

### **Description**

The SLM6800 is a two-cell Li-Ion battery synchronous boost current circuit for a 5V adapter. It is a fully integrated power MOS device and a synchronous boost converter with a 750KHz switching frequency, so it has a charging efficiency of over 92% and a maximum charging current of 1.5A.

The SLM6800 includes a complete charge termination circuit, automatic recharge, and a preset charge voltage of 8.4V with an accuracy of  $\pm 1\%$ . It integrates output short-circuit protection, chip and battery temperature protection.

The SLM6800 adapts the current supply capability of the adapter to ensure that the input adapter is not overloaded, making it suitable for a wide range of DC devices as well as standard USB charging devices.

The SLM6800 integrates a 20V power MOSFET. It can withstand voltages up to 20V and integrates under-voltage and over-voltage protection for high reliability without the need for additional surge or over-voltage protection.

The SLM6800 is available in a small form factor QFN4x4-16L package that saves PCB area.

### **Absolute Maximum Ratings**

- Input Supply Voltage (VIN): -0.3V~22V
- BAT: -0.3V~22V
- TM: -0.3V~7V
- Others: -0.3V~VIN+0.3V
- BAT Short Circuit Duration: Continuous
- Maximum junction temperature: 145°C
- Operating Temperature Range: -40°C~85°C
- Storage Temperature Range: -65°C~125°C
- Lead Temperature (Soldering, 10 sec): 260°C

### **Features**

- Up to 20V Input Voltage Protection
- Fully Integrated Power MOSFET
- Up to 92% Output Efficiency
- Maximum 1.5A Adjustable Output Current
- Input Current Automatic Identification, Adapter Adaptation
- Chip High Temperature Automatic Current Limiting and Over Temperature Shutdown Protection
- No External Power MOS
- Accuracy of 8.4V $\pm 1\%$  Charging Voltage
- Charging Status Dual Lamp Indication, No Battery or Fault Status Indication
- Double Cell 5.6V Trickle Charge Voltage Switching
- Integrated Under-voltage and Over-voltage Protection
- Battery Temperature Monitoring
- Output Short Circuit Protection
- Small QFN4x4-16L Package

### **Applications**

- Mobile Phone
- Tablet PC
- Bluetooth Speaker
- Digital Camera
- Mobile Power
- GPS
- Portable Devices, Various Chargers

