Accuracy and Boost output Voltage: 5.1V (±2%)
- Automatic Recharge
- Low Shutdown-Mode I_{BAT} Current
- Up to 90% Boost Conversion Efficiency
- Up to 2A Boost Output Current (V_{BAT}>3.3V)
- Battery capacity Indicator
- SCP & OCP & OVP for Boost Output
- Thermal Protection

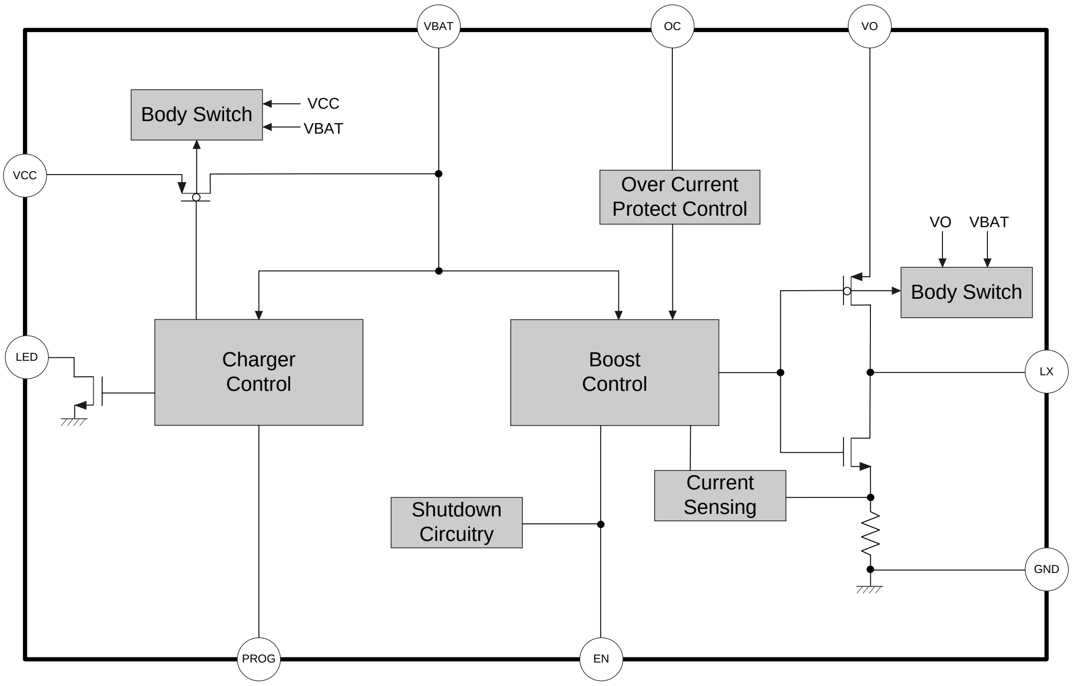
Applications

- Portable Power Bank Applications

Typical Application Circuit



Function Block Diagram



Only Battery Charging Status Indicators

Status	LED light
In Charging, V_{BAT}<3.7V	High speed strobe (T=0.6sec)
In Charging, 3.7V<V_{BAT}<4.1V	Low speed strobe (T=2.4sec)
In Charging, 4.1V<V_{BAT}<4.2V	ON
Charge Termination	OFF

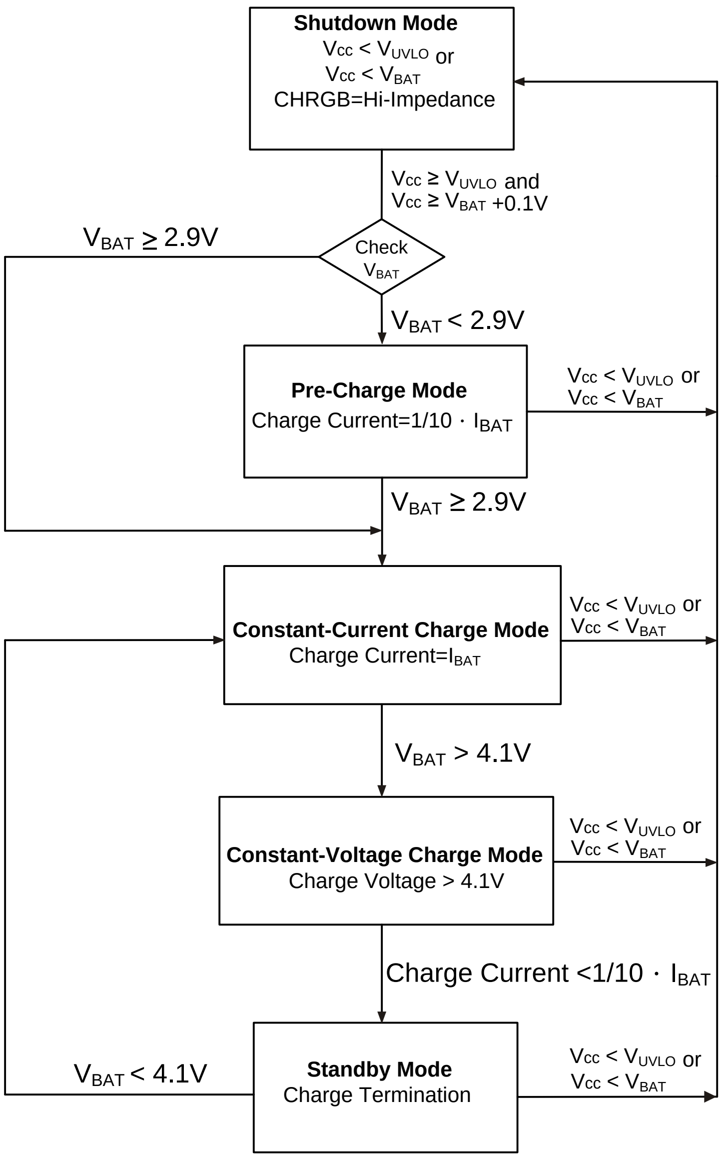
Only Battery Discharging Status Indicators

