SLM6900

Multi-Cell Li-Ion Battery Switching Charger

Description

The SLM6900 is a charging circuit that supports multi-cell lithium or lithium iron phosphate batteries. It is preset with a three- or four-cell lithium battery charging mode and supports other output voltage modes that are regulated by a peripheral divider resistor. It is a step-down switching converter with a fixed frequency of 300KHz, so it has high charging efficiency and very low heat generation.

The SLM6900 includes a complete charge termination circuit, automatic recharge, and a charge voltage control circuit with an accuracy of ±1.0%. It integrates input low voltage protection, output short circuit protection, and battery temperature protection.

The SLM6900 is housed in a TSSOP-14L package and has a simple peripheral application as an efficient charger for large-capacity batteries.

Absolute Maximum Ratings

- COMP: -0.3V~7.5V
- VIN: -0.3V~45V(Inrush)
  -0.3V~30V(Continuous)
- Others: -0.3V~VIN+0.3V
- BAT Short Circuit Duration: Continuous
- Maximum Junction Temperature: 145℃
- Operating Temperature Range: -40℃~85℃
- Storage Temperature Range: -65℃~125℃
- Lead Temperature (Soldering, 10 sec): 260℃

Features

- Wide Input Voltage Range
- 300KHz Fixed Switching Frequency
- Preset 3 or 4 Lithium Battery Output Voltages
- Adjustable Output Voltage
- Output Voltage Accuracy: ±1.0%
- Charging Status Dual Indication, No Battery and Fault Status Indication
- Low voltage trickle charging function
- Soft Start Limits Inrush Current
- Battery Temperature Monitoring Function
- High Surge Voltage Capability
- Packaging with TSSOP-14L

Applications

- Handheld Device
- Laptop
- Convenience Industrial or Medical Equipment
- Power Tools
- Lithium Battery or Lithium Iron Phosphate Battery

Pin Configuration

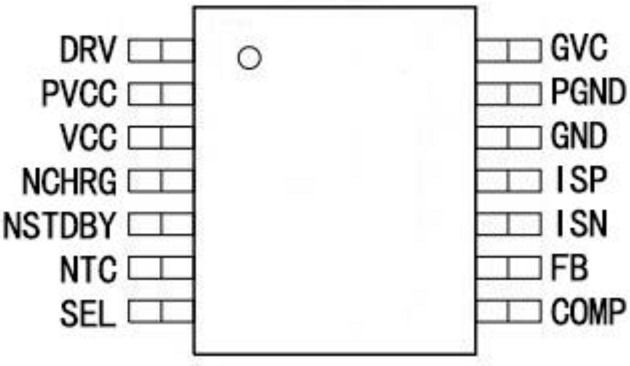


Figure 1

Pin	Name	Description
1	DRV	Power MOSFET Gate Driver
2	PVCC	Gate Driver Supply Input
3	VCC	Chip Supply Input
4	NCHRG	Battery Charging Indicator
5	NSTDBY	Battery Charging Done Indication
6	NTC	Battery Temperature Detection
7	SEL	Output Voltage Selection
8	COMP	Loop Stability Compensation
9	FB	Battery Voltage Feedback
10	ISN	Charge Current Sense Negative Terminal
11	ISP	Charge Current Sense Positive Terminal
12	GND	Small Signal Ground
13	PGND	Gate Driver Ground
14	GVC	Gate Driver Voltage Clamp

Pin Assignment

DRV(Pin1): External PMOS transistor gate drive terminal. This terminal voltage is clamped by GVC within the range of VCC-6.3V (Typ.), so that the external PMOS can be selected with a low V_{GS} type to improve charging efficiency and reduce cost.

PVCC, VCC(Pin2、3): Power supply voltage terminal.

NCHRG(Pin4): Charge status indicator. When the charger charges the battery, the pin is pulled low by the internal switch, indicating that charging is in progress, otherwise the pin is in a high impedance state.

NSTDBY(Pin5): Charging completion indicator. When the battery is fully charged, the pin is pulled low by the internal switch, indicating that charging is complete. Otherwise the pin is in a high impedance state.