### Complete Charge Cycle

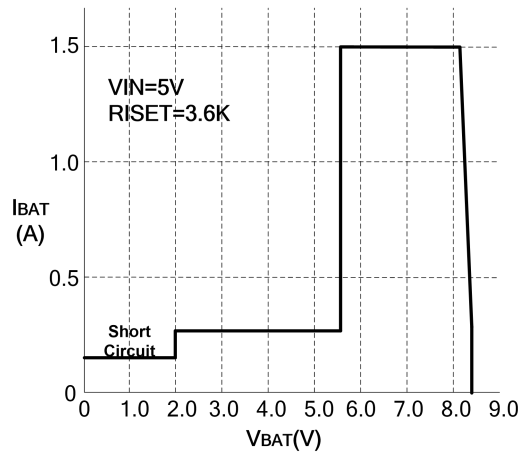


Figure 1

### Typical Application

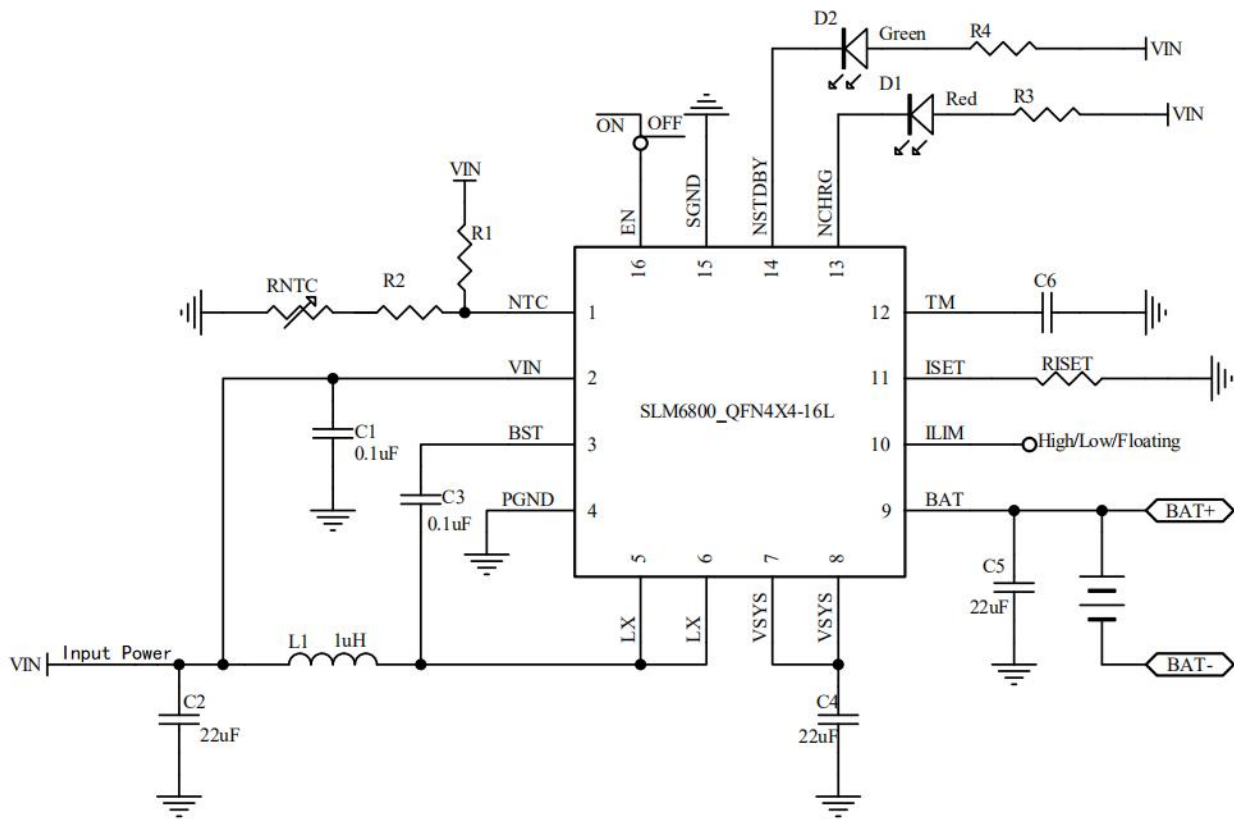


Figure 2

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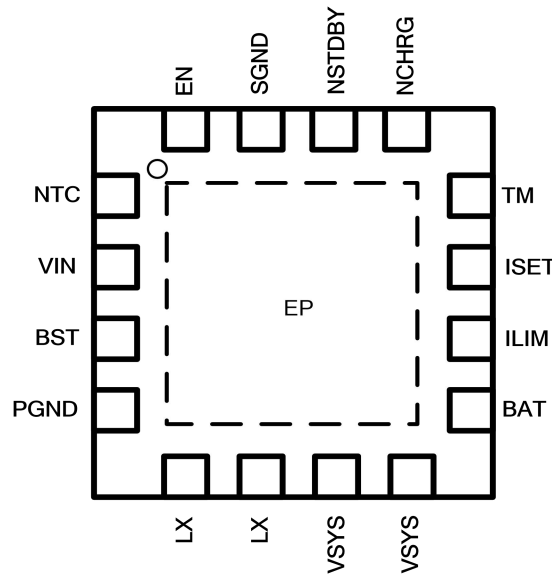
**Pin Configuration**

Figure 3

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**Pin Assignment**

**NTC(Pin1):** Battery temperature monitoring, when the voltage is in the range of 30% to 75% of VIN, the chip is normally charged.

**VIN(Pin2):** The power input terminal is internally integrated with under-voltage and over-voltage protection.

**BST(Pin3):** Bootstrap, a 0.1uF capacitor is connected between the pin and the LX pin to provide drive capability to the internal power MOS.

**PGND(Pin4):** Power ground.

**LX(Pin5, 6):** Switch terminal, external connection inductor.

**VSYS(Pin7, 8):** At the boost output, connect at least one 10uF capacitor to ground.

**BAT(Pin9):** Battery terminal, connected to the battery positive.

**ILIM(Pin10):** Input VIN current limit terminal, there are three states of high, ground, and floating, which can be set to allow the maximum decrease of VIN voltage drop.