Status	LED light
Discharging, V_{BAT}<3.5V	High speed strobe (T=0.6sec)
Discharging, 3.5V<V_{BAT}<3.8V	Low speed strobe (T=2.4sec)
Discharging, V_{BAT}>3.8V	ON

Battery Charging and Discharging simultaneously

Status	LED light
V_{BAT}<3.5V	High speed strobe (T=0.6sec)
3.5V<V_{BAT}<4.1V	Low speed strobe (T=2.4sec)
4.1V<V_{BAT}<4.2V	ON

Battery Charging State Diagram

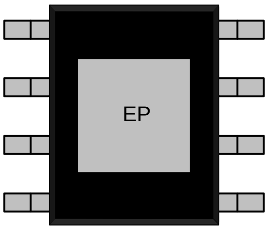


Pin Descriptions

SOP-8L (EP)

Top View

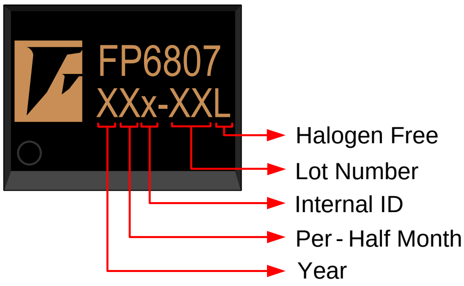
Bottom View



Name	No.	I / O	Description
VBAT	1	P	Battery Voltage
EN	2	I	Boost Enable Control
OC	3	I	Adjustable Current Limit (Floating invalid)
LX	4	I	Switch node and inductor connection pin
VO	5	I	Booster Output Voltage
LED	6	O	Battery Voltage Indicator
PROG	7	I	CC Charge Current Setting & monitor
VCC	8	P	Supply Voltage
EP	9	P	IC Ground , Exposed PAD-Must connect to Ground

Marking Information

SOP-8L(EP)



Halogen Free: Halogen free product indicator

Lot Number: Wafer lot number's last two digits

For Example → Lot : 123456 → XXx-56L

Internal ID: Internal Identification Code

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

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

Year: Production year's last digit

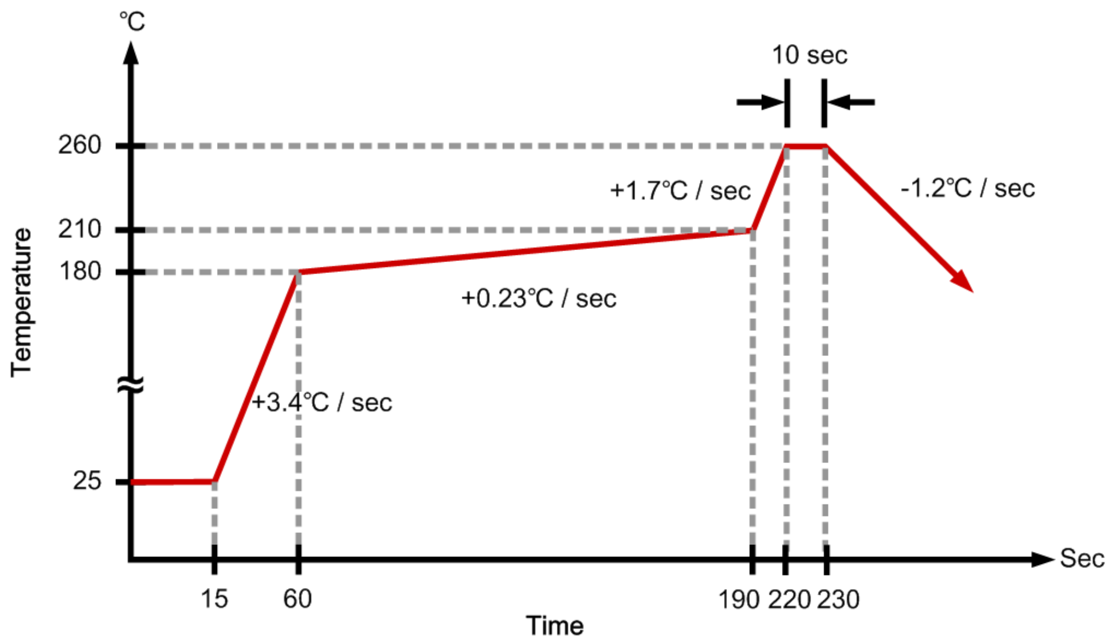
Ordering Information

Part Number	Operating Temperature	Package	MOQ	Description
FP6807XR-G1	-25°C ~ +85°C	SOP-8L(EP)	2500EA	Tape & Reel

Absolute Maximum Ratings

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Supply Voltage	V_{IN}		-0.3		6	V
EN Voltage	V_{EN}		-0.3		V_{BAT}+0.3	V
LX Voltage	V_{LX}		0		10	V
All Other Pins			-0.3		6	V
BAT Pin Current	I_{BAT}				1.2	A
Junction Temperature	T_J				+150	°C
Storage Temperature	T_S		-65		+150	℃
Thermal Resistance	θ_{JA}	SOP-8L(EP)			60	℃ / W
	θ_{JC}				10	℃ / W
Operating Temperature			-25		+85	℃
Lead Temperature (Soldering, 10 Sec)					+260	℃

Suggested IR Re-flow Soldering Curve



Recommended Operating Conditions

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Supply Voltage	V_{IN}		4.35		5.5	V
Booster Operation Supply Voltage	V_{BAT}		3		4.2	V
Operating Temperature		Ambient Temperature	-25		85	°C