NTC(Pin6): The battery temperature detection terminal connects this terminal to the negative temperature coefficient thermistor of the battery. If this function is not used, it will be suspended or connected to VCC, and the grounding will turn off the charging function.

SEL(Pin7): Battery output voltage selection terminal. If this terminal is grounded, it is selected as a 3-cell lithium battery solution, if it is connected to VCC, it is a 4-cell lithium battery solution, if it is left floating, the battery full voltage is determined by an external voltage dividing resistor.

COMP(Pin8): Charging loop stability compensation terminal. Connect a series resistor and capacitor to ground.

FB(Pin9): Battery voltage feedback terminal. When SEL is connected to GND or VCC, the series resistor can slightly increase the saturation voltage to compensate for the line and battery internal resistance loss. When the SEL is floating, the FB terminal is fixed at 1.2V, and the external charging resistor determines the battery charging voltage.

ISN(Pin10): Charge current detection negative terminal. Connect this terminal to the negative terminal of the charge current setting resistor.

ISP(Pin11): The charging current is detected at the positive terminal. Connect this terminal to the positive terminal of the charge current setting resistor.

GND, PGND(Pin12、13): Power ground.

GVC(Pin14): Drive the gate voltage clamp. A 100nF capacitor is connected between this terminal and VCC, so that the external driver tube gate voltage is clamped within a range of not less than VCC-6.3V.

Electrical Characteristics

(Unless otherwise specified, VIN=15V, TA = 25℃)

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
VIN	Input supply voltage		6.8		28	V
I_{CC}	Input supply current	Standby mode (charge termination)		0.75	1.5	mA
		Shutdown mode (VIN<V_{BAT} or VIN<V_{UV}, or SEL=GND)			35	uA
V_{FLOAT}	Regulated output voltage	SEL= Low	12.47	12.60	12.73	V
		SEL= High, VIN=20V	16.63	16.80	16.97	V
V_{FB}		SEL Open	1.193	1.205	1.217	V
I_{BAT}	BAT Pin leakage current	V_{BAT} = V_{FLOAT} + 0.2V		10	15	uA
		Shutdown mode (VIN<V_{BAT} or VIN<V_{UV} or NTC ground)			15	uA
I_{CHRG}	Fast charging current	V_{BAT}>V_{TRIKL}, RS=0.05Ω, Current mode	2.2	2.4	2.6	A
I_{TRIKL}	Trickle charging current	V_{BAT}<V_{TRIKL}, RS=0.05Ω, Current mode		550		mA
V_{TRIKL}	Trickle charge threshold voltage	VBAT rising (SEL ground)		8.4		V
		VBAT rising, VIN=20V (SEL is high)		11.2		V
		VBAT rising (SEL is suspended)		66		%VFB
V_{TRHYS}	Trickle charging hysteresis voltage		60	100	150	mV
V_{UV}	VIN under-voltage lockout threshold	From VIN low to high		7.2		V
V_{UV_HYS}	VIN under-voltage lockout hysteresis			400		mV
V_{ASD}	VIN-V_{BAT} blocking threshold voltage	VIN From low to high	50	250	350	mV
		VIN From High to low	20	150	250	mV
I_{TERM}	Charge termination current threshold	RS=0.05Ω	100	200	300	mA
V_{NCHRG}	NCHRG pull down voltage	I_{NCHRG}=5mA		0.3	0.6	V