**ISET(Pin11):** Charging current setting, the setting formula is  $I_{BAT} = (1.0V / RISET) * 5000(A)$ .

**TM(Pin12):** Charging time limit setting pin.

**NCHRG(Pin13):** The charging indicating end indicates the charging state through the light emitting diode, the light is on when charging, the light is off when the battery is full, and the frequency is blinking at about 1 Hz when the charging is abnormal.



**SLM6800**

***Two-Cell Boost Mode Li-Ion Battery Charger***

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**NSTDBY(Pin14):** The indicator is fully charged, and the state of fullness is indicated by a light-emitting diode. When the battery is full, the light is on, and other status lights are off.

**SGND(Pin15):** Signal ground.

**EN(Pin16):** Enable pin, high active.



# SLM6800

## Two-Cell Boost Mode Li-Ion Battery Charger

### Electrical Characteristics

(Unless otherwise specified,  $V_{IN} = 5V \pm 5\%$ ,  $T_A = 25^\circ C$ ,  $V_{BAT} = 7.6V$ ,  $R_{ISET} = 5.1K\Omega$ , EN is high)

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
V <sub>IN</sub>	Input supply voltage		3.0	5.0	20	V
V <sub>UVLO</sub>	Under-voltage protection voltage	V <sub>IN</sub> rising		2.6	2.9	V
V <sub>UVLO_HYS</sub>	Under-voltage protection hysteresis			100		mV
V <sub>OVLP</sub>	Over-voltage protection voltage	V <sub>IN</sub> rising	5.9	6.3		V
V <sub>OVLP_HYS</sub>	Over-voltage protection hysteresis			350		mV
I <sub>CC</sub>	Input supply current	Standby mode (charge termination)		0.5	1.0	mA
		Stop mode (EN is low)		0.1	5	uA
V <sub>FLOAT</sub>	Regulated output voltage		8.32	8.4	8.48	V
I <sub>BAT</sub>	BAT pin current	R <sub>ISET</sub> =5.1K $\Omega$ , Charging mode	0.9	1.0	1.1	A
		R <sub>ISET</sub> =3.6K $\Omega$ , Charging mode	1.35	1.5	1.65	A
		Standby mode (charge termination), V <sub>BAT</sub> =8.4V		230		uA
		V <sub>IN</sub> is not connected or shutdown mode (EN is low), V <sub>BAT</sub> =8.4V		2.3	5	uA
V <sub>TRIKL</sub>	Trickle charge threshold voltage	V <sub>BAT</sub> rising		5.6		V
V <sub>TRHYS</sub>	Trickle charging hysteresis voltage			340		mV
V <sub>SHORT</sub>	Short circuit protection voltage			2.0		V
I <sub>TRIKL</sub>	Trickle charging current	V <sub>SHORT</sub> <V <sub>BAT</sub> <V <sub>TRIKL</sub> , Charging mode		200		mA
I <sub>SHORT</sub>	Short circuit protection current	V <sub>BAT</sub> <V <sub>TRIKL</sub>		160		mA
I <sub>TERM</sub>	Charge termination current threshold		60	100	150	mA



# SLM6800

## Two-Cell Boost Mode Li-Ion Battery Charger

$\Delta V_{RECHRG}$	Recharge battery threshold voltage		120	225	350	mV
$V_{SYS}$	V <sub>SYS</sub> terminal voltage range	$V_{BAT} \leq 5.6V$	5.6	6.0	6.3	V
		$5.6V < V_{BAT} \leq 8.4V$		$V_{BAT} + 0.1$		V
$f_{OSC}$	On-off level			750		KHz
$V_{INSL}$	Input voltage drop protection	ILIM is low		375		mV
		ILIM is high		500		mV
		ILIM is suspended		650		mV
$R_{LON}$	Low-side drive MOS on-resistance			110		m $\Omega$
$R_{HON}$	High-side drive MOS on-resistance			100		m $\Omega$
$R_{BON}$	Block MOS on resistance			70		m $\Omega$
$T_{TRIKL}$	Trickle charging maximum time	$C_{TM} = 330nF$		0.5		hr
$T_{CC}$	Constant current charging maximum time	$C_{TM} = 330nF$		4.5		hr
$T_{TERM}$	Charge termination detection delay			30		ms
$T_{RCHG}$	Recharge detection delay			30		ms
$V_{NCHRG}$	NCHRG output low level	$I_{NSTDBY} = 5mA$		0.2	0.5	V
$V_{NSTDBY}$	NSTDBY output low level	$I_{NSTDBY} = 5mA$		0.2	0.5	V
$V_{NTC-H}$	NTC high threshold voltage		70	75	80	%VIN
$V_{NTC-L}$	NTC low threshold voltage		28	30	32	%VIN
$V_{EN\_H}$	EN input high level		1.3			V
$V_{EN\_L}$	EN input low level				0.4	V
$T_{LIM}$	Thermal regulation threshold			125		$^{\circ}C$