DC Electrical Characteristics (V_{IN}=5V, V_{BAT}=3.3V ,T_A= 25°C, unless otherwise noted)

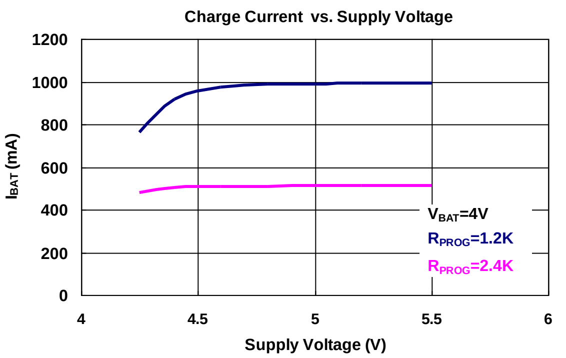
Parameter	Symbol	Test Conditions	Min.	Typ.	Max.	Unit
V_{IN} Standby Current	$I_{VIN,STB}$	Charge Termination		200		µA
V_{IN} Shutdown Supply Current	$I_{VIN,SHDN}$	V_{IN}< V_{BAT} , V_{IN}< $V_{ADP,UV}$ V_{BAT}< $V_{BAT,UV}$		50		µA
BAT Pin Current	I_{BAT}	R_{PROG}=2.4K	450	500	550	mA
		R_{PROG}=1.2K	900	1000	1100	mA
		Standby-Mode, V_{BAT}=4.2V	0	-6	-15	µA
		Shutdown-Mode		±6	±12	µA
BAT CV Output (Float) Voltage	V_{FLOAT}	0°C<T_A<85°C	4.158	4.2	4.242	V
V_{IN} Charge Under Voltage Lockout Threshold	$V_{IN,UV}$	V_{IN} Rising	3.5	3.7	3.9	V
V_{IN} Charge Under Voltage Lockout Threshold Hysteresis	$V_{IN.UVHYS}$			500		mV
V_{IN}-V_{BAT} Charge Lockout Threshold	V_{ASD}	V_{IN} Rising		120		mV
		V_{IN} Falling		10		mV
C/10 Charge Termination Current Threshold	I_{TERM}	R_{PROG}=1.2K		100		mA
LED Pin Output Sink Current	I_{LED}			3.5		mA
Battery Recharge Threshold Voltage	V_{RECHRG}	V_{FLOAT}-V_{RECHRG}		100		mV
Recharge Comparator Filter Time	T_{RECHRG}	V_{BAT} High to Low		0.8		mS
C/10 Charge Termination Comparator Filter Time	T_{TERM}	I_{BAT} Falling below I_{TERM}		0.8		mS
Booster Under Voltage Lockout falling threshold	V_{UVLO-F}			2.2		V
Booster Under Voltage Lockout rising threshold	V_{UVLO-R}			2.6		V
Booster Operation Frequency	F_{OSC}		400	500	600	KHz
Frequency Change with Voltage	∆ f / ∆ V	V_{BAT}=3.0V to 4.2V		5		%
Maximum Duty Cycle	T_{DUTY}			90		%
Booster Output Voltage	V_O		4.998	5.1	5.202	V
Line Regulation		V_{BAT}=3.0V ~ 4.2V		0.2		% / V
Soft-Start Time	T_{SS}	V_{BAT}=4.5V		2		ms
OCP Current	I_{OCP}	R_{OCSET}=75kΩ		3.43		A
Standby current	I_{STB}	No Vcc,No loading		120		uA

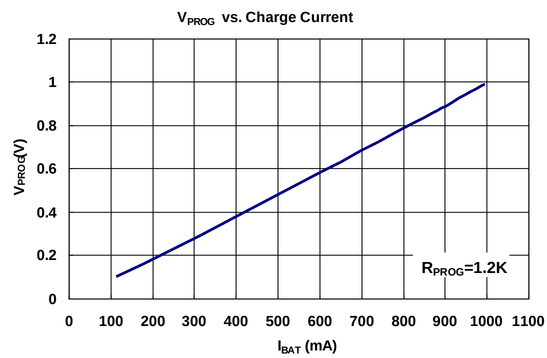
DC Electrical Characteristics (V_{IN}=5V, V_{BAT}=3.3V,T_A= 25°C, unless otherwise noted)

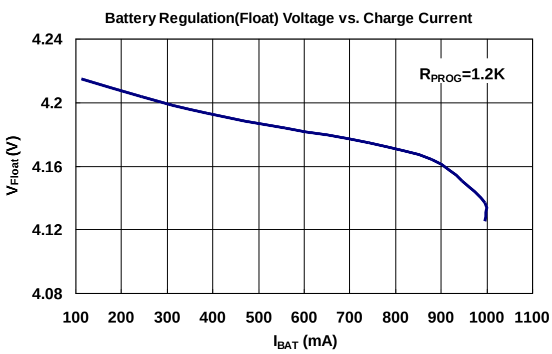
Parameter	Symbol	Test Conditions	Min.	Typ.	Max.	Unit
High Side Switch RDS(ON)	$R_{ON\text{-}PMOS}$			75		mΩ
Low Side Switch RDS(ON)	$R_{ON\text{-}NMOS}$			75		mΩ
Thermal Shutdown	T_{LIM}			150		°C
Thermal Shutdown Hysteresis				40		°C
EN Enable Voltage	$V_{EN,H}$			1.2		V
EN Shutdown Voltage	$V_{EN,L}$			1.1		V