V_{NSTDBY}	NSTDBY pull down voltage	I_{NSTDBY}=5mA		0.3	0.6	V
I_{NTC}	NTC pin current		45	50	55	uA
V_{NTCH}	NTC High-end flip voltage			1.46		V
V_{NTCH_HYS}	NTC High-end flip voltage hysteresis			100		mV
V_{NTCL}	NTC Low-end flip voltage			190		mV
V_{NTCL_HYS}	NTC Low-end flip voltage hysteresis			40		mV
ΔV_{RECHRG}	Recharge battery threshold voltage	SEL Low		450		mV
		SEL High, VIN=20V		600		mV
		SEL suspended		3.6		%VFB
f_{OSC}	Oscillating frequency		250	300	350	KHz
D_{MAX}	Maximum duty cycle			95		%
V_{DRV-H}	DRV high level	VCC-V_{DRV}		60		mV
V_{DRV-L}	DRV low level	VCC-V_{DRV}		6.5	7.5	V
t_r	DRV rise time	C_{LOAD}=1.5nF		30		ns
t_f	DRV fall time	C_{LOAD}=1.5nF		30		ns
t_{SS}	Soft start time			30		ms
t_{RECHRG}	Recharge comparator filter time			10		ms
t_{TERM}	Charging termination comparator filter time			10		ms

Principle

The SLM6900 is a charging circuit that supports multi-type lithium or lithium iron phosphate batteries. It is preset with a three- or four-cell lithium battery charging mode and supports other output voltage modes that are regulated by a peripheral divider resistor. It is a synchronous buck converter with a fixed frequency of 300KHz. It has extremely high charging efficiency, supports high-power charging, and has very low heat generation.

The SLM6900 contains two open-drain status indicators, a charge status indicator NCHRG and a charge done status indicator NSTDBY.

When the input voltage is greater than V_{UV}, the SLM6900 begins to charge 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 trickles the battery with a small current. When the constant current mode charges the battery, the charging current is determined by the resistance RS. When the battery voltage approaches V_{FLOAT}, the charging current will gradually decrease and the SLM6900 enters the constant voltage mode. When the charging current decreases to the charging end threshold, the charging cycle ends, the NCHRG terminal outputs a high-impedance state, and the NSTDBY terminal outputs a low level. The charge cutoff current threshold is I_{TERM}.

When the battery voltage drops below the recharge threshold, the SLM6900 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. When the input voltage is powered down or the input voltage is lower than the battery voltage, the charger enters a low-power sleep mode, and the battery terminal consumes less than 15uA, which increases standby time.

Charging Current Setting

The current I_{BAT} of the battery is determined by the external current detecting resistor Rs connected to the ISP terminal and the ISN terminal. The relationship between the resistance and the I_{BAT} is shown in Table 1. Rs can be determined by the ratio of the adjusted threshold voltage Vs and the constant current charging current across the resistor, and the voltage Vs across Rs in the constant current state is 120 mV.

Set the resistor and charge current using the following formula:

RS=0.12 / I_{BAT} (Current unit A, resistance unit Ω)

For example: you need to set the charging current 1.2A, and bring it into the formula to calculate Rs=0.1Ω

R_S	I_{BAT}
0.1 ohm	1.2A
0.067 ohm	1.8A
0.05 ohm	2.4A
0.033 ohm	3.6A

Table 1

Charging Voltage Setting

SLM6900 IC is preset with a three or four-cell lithium battery charging mode, which can be set by SEL Pin. When SEL Pin is linked with GND, SLM6900 IC works in the output mode of three lithium batteries with a typical fulled charge voltage, which is 12.6V. If SEL Pin is connected with VCC, SLM6900 IC works in the output mode of four lithium batteries with a typical fulled charge voltage, which is 16.8V. As the same time, users can link a resistor at FB port, which can further increase the fulled voltage to compensate for the insufficient charge caused by parasitic resistance. As shown in R4_OPT in fig2. The specific compensation voltage can be estimated as follows：

$$\Delta V = R4\_OPT \times 0.00001$$

If SEL Pin is suspended, the output fulled voltage of SLM6900 will be determined by the external voltage driver. The application figure is shown in figure3, and the specific fulled voltage can be calculated as follows:

$$V_{FLOAT} = 1.205 \times \frac{R4 + R5}{R5}$$

In this mode, its output voltage has a great degree of freedom, which can meet various requirements within the voltage range of 5V to VCC. It can be used for charging lithium battery, lithium iron phosphate battery, ternary battery and other rechargeable batteries ,in addition,R4+R5>1Mohm.

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}, the SLM6900 terminates the charging cycle. In this state, all loads on the BAT pin must be powered by the battery.