**SLM6800**  
*Two-Cell Boost Mode Li-Ion Battery Charger*

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TSD	Thermal shutdown temperature hysteresis			150		°C
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### **Principle**

The SLM6800 is a dual-cell Li-Ion battery charging circuit for 5V adapters. It is a synchronous boost converter with a 750KHz switching frequency, fully integrated power MOSFET, for turbulent, constant current and constant voltage charging of series two-cell batteries. The charging current can be programmed with an external resistor. The maximum continuous charging current can reach 1.5A. No other power MOSFET or Schottky diode is needed. The peripheral components are simple, with charging efficiency of up to 92%.

The SLM6800 has an adaptive adapter matching function. When it detects that the input voltage is pulled down to a certain value, the chip will enter the adaptive protection state. At this time, the charging current will decrease, and the output voltage will remain above the set allowable value, protect the adapter output.

The SLM6800 contains two open-drain status indicators, a charge status indicator NCHRG and a fully charged status indicator NSTDBY. The internal power management circuit automatically reduces the charging current when the junction temperature exceeds 125 °C. This function allows the user to maximize the chip processing capability without worrying about chip overheating and damage the chip or damage external components.

The SLM6800 has a battery detection function. When the battery is not connected or the battery is short-circuited, the chip will enter the standby state. At this time, the charging does not work and the NCHRG indicator will flash.

When the battery status is normal and the input voltage is between  $V_{UVLO}$  and  $V_{OVP}$ , the SLM6800 starts charging the battery and the NCHRG pin outputs a low level, indicating that charging is in progress. If the battery voltage is lower than  $V_{TRIKL}$ , the charger will trickle precharge the battery with a small current. When the voltage is higher than  $V_{TRIKL}$ , it will be converted to fast charge. The charge current value can be set by the resistor R<sub>SET</sub>. When the battery voltage approaches  $V_{FLOAT}$ , the charging current will gradually decrease and the SLM6800 enters the constant voltage mode. When the charging current decreases to the charging end threshold  $I_{TERM}$ , the charging cycle ends, the NCHRG terminal outputs a high impedance state, and the NSTDBY terminal outputs a low level.

When the battery voltage drops below the recharge threshold, the SLM6800 automatically begins a new charge cycle. The high-precision voltage reference source inside the chip, the error amplifier and the resistor divider network ensure that the accuracy of the battery-side modulation voltage is within 1%, which satisfies the requirements for accurate charging of lithium-ion batteries and lithium polymer batteries.



### Charging Current Setting

The battery charging currents  $I_{TRIKL}$  and  $I_{BAT}$  are determined by the resistor  $R_{ISET}$  connected to the ISET terminal. The ISET terminal internally presets a 1.0V reference voltage and has a 1/5000 mirror relationship with the  $I_{BAT}$  current. Therefore, the charging current can be set by the following formula:

$$I_{BAT} = \frac{1.0}{R_{ISET}} \times 5000$$

The  $I_{TRIKL}$  current is about 1/5 of the  $I_{BAT}$ , ie:

$$I_{TRIKL} = I_{BAT} \times 0.2$$

The value of the full cutoff current  $I_{TERM}$  is about 1/10 of the  $I_{BAT}$ .

### Charge Termination

When the charging current drops to about  $I_{TERM}$  after reaching the final full voltage, the charging cycle is terminated.

The chip contains a charging voltage and current monitoring module. When the charging voltage reaches  $V_{FLOAT}$  and the charging current is lower than  $I_{TERM}$  and lasts for  $T_{TERM}$ , the SLM6800 terminates the charging cycle. In this state, all loads on the BAT pin must be The battery is used to supply power.

However, if the protective charging current is reduced due to over-temperature or the input voltage is low to  $V_{INSL}$ , the internal charge termination module will be disabled to prevent the battery from being properly charged due to temporary protective measures of the chip.