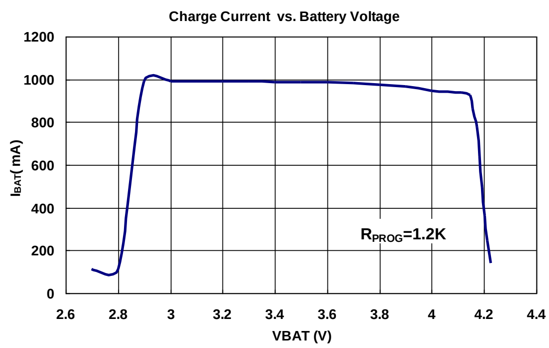
Typical Operating Characteristics

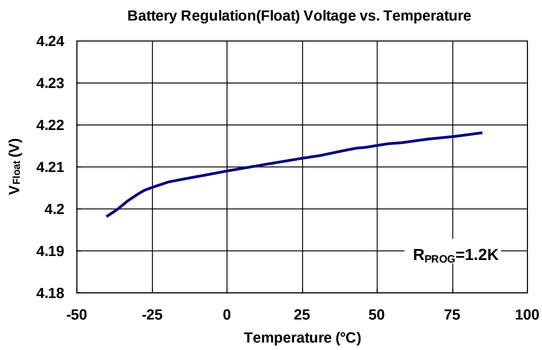
(Charger : V_{CC}=5V, T_A= 25°C, unless otherwise noted)

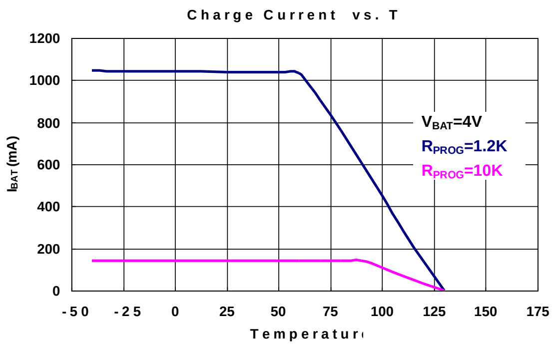




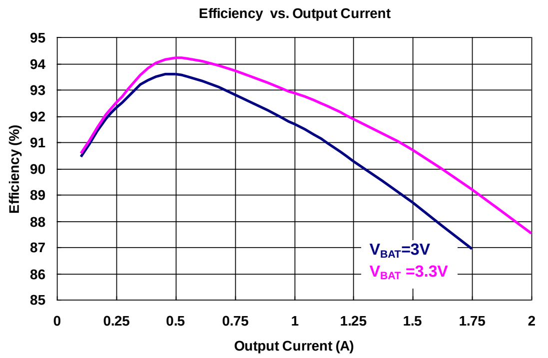


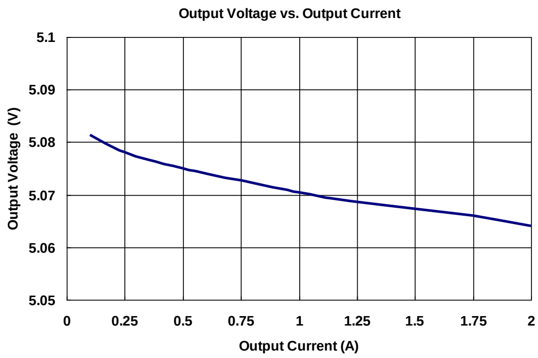


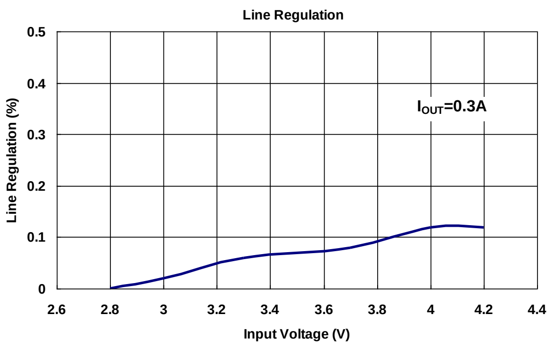


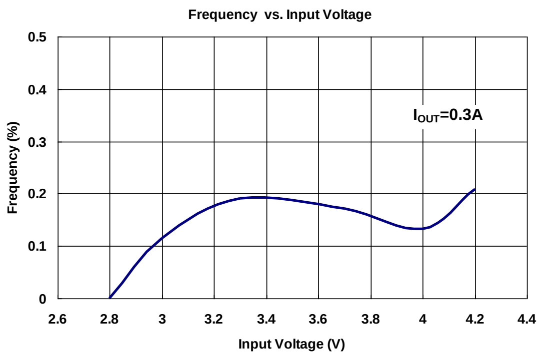


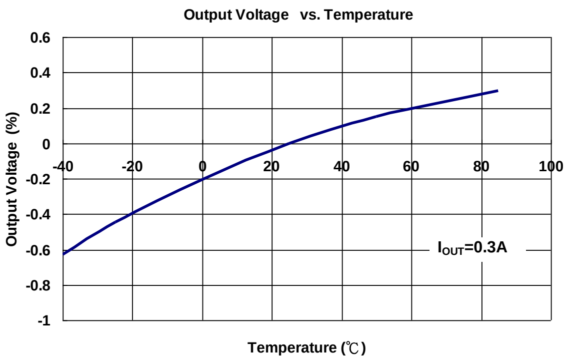
(Boost : V_{BAT}=3.3V, Vout=5.1V，T_A= 25°C, unless otherwise noted)