In full standby mode, the SLM6900 continuously monitors the BAT pin voltage. If the pin voltage drops below the recharge threshold of the V_{FLOAT} voltage by ΔV_{RECHRG}, another charge cycle begins and supplies current to the battery again.

Charging Status Indication

The SLM6900 has two open-drain status indicator outputs.

NCHRG and NSTDBY, in general, NCHRG is connected to red light, and NSTDBY is connected to green light. When the charger is in the charging state, NCHRG is pulled low, NSTDBY is in high impedance state, that is, red light is on, green light is off; when in full state, NSTDBY is pulled low, NCHRG is in high resistance State, green light is on, red light is off; when the charging state is abnormal, NCHRG and NSTDBY are in high impedance state, and both lights are off.

When the battery is not connected, the NCHRG pin outputs a pulse. When the external capacitor of the BAT pin is 10uF,the NCHRG flicker frequency is about 1-4Hz. When the indication function is not required, the unused status indication output is connected to ground.

Charging Status	Red Light NCHRG	Green Light NSTDBY
Charging	Light	Dark
Charging done	Dark	Light
VIN over-voltage, battery short circuit or NTC abnormality	Dark	Light
The battery is not connected, the BAT pin is connected to the 10uF capacitor	Green light is on, red light is flashing F=1～4 Hz	

Table 2

Battery Temperature Monitoring

In order to prevent damage to the battery caused by excessive or too low temperature, the SLM6900 integrates a battery temperature monitoring circuit.

Battery temperature monitoring is achieved by monitoring the thermistor that is in close proximity to the negative temperature coefficient of the battery. The thermistor is connected between NTC and GND.

Inside the chip, the NTC pin is connected to the input of two voltage comparators with a low voltage threshold of 190mV, corresponding to the upper temperature point of the normal temperature range; the high voltage threshold is 1.46V, corresponding to the lower temperature point of the normal temperature range. If the voltage of the NTC pin is within this range, the chip is normally charged, otherwise the battery temperature is too high or too low, and the charging process will be suspended.

The pull-up current of the NTC pin is 50uA, so the thermistor value of the negative temperature coefficient should be 10KΩ at 25°C, and the value is about 3.8KΩ (about 52°C) at the upper limit temperature point. The value is approximately 29 KΩ (approximately -1°C). Users can choose the right model according to their specific needs.

If you need to adjust the upper or lower temperature protection point, you can do this by connecting a normal resistor in parallel with the thermistor or in series.

If the battery temperature monitoring function is not required, the NTC pin can be left floating or connected to VIN.

Power Mosfet Selection

The DRV pin of the SLM6900 is used to drive an off-chip power PMOS field effect transistor. The performance of the PMOS tube directly affects the charging efficiency and stability of the battery.

The SLM6900 is internally equipped with a PMOS transistor gate voltage clamp circuit, which can clamp the gate voltage turn-on voltage V_{GS} of the off-chip power transistor to about 6.5V. Therefore, the off-chip power transistor can be selected with a low V_{GS} model without worrying about the input voltage. The super-gate is under pressure and damages the peripherals. In general, low V_{GS} models of MOS tubes offer lower cost and higher turn-on performance, resulting in higher charging efficiency.

Input and Output Capacitor

The input and output capacitors directly affect the stability of the charging circuit operation. The input capacitor filters the input voltage and needs to absorb the large ripple current generated by the PMOS transistor switch when the SLM6900 is operating. Therefore, the input capacitor must have sufficient filtering capability. It is recommended to use multiple low ESR ceramic capacitors in parallel for better filtering.

The output capacitor can reduce the ripple voltage at the output and improve the transient characteristics. Under normal circumstances, ceramic capacitors of 10uF~22uF can meet the application requirements.