The SLM6800 continuously monitors the BAT pin voltage while the battery is fully charged and in standby mode. If the pin voltage drops below the recharge threshold of  $V_{FLOAT}$  by  $\Delta V_{RECHRG}$  and continues  $T_{RCHG}$ , another charge cycle begins and supplies current to the battery again.

### Maximum Charging Time Setting

A timing function is integrated inside the chip, and the maximum charging time can be set by the capacitor  $C_{TM}$  connected to the TM terminal. The maximum charging time for fast charging can be calculated as follows:

$$T_{CC}(hr) = \frac{C_{TM}(nF)}{73}$$

The maximum charging time for trickle charging is about 1/9 of TCC.

When the charging time reaches the set maximum charging time and the battery is not fully charged, the chip will stop charging and switch to the abnormal indication state. At this time, the NCHRG indicator will flash and the NSTDBY indicator will turn off.

Grounding the TM pin directly turns off the internal timing function of the chip. At this time, the charging time will not be limited.

### **Adapter Adaptive Protection**

The SLM6800 has an adapter self-adaptive function. When it is connected to VIN, the chip will first self-test and record the value of VIN. When the self-test is completed, it will enter the boost charging state. At this time, the VIN value may be due to the adapter. The load capacity limit or the internal resistance loss of the wire is reduced. The chip compares the value of VIN with the previously recorded value in real time during the whole work. When the voltage is found to decrease  $V_{INSL}$ , the charging current is automatically reduced to ensure VIN. The value does not drop above the  $V_{INSL}$  value, which ensures that the adapter is not overloaded, so the SLM6800 is suitable for a wide range of DC devices as well as standard USB charging devices.

### **Charging Status Indication**

The SLM6800 has two open-drain status indication outputs, NCHRG and NSTDBY, which can be connected to red and green LEDs respectively. When the charger is in the charging state, the red indicator light is on and the green indicator is off; when the charger is in the full state, the red indicator light is off and the green indicator light is on.

When the input VIN is over voltage, the battery is shorted or the NTC voltage is detected to be too high or too low, or the charging timeout occurs, the green indicator light is off and the red indicator light flashes at 1 Hz.

When the battery is not connected, and the NTC voltage is normal, the green indicator light is always on, the red indicator light is blinking, the blinking frequency is related to the BAT terminal capacitance, and the flashing frequency is about 1~4Hz under the 10uF capacitor.

When the battery is not connected, and the NTC is connected high, the green light is on and the red light is off. At this time, the chip works in a pure boost state, and can be used as a DC-DC boost chip, and the output voltage is  $V_{FLOAT}$ .

The corresponding status of the indicator status can be found in the following table:

<b>Charging Status</b>	<b>Red Light NCHRG</b>	<b>Green Light NSTDBY</b>
Charging	Light	Dark
Charging done	Dark	Light
VIN over-voltage, battery short circuit or NTC abnormality	1Hz flicker	Dark
The battery is not connected and the NTC is normal.	1~4Hz flicker	Light
The battery is not connected and the NTC is connected high	Dark	Light
Other state	Dark	Dark

### Chip Over Temperature Protection

If the die temperature rises above the preset value of TLIM, an internal thermal feedback loop will reduce the charge current until the chip above TSD is completely turned off. This feature prevents the SLM6800 from overheating and allows the user to increase the power handling capability of a given board within the SLM6800's allowable range.

### Battery Temperature Monitoring

In order to prevent damage to the battery caused by excessive or too low temperature, the SLM6800 integrates a battery temperature monitoring circuit.

Battery temperature monitoring is achieved by measuring the voltage of the NTC pin. The voltage of the NTC pin is implemented by the NTC thermistor in the battery and a resistor divider network, as shown in Figure 2.

The SLM6800 compares the voltage at the NTC pin to the two thresholds VNTC\_L and VNTC\_H inside the chip to verify that the battery temperature is outside the normal range. If the voltage of the NTC pin is VNTC < VNTC\_L or VNTC > VNTC\_H, it means that the temperature of the battery is too high or too low, and the charging process will be suspended.

If NTC is connected to VIN, the chip is in a pure boost state, the chip is equivalent to a switching power supply, and the output voltage is VFLOAT.

If the NTC is grounded, the chip stops charging.

The values of R1 and R2 in Figure 2 are determined according to the temperature monitoring range of the battery and the resistance value of the thermistor.