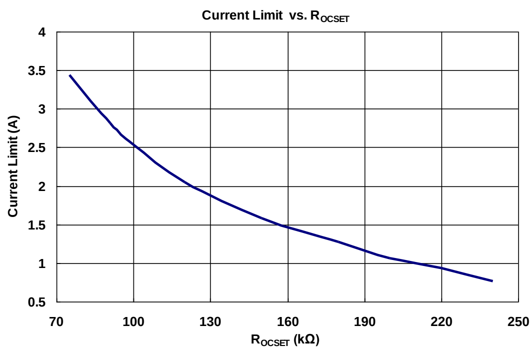






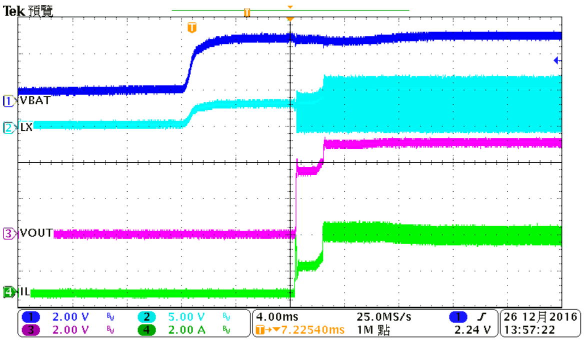






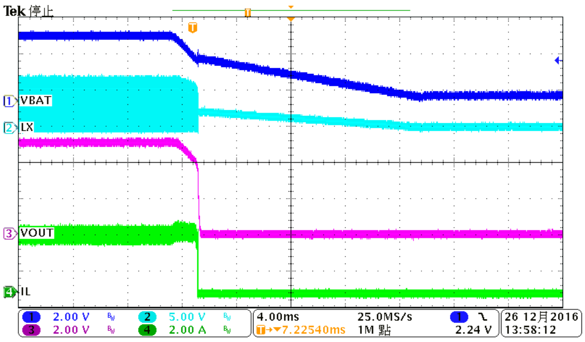
Power ON Test

(V_{BAT}=3.7V，Vout=5.1V，Iout=2A)



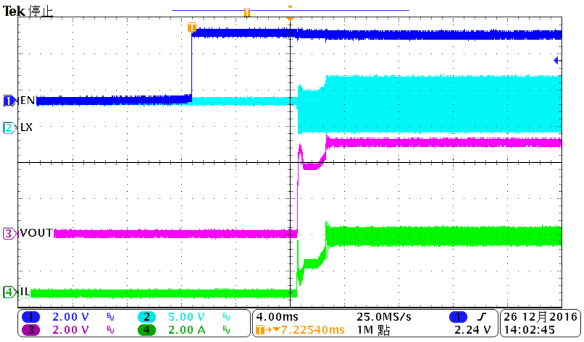
Power OFF Test

(V_{BAT}=3.7V，Vout=5.1V，Iout=2A)



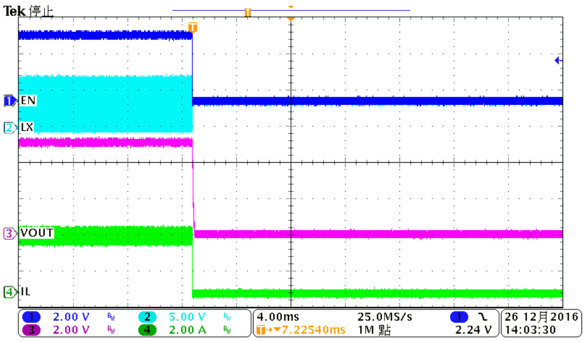
EN ON Test

(V_{BAT}=3.7V，Vout=5.1V，Iout=2A)



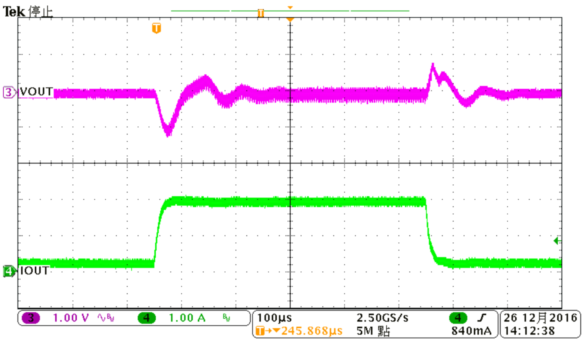
EN OFF Test

(V_{BAT}=3.7V，Vout=5.1V，Iout=2A)



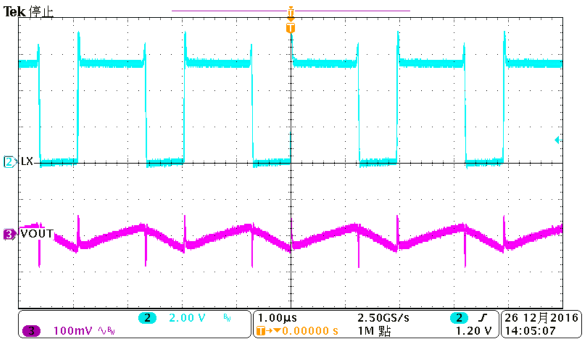
Transient Response

(V_{BAT}=3.7V，Vout=5.1V，Iout=0.2A~2A)



Full Load Output Ripple

(V_{BAT}=3.7V，Vout=5.1V，Iout=2A)



Function Description

For Battery Charging

Operation

The FP6807 is with a linear battery charger designed primarily for charging single cell lithium-ion battery. The charger uses a constant-current/constant-voltage charging algorithm with programmable current. Charging current can be programmed up to 1A by an external single resistor. The FP6807 includes an internal P-channel power MOSFET and thermal regulation circuitry. No blocking diode or external sense resistor are required. Thus, the basic charger circuit requires only two external components. Furthermore, The FP6807 is capable of operating from a USB power source.

Normal Charge Cycle

A charge cycle begins when the voltage at the V_{IN} pin rises above the UVLO threshold. If the BAT pin voltage is smaller than 2.9V, the charger enter trickle charge mode. In this mode, the FP6807 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 above 2.9V, the charger enters constant-current mode, where the full programmed charge current is supplied to the battery. When the BAT pin approaches the final float voltage (4.1V), the FP6807 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 ended.