Inductor Selection

In order to ensure system stability, the system needs to ensure continuous operation (CCM) during the pre-charging and constant-current charging phases. According to the inductor current formula:

$$\Delta I = \frac{1}{L \times FS}\left(\frac{V_{IN} - V_{BAT}}{V_{IN}}\right) \times V_{BAT}$$

ΔI is the inductor ripple and FS is the switching frequency. In order to ensure that both pre-charging and constant-current charging are in CCM mode, ΔI takes the pre-charging current value, which is 1/10 of constant current charging, which can be calculated according to the input voltage requirement. Inductance value.

The inductance is 10uH~20uH. The rated current of the inductor is selected to be larger than the charging current, and the internal resistance is small. At the same time, in order to ensure a low electromagnetic radiation, the inductor is preferably a chip-type shielding inductor.

Diode Selection

D1 and D2 in the typical application diagram are Schottky diodes. The D1 acts to prevent battery current from being reversed to the input, and D2 is the inductor's freewheeling diode. Both diodes have a current capability that is at least greater than the charge current and the withstand voltage is greater than the maximum input voltage.

If the anti-backfill diode D1 is not used, the charging circuit can work normally, and the charging efficiency will be higher because the power consumption on the D1 is subtracted.However, since there is no anti-backflow function, when the VIN is not connected.

There will be 40uA.Leakage current flows from the battery through the off-chip PMOS transistor to VIN, which increases the standby power consumption of the battery and affects the standby time. The user can consider various factors.

PCB Layout Consideration

Good PCB design is very important to ensure long-term stable operation of the SLM6900 charging circuit.

When the SLM6900 is charging, the DRV pin is in constant switching state. In order to minimize EMI, the input capacitor, off-chip PMOS FET, two Schottky diodes, inductors, etc. must be as short as possible, and the input capacitor should be close to the PMOS. The source of the tube. At the same time, in order to reduce the interference of the switching ripple on the SLM6900, a capacitor should also be placed between VIN and GND. This capacitor should be close to the SLM6900.

The compensation capacitor connected to the COMP pin should be returned as close as possible to the GND of the SLM6900, which will prevent the GND and PGND noise from disturbing the stability of the loop.

As a current sense pin, the ISP and ISN should be connected directly to both ends of the RS resistor for the most accurate charge current monitoring results.

The SLM6900 chip itself generates very little heat, but off-chip power devices such as PMOS, diodes, inductor, etc., will generate a large amount of heat during high-power charging. The area of the PCB must be considered to have sufficient heat dissipation capacity to meet the long Time is stable and reliable.