Assume that the set temperature range is VL~VH, the negative temperature coefficient thermistor (NTC) is used in the battery, RTL is the resistance value at temperature TL, and RTH is the resistance value at temperature TH, then RTL > RTH. At temperature TL, the voltage at the NTC terminal is:

$$V_{TEMPL} = \frac{R2 + R_{TL}}{R1 + R2 + R_{TL}} \times VIN$$

At temperature TH, the voltage at the NTC terminal is:

$$V_{TEMPH} = \frac{R2 + R_{TH}}{R1 + R2 + R_{TH}} \times VIN$$

By VTEMPL=VHIGH=K2×VIN (K2=VNTC\_H)

VTEMPH=VLOW=K1×VIN (K1=VNTC\_L)

Available:

$$R2 = \frac{K2(1 - K1)R_{TH} - K1(1 - K2)R_{TL}}{K1 - K2}$$

$$R1 = \left(\frac{1}{K2} - 1\right) \times (R2 + R_{TL})$$

It can be seen from the above derivation that the temperature unit to be set is independent of the power supply voltage VIN, and is only related to R1, R2, RTH, and RTL. RTH and RTL can be known by consulting the relevant battery manual.

In practical applications, if you only care about the temperature characteristics of one end, such as overheat protection, you can only connect R1.

### **Input Under-voltage, Over-voltage Protection**

The SLM6800 integrates a high-voltage MOSFET integrated to withstand a maximum input voltage of 20V, and an integrated input monitoring circuit internally monitors the input voltage for continuous real-time monitoring. The SLM6800 will only start and operate normally when the VIN voltage is in the appropriate range. When the VIN voltage is lower than  $V_{UVLO}$ , the chip is in under-voltage protection state. When the VIN voltage is higher than  $V_{OVP}$ , the chip is in over-voltage protection state. In the under-voltage or over-voltage state, the chip will not turn on the boost or charge circuit, and During the chip process, the input voltage monitoring will be performed in real time. At any time, the VIN voltage is detected to leave the allowed working range, and the boosting and charging process is immediately terminated to protect the chip, battery or other related components from damage.

### **Automatic Restart**

After a single charge cycle, the SLM6800 immediately uses a comparator with a 30ms filter time ( $T_{RCHG}$ ) to continuously monitor the battery voltage on the BAT pin. When the battery voltage drops below  $V_{FLOAT}$  by  $\Delta V_{RECHRG}$ , the boost and charge cycles resume. To prevent the battery from being too low due to working discharge.

### **Batteryless Boost Mode**

The SLM6800 can be set to operate in a battery-free boost mode. When VIN is in the operating voltage range and the NTC voltage is connected to VIN, the SLM6800 can be used as a DC-DC boost circuit. In this mode of operation, when the BAT load is applied. Normally, the SLM6800 will output a constant  $V_{FLOAT}$  voltage with no charge termination and is not limited by the maximum charge time. When the BAT load is too heavy, the SLM6800 will output a constant current and the output current will be limited to the value set by ISET. In particular, in this mode of operation, the indicator end NCHRG is in a high impedance state and NSTDBY is pulled low.

### **Input and Output Capacitor**

At the VIN, VSYS, BAT, etc., each need to have a high-quality power capacitor. It is recommended that the capacitance of these three terminals be no less than 10uF chip capacitor and be close to the chip, and use a larger capacitor, corresponding output ripple is smaller and better EMI characteristics. If a battery-free boost mode is to be used, it is recommended to connect a 100uF electrolytic capacitor in parallel at the BAT terminal to improve the stability of the loop operation.

### ***Inductor Selection***

The SLM6800 has a switching frequency of approximately 750KHz, so it is possible to select a power inductor with a lower inductance. The choice of inductor must take into account factors such as output ripple, maximum current capability, and efficiency.

Output ripple is the primary consideration, and a larger inductance corresponds to a lower output ripple. However, a larger inductance often means a larger inductor cost, volume, and DC resistance, considering the performance requirements. Is the best choice.

In general, a power inductor with an inductance of 0.68uH~3.3uH can meet the application requirements. The current capability of the inductor must be more than twice the set charging current, and the DC resistance (DCR) is as small as possible. It is recommended that  $DCR < 10m\Omega$ .