Programming Charge Current

The charge current is programmed by a single resistor connected from the PROG pin to ground. The battery charging current is 1200 times the current flowing out of the PROG pin. The required resistor value can be calculated from the charge current with following equation:

$$R_{PROG}=\frac{1200}{I_{CHG(MAX)}}$$

The instantaneous charging current may differ from above equation in trickle or constant voltage modes. The instantaneous charging current provided to the battery can be determined by monitoring the PROG pin voltage at any time with the following equation:

$$I_{CHG}=\frac{V_{PROG}}{R_{PROG}}\times 1200$$

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. The charge current is shut off and the FP6807 enters standby mode, where the input supply current drops to 200uA. The FP6807 draws very few current from the battery in standby mode. This feature reduces the charge and discharge cycles on the battery, further prolong the battery life.

Thermal Protection when charging

An internal thermal feedback loop reduces the fixed charge current if the die temperature rises above a preset value of approximately 100°C. This feature protects the FP6807 from excessive temperature and allows the user to push the limits of the power handing capability of a given circuit board without risk of damaging the FP6807. The charge current can be set according to typical ambient temperature with the assurance that the charge will automatically reduce the current in worst case condition.

V_{IN} 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 500mV. Furthermore, to protect against reverse current in the power MOSFET, the UVLO circuit force the FP6807 to enter shutdown mode if V_{IN} falls to within 10mV of the battery voltage. If the UVLO comparator is tripped, the charger will not come out of shutdown mode until V_{IN} rises 100mV above the battery voltage.

Automatic Recharge

Once the charge cycle is terminated, the FP6807 continuously monitors the voltage on the BAT pin using a comparator with a 0.8ms filter time ($T_{RECHARGE}$). A charge cycle restarts when the battery voltage falls below 4.1V (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. LED output enters a strong pull-down state during recharge cycles.

For Booster

Operation

The FP6807 is with a current mode boost converter. The constant switching frequency is 500KHz and operates with pulse width modulation (PWM). The control loop architecture is peak current mode control; therefore slope compensation circuit is added to the current signal to allow stable operation for duty cycles larger than 50%.

Soft Start Function

Soft start circuitry is integrated into the FP6807 to avoid inrush current during power on. After the IC is enabled, the output of error amplifier is clamped by the internal soft-start function, which causes PWM pulse width increasing slowly and thus reducing input surge current.

Output No Load Automatic LED OFF

The FP6807 will be turn off the LED when the booster output is no load and no battery discharging.

Over Temperature Protection (OTP)

The FP6807 will be shutdown automatically when the internal junction temperature is over 150°C. The IC wake up when the junction temperature drops 40°C under the OTP threshold temperature.

Current Limit Program (OCP)

A resistor between OC and GND pin programs peak switch current. The resistor value should be between 75k and 240k. The current limit can be set from 3.43A to 0.85A. Keep traces at this pin as short as possible. Do not put capacitance at this pin. Set the over current trip point according to the following equation :

$$I_{OCP} = \frac{280000}{R3} - 0.3$$

※ OC pin can't floating.

Application Information

Power Dissipation

The conditions that cause the FP6807 to reduce charge current through thermal feedback can be approximated by considering the power dissipated in the IC. For high charge current, the FP6807 power dissipation is approximately:

$$P_D = (V_{IN} - V_{BAT}) \cdot I_{BAT}$$

Where P_D is the power dissipated, V_{CC} is the input supply voltage, V_{BAT} is the battery voltage and I_{BAT} is the charge current. It is not necessary to check any worst-case power dissipation scenarios because the FP6807 will automatically reduce the charge current to maintain the die temperature under 140°C approximately. The approximate ambient temperature at which the thermal feedback begins to protect the IC is:

$$T_A = 140°C - P_D \theta_{JA}$$
$$= 140°C - (V_{IN} - V_{BAT}) \cdot I_{BAT} \cdot \theta_{JA}$$

For example: Consider an FP6807 operating from a 5V wall adapter providing 0.5A to a 4.0V Li-Ion battery. The ambient temperature above which the FP6807 will begin to reduce the 0.5A charge current is approximately:

$$T_A = 140°C - (5V - 4.0V) \bullet (0.5A) \bullet 60°C/W$$
$$= 140°C - 0.5W \bullet 60°C/W = 140°C - 30°C$$
$$= 110°C$$

The FP6807 can be used above 110°C, but the charge current will be reduced to smaller than 500mA. The approximate current at a given ambient temperature can be calculated:

$$I_{BAT} = \frac{140°C - T_A}{(V_{IN} - V_{BAT}) \cdot \theta_{JA}}$$

Using the previous example with an ambient temperature of 90°C, the charge current will be reduced to approximately:

$$I_{BAT} = \frac{140°C - 90°C}{(5V - 3.6V) \cdot 60°C/W} = 595mA$$

Furthermore, the voltage at the PROG pin will change proportionally with the charge current as discussed in the Programming Charge Current section. It is important to remember that FP6807 applications do not need to be designed for worst-case thermal conditions since the IC will automatically reduce power dissipation when the junction temperature reaches approximately 140°C.

Board Layout Considerations

Because of the small size of the SOP-8L(EP), 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.

V_{IN} Bypass Capacitor

Many types of capacitors can be used for input bypassing, however, caution must be exercised when using multilayer ceramic capacitors. Because of the self-resonant and high Q characteristics of some types of ceramic capacitors, high voltage transients can be generated under some start-up conditions, such as connecting the charger input to a live power source. Adding a 0.4Ω resistor in series with an X5R ceramic capacitors (as shown in Figure 1) will minimize start-up voltage transients.