Application Information

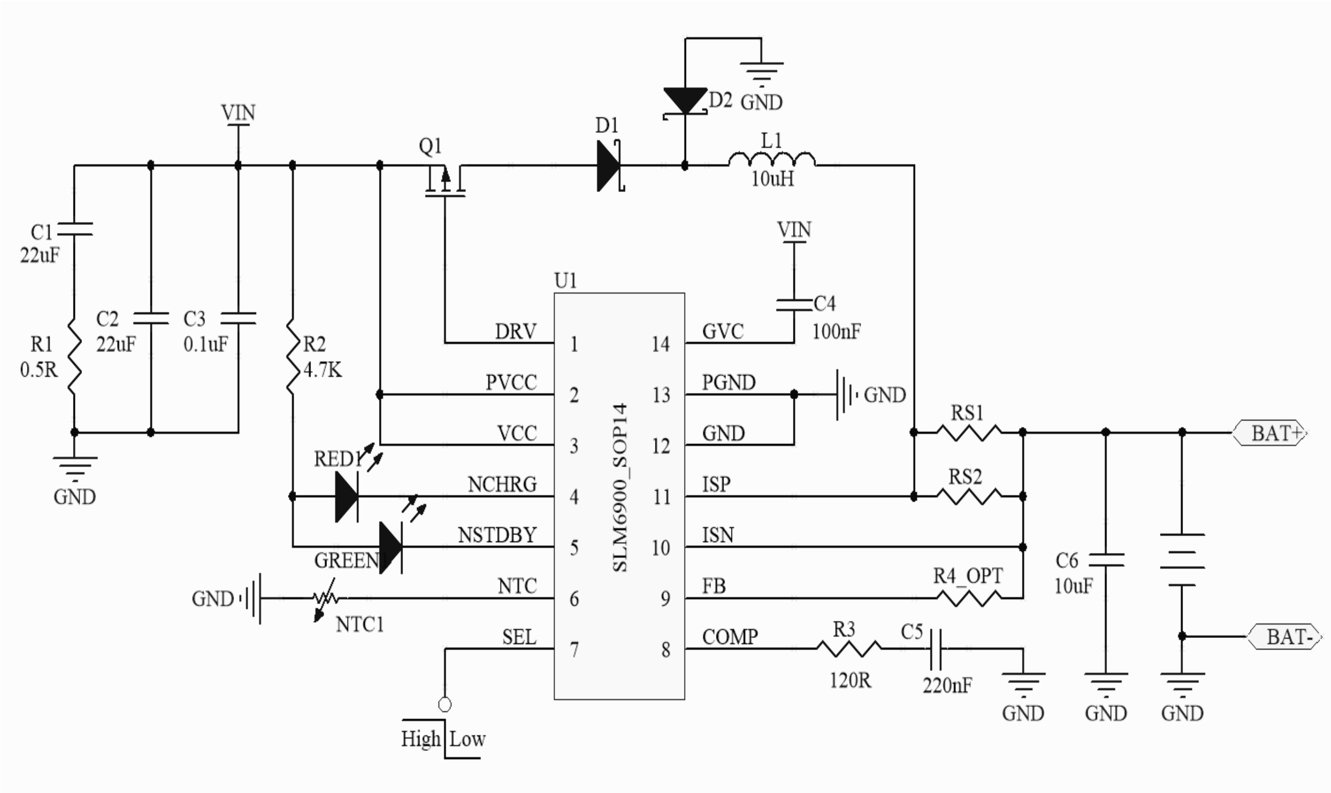


Figure 2. Typical application circuit
(Preset three- and four-cell lithium battery charging mode)