### ***PCB Layout and Thermal Considerations***

For main path currents and power to ground paths, use wide and short lines. The input/output capacitors and electrical induction are placed as close as possible to the chip. Use a power ground and a different analog ground to reduce the effects of ground noise. Place the ground as close as possible to the chip.

The QFN4x4-16L package has a small external size. Due to the thermal dissipation of the chip, the layout of the PCB requires special attention to improve the heat dissipation capability and reduce the temperature of the chip and the PCB. The heat dissipation path for dissipating the heat generated by the IC goes from the chip to the lead frame and through the heat sink at the bottom to the copper surface of the PCB. The copper foil of the PCB is used as the main heat sink of the IC, and its area should be as wide as possible and extend outward to a large copper foil area to spread heat to the surrounding environment.

Placing vias on the PCB to the inner or back layer also has a significant effect in improving the overall thermal performance of the charger, see Figure 3. At the position of the SLM6800 PCB, place a square PAD as the heat sink of the SLM6800, and place several vias on the PAD as the heat dissipation holes. When the chip is soldered, the solder is poured from the back layer of the PCB, so that the heat sink on the bottom of the SLM6800 is effectively connected with the heat sink of the PCB board, thereby ensuring efficient heat dissipation of the SLM6800. The efficient heat dissipation of the chip is a prerequisite for ensuring that the chip maintains a large charging current for a long time.

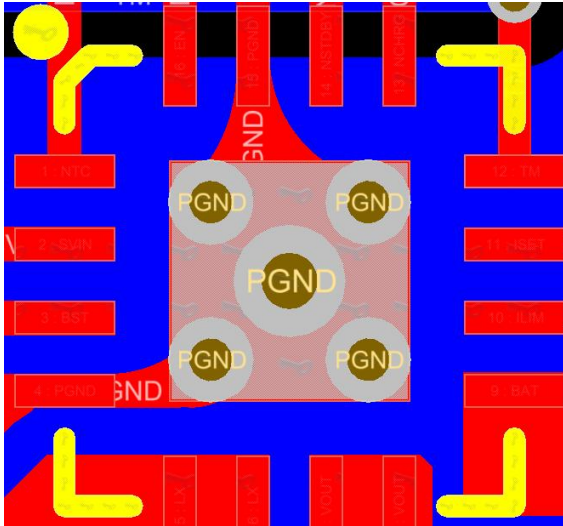


Figure 4

When designing the PCB layout, other heat sources on the board that are not related to the charging IC should also be considered, as their own temperature will have an effect on the overall temperature rise and maximum charging current.