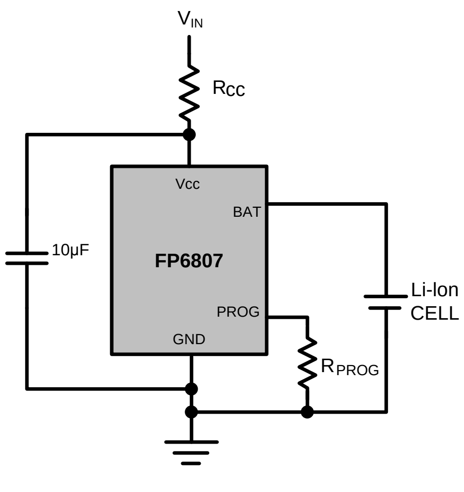


FIGURE 1

USB and Wall Adapter Power

Although the FP6807 allows charging from a USB port, a wall adapter can also be used to charge Li-ion batteries. Figure 2 shows an example of how to combine wall adapter and USB power inputs. A P-channel MOSFET, MP1, is used to prevent back conducting into the USB port when a wall adapter is present. The schottky diode, D1, is used to prevent USB power loss through the 10kΩ pull-down resistor.

Typically, a wall adapter can supply significantly more current than the 500mA-limited USB port. Therefore, an N-channel MOSFET, MN1, and an extra program resistor are used to increase the charge current to 600mA when the wall adapter is present.

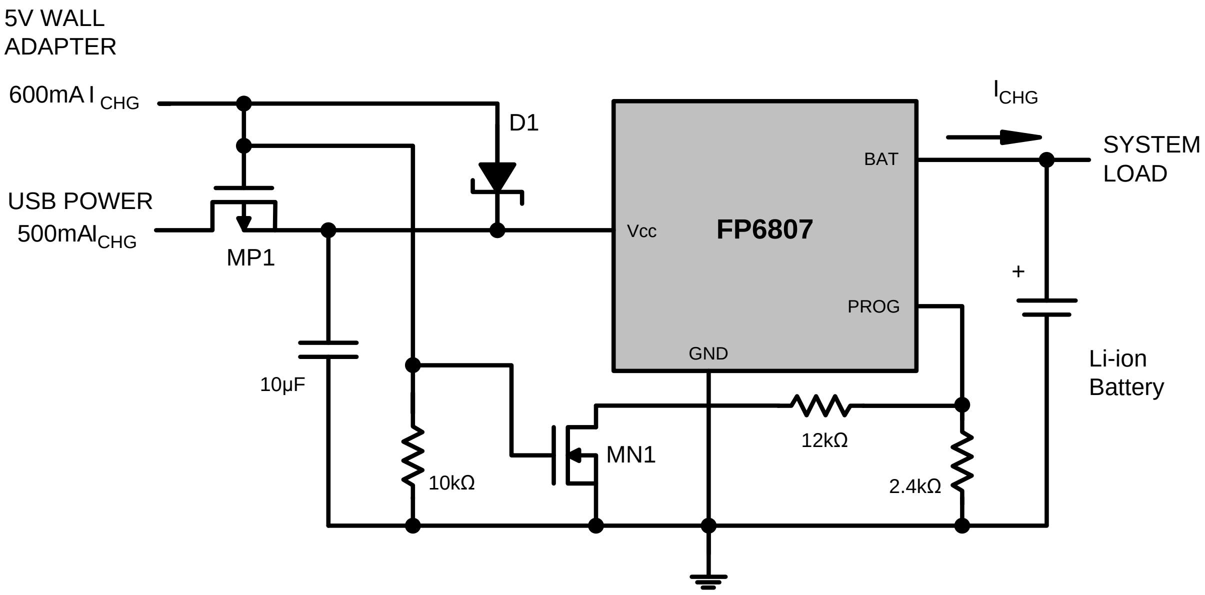


FIGURE 2

Inductor Selection

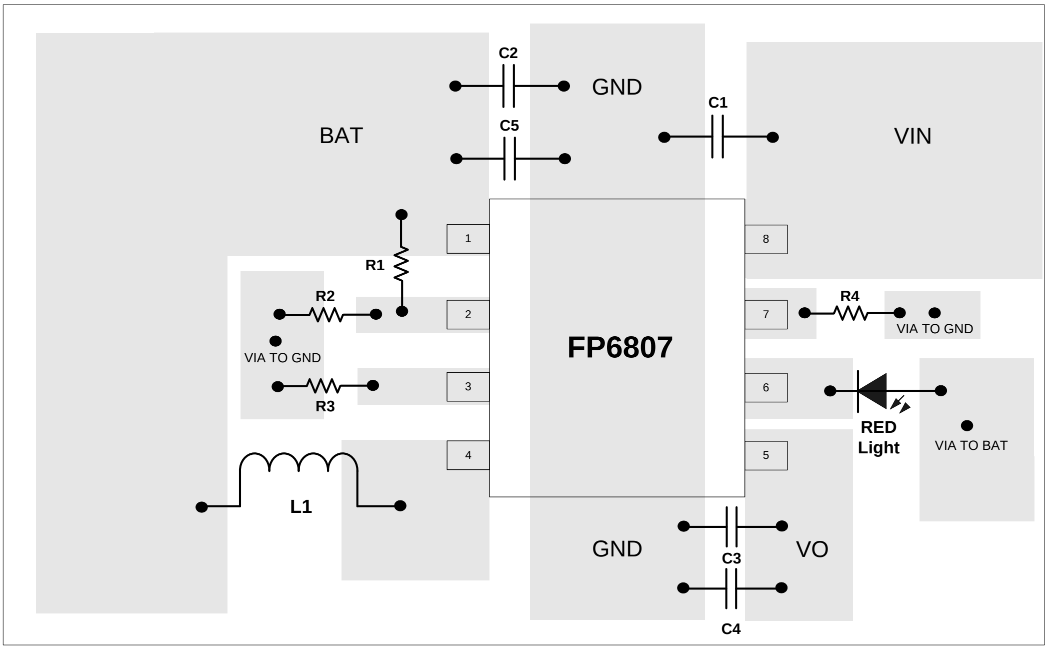
Inductance value is decided based on different condition. 2.2uH to 4.7μH inductor value is recommended for general application circuit. There are three important inductor specifications, DC resistance, saturation current and core loss. Low DC resistance has better power efficiency. Also, it avoid inductor saturation which will cause circuit system unstable and lower core loss at 1 MHz.