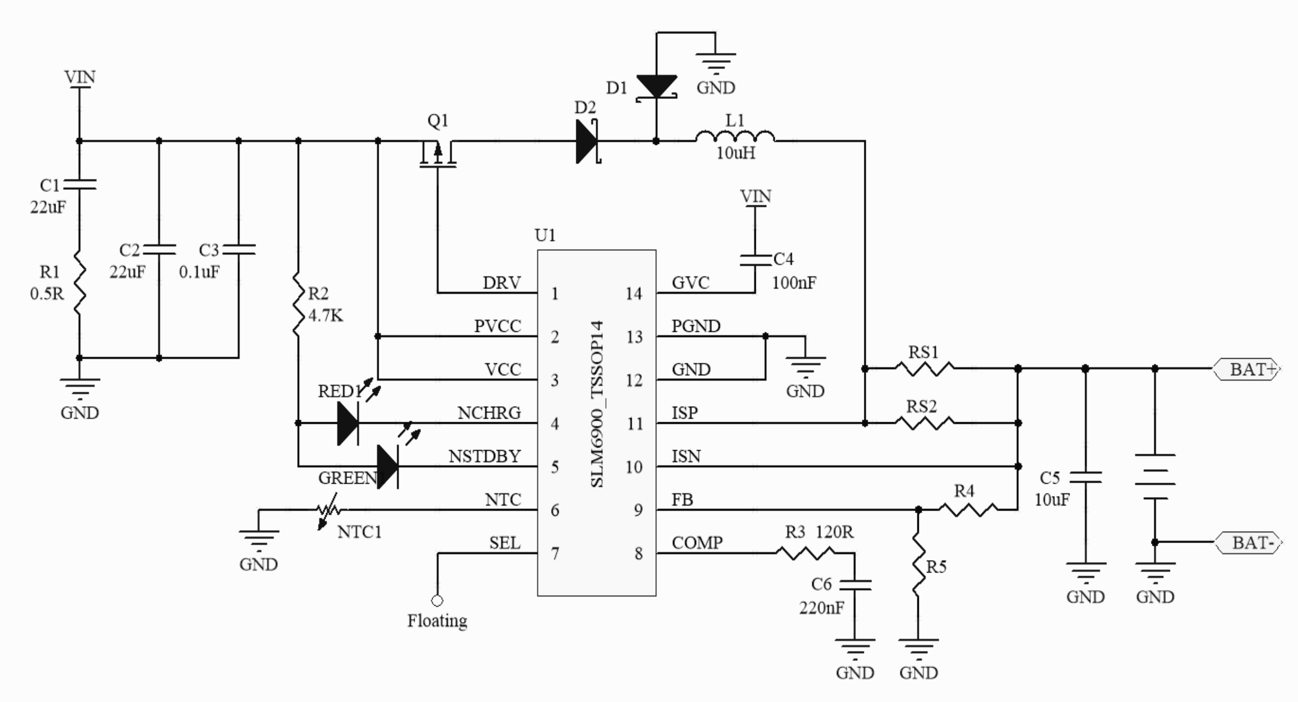
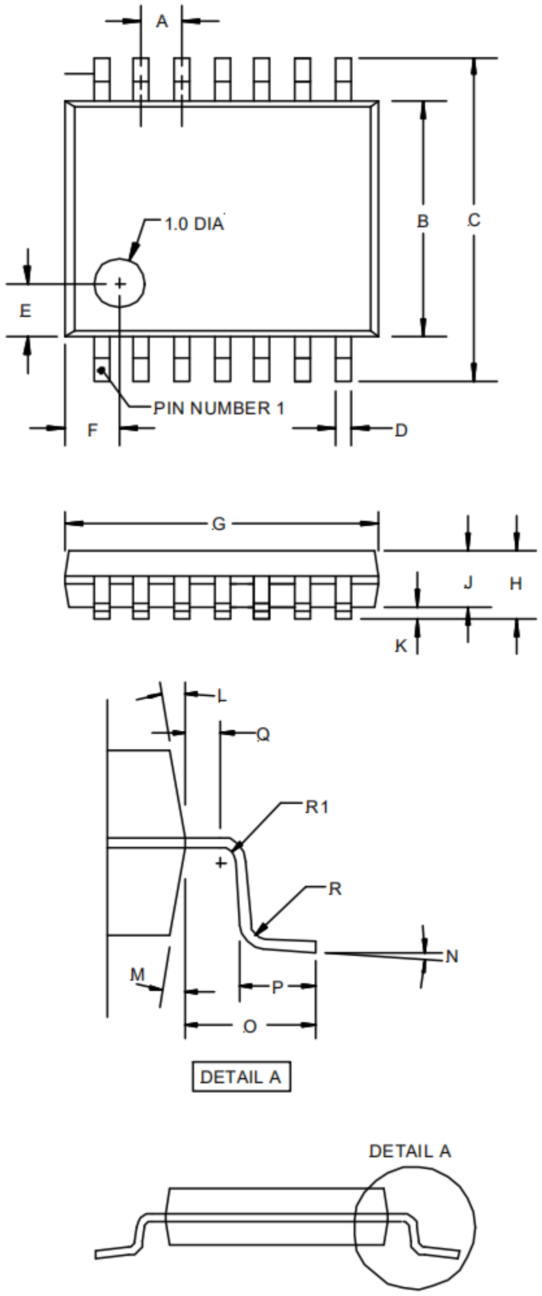


Figure 3. Typical application circuit
(Other output voltage modes adjusted by peripheral voltage divider resistors)

Package Description

TSSOP-14L Package (Unit: mm)



SYMBOL DESIG	14-PIN		
	MIN	NOM	MAX
A	0.65 BSC		
B	4.30	4.40	4.50
C	6.40 BSC		
D	0.19	---	0.30
E	1.00		
F	1.00		
G	4.90	5.00	5.10
H	---	---	1.10
J	0.85	0.90	0.95
K	0.05	---	0.15
L	12 REF		
M	12 REF		
N	0	---	8
O	1.00 REF		
P	0.50	0.60	0.75
Q	0.20		
R	0.09	---	---
R1	0.09	---	---