### Application Information

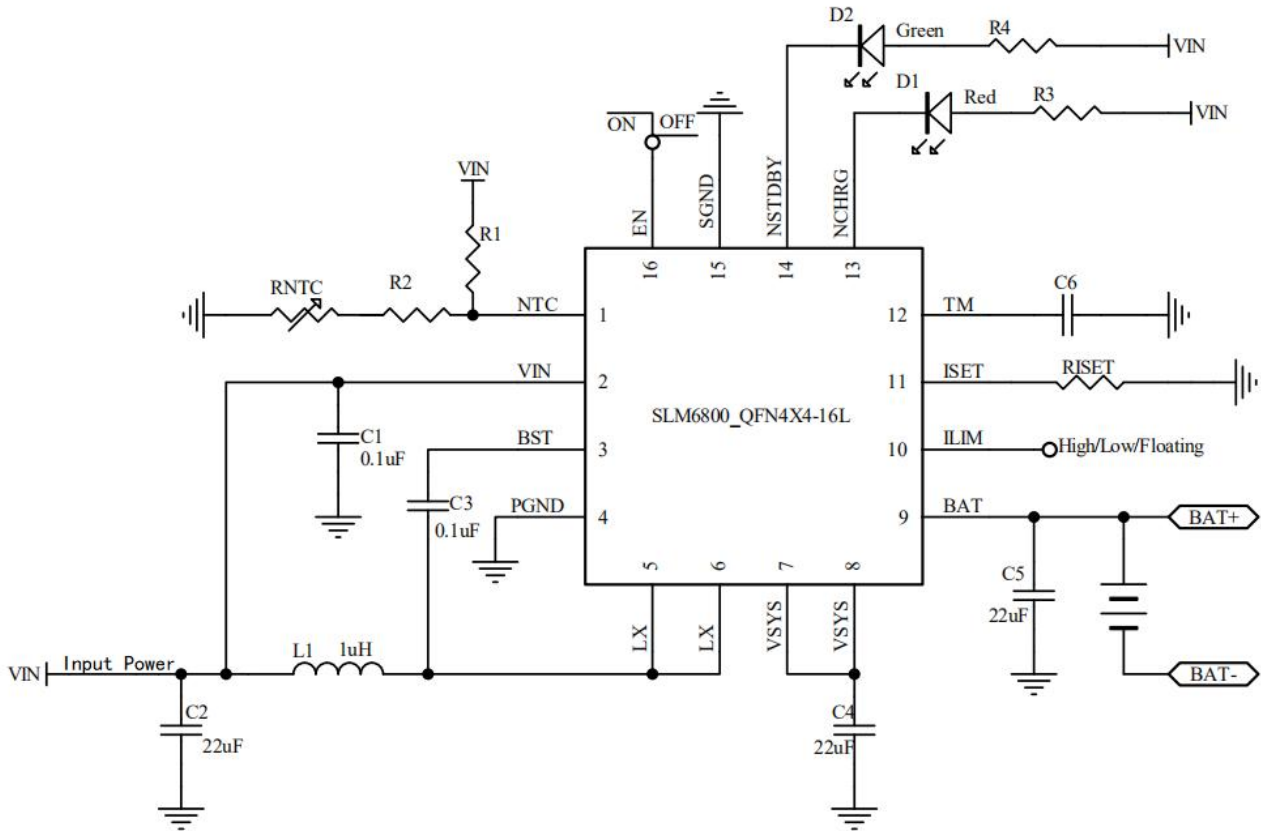
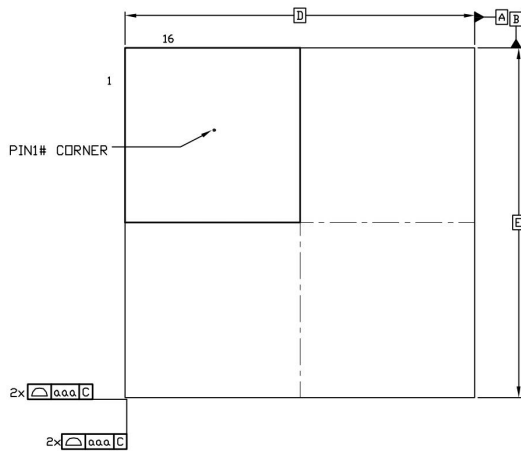


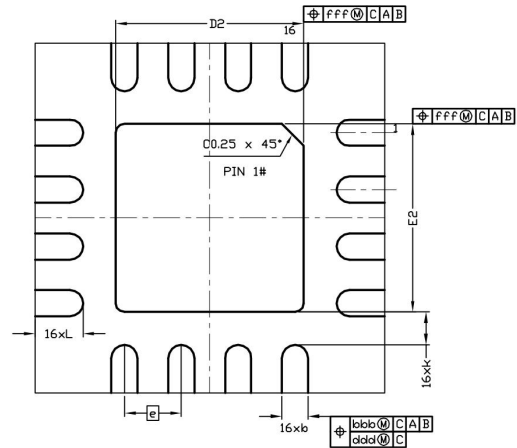
Figure 5

### Package Description

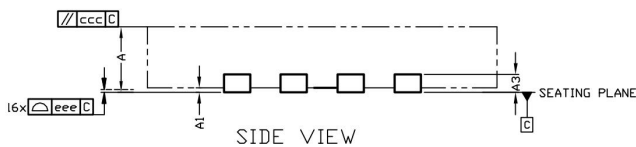
#### QFN4X4-16L Package (Unit: mm)



TOP VIEW



BOTTOM VIEW



SIDE VIEW

DIM SYMBOL	MIN.	NOM.	MAX.
A	0.70	0.75	0.80
	0.85	0.90	0.95
A1	0	0.02	0.05
A3	-	0.20 REF	-
b	0.25	0.30	0.35
D	4.00BSC		
E	4.00BSC		
D2	2.05	2.15	2.25
E2	2.05	2.15	2.25
e	0.65BSC		
L	0.50	0.55	0.60
K	0.20	-	-
aaa	0.10		
bbb	0.10		
ccc	0.10		
ddd	0.05		
eee	0.08		
fff	0.10		