Capacitor Selection

The output capacitor is required to maintain the DC voltage. Low ESR capacitors are preferred to reduce the output voltage ripple. Ceramic capacitor of X5R and X7R are recommended, which have low equivalent series resistance (ESR) and wider operation temperature range.

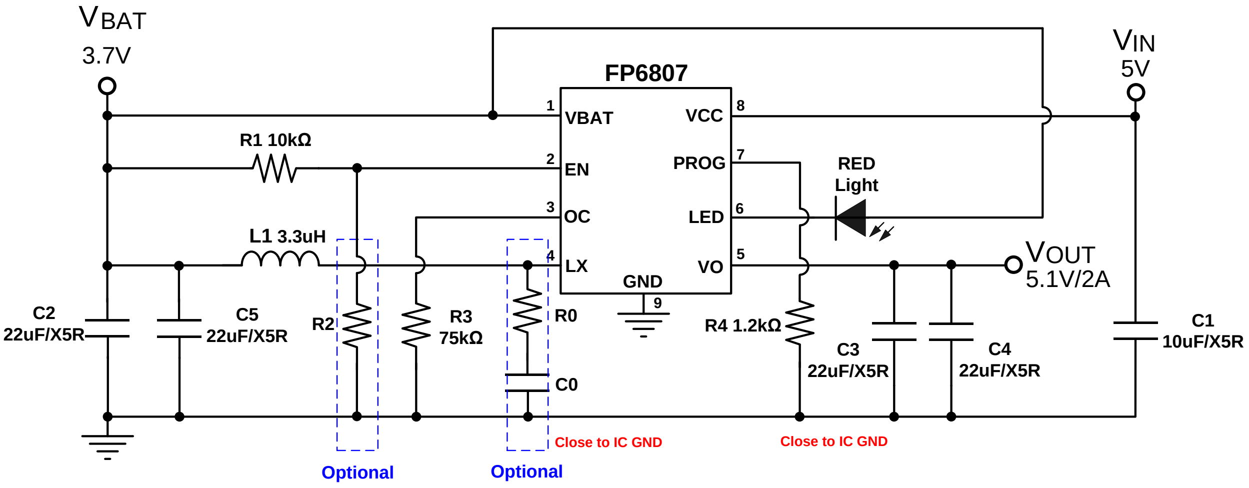
Layout Considerations

1. The power traces, consisting of the GND trace, the LX trace,the Vcc trace and the V_{BAT} trace should be kept short, direct and wide.
2. Layout LX switching node wide and short trace to reduce EMI.
3. Place C2 and C5 near VBAT pin as closely as possible to maintain input voltage steady and filter out the pulsing input current.
4. The GND of the IC, C2, C5 and C3, C4 should be connected close together directly to a power ground plane.



Suggested Layout

Typical Application

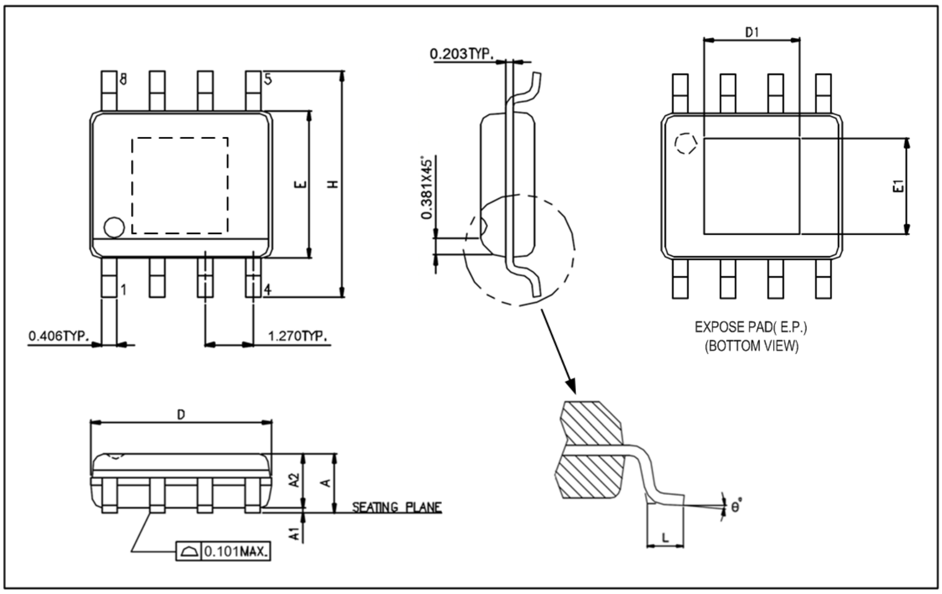


Note:

1. Use ceramic capacitor of X5R or X7R for C1，C2，C3，C4 and C5.
2. EN voltage must be less than or equal to V_{BAT} voltage.

Package Outline

SOP-8L (EP)



Symbols	Min. (mm)	Max. (mm)
A	1.346	1.752
A1	0.050	0.152
A2		1.498
D	4.800	4.978
E	3.810	3.987
H	5.791	6.197
L	0.406	1.270
θ°	0°	8°

Exposed PAD Dimensions:

Symbols	Min. (mm)	Max. (mm)
E1	2.184 REF	
D1	2.971 REF	

Note:

1. JEDEC Outline : N/A
2. Dimensions “D” does not include mold flash, protrusions or gate burrs mold flash
3. Protrusions and gate burrs shall not exceed .15mm (.006in) per side.
   Dimensions “E” does not include inter-lead flash or protrusions inter-lead flash and protrusions
4. Shall not exceed 25mm (.010in) per side.