Description

SM5102 is a dedicated lithium battery charge and discharge management IC. During charging, it charges 3.7 V lithium-ion batteries with a maximum configurable charging current of 1 A. In discharge mode, it adopts a synchronous buck converter with a 1MHz switching frequency, delivering discharge current up to 3A. It integrates under-voltage protection, short-circuit protection, and thermal over-temperature protection circuits on chip. SM5102 provides indicator signals for charging, full-charge, and short-circuit states. The NTC pin monitors battery temperature in real time to guarantee battery safety. The quiescent current of the SM5102 under no-load condition is only 6μA.

Application

- **Replaces traditional 1.5V dry cell**

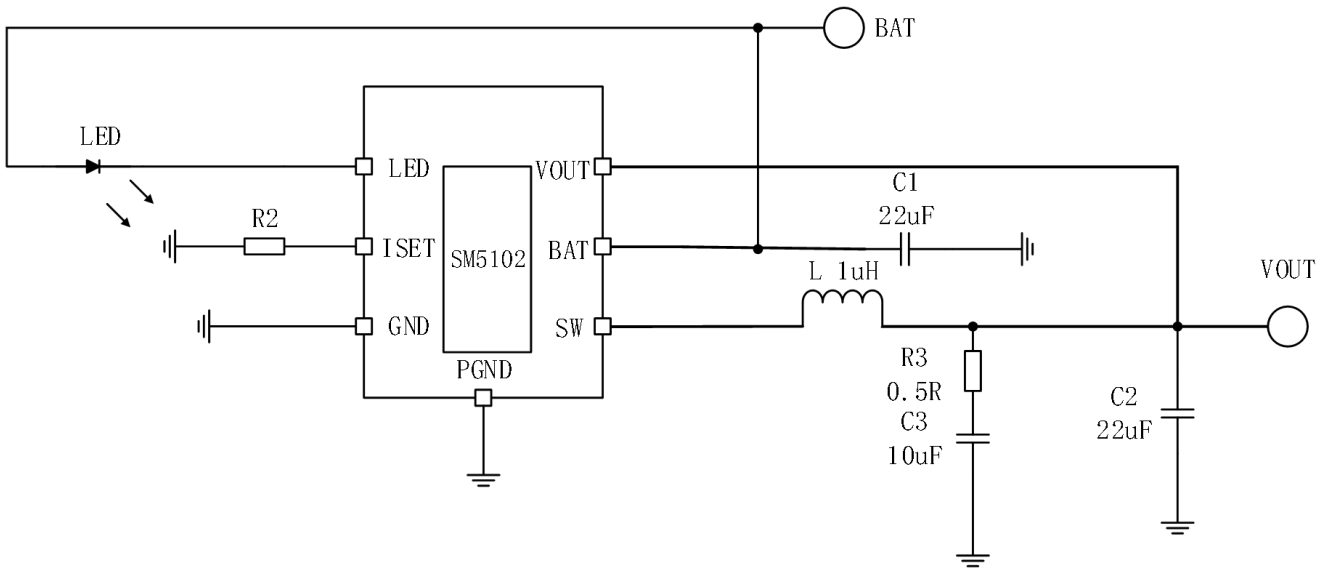
Features

- Integrated charging and step-down discharge management

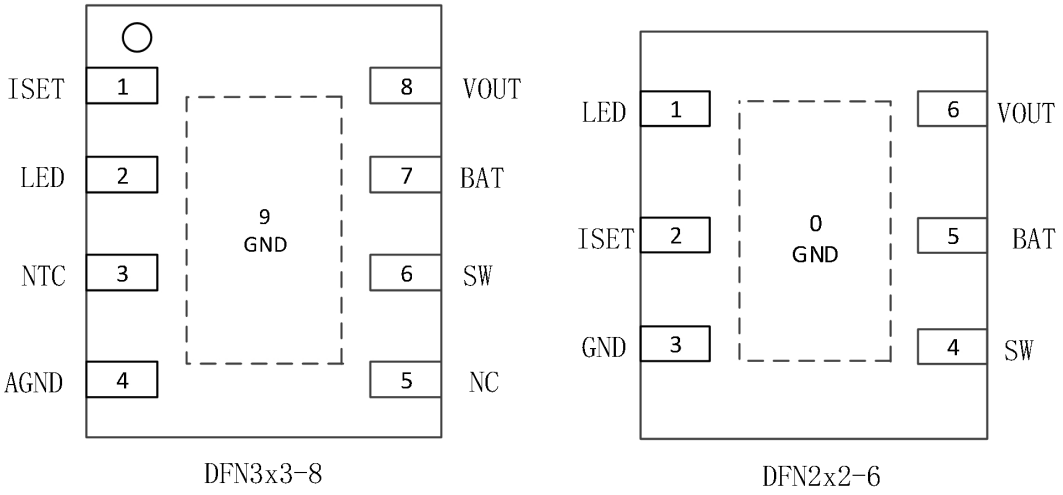
SM5102 - 3.7V (Supports 3.7V lithium-ion battery)

- Adjustable charging current up to 1A
- Integrated charging indicator
- High discharge current up to 3A
- No-load discharge current is only 6μA.
- Discharge efficiency up to 92%
- 1.5V outputs support series connection
- Built-in under-voltage protection
- Built-in short-circuit protection
- NTC pin for battery temperature monitoring
- Package: DFN3x3-8 / DFN2x2-6

Typical Application Circuit



PIN CONFIGURATION



Pin Definition

Pin	Pin NO.		Description
	DFN3x3-8	DFN2x2-6	
ISET	**1**	**2**	Constant Current Charging Current Settings and Charging Current Monitoring Port
LED	**2**	**1**	Charging Status Indicator Port
NTC	**3**	**-**	Battery Temperature Detection Input Port
AGND	**4**	**3**	Simulation Ground
NC	**5**	**-**	No Connection
SW	**6**	**4**	Power switching transistor output, connected to an inductor
BAT	**7**	**5**	Charging Current Output Pin
VOUT	**8**	**6**	Adapter Voltage Input : 1.5V; Battery Output : 1.5V
PGND	**9**	**-**	Power Ground

Max. Rating(1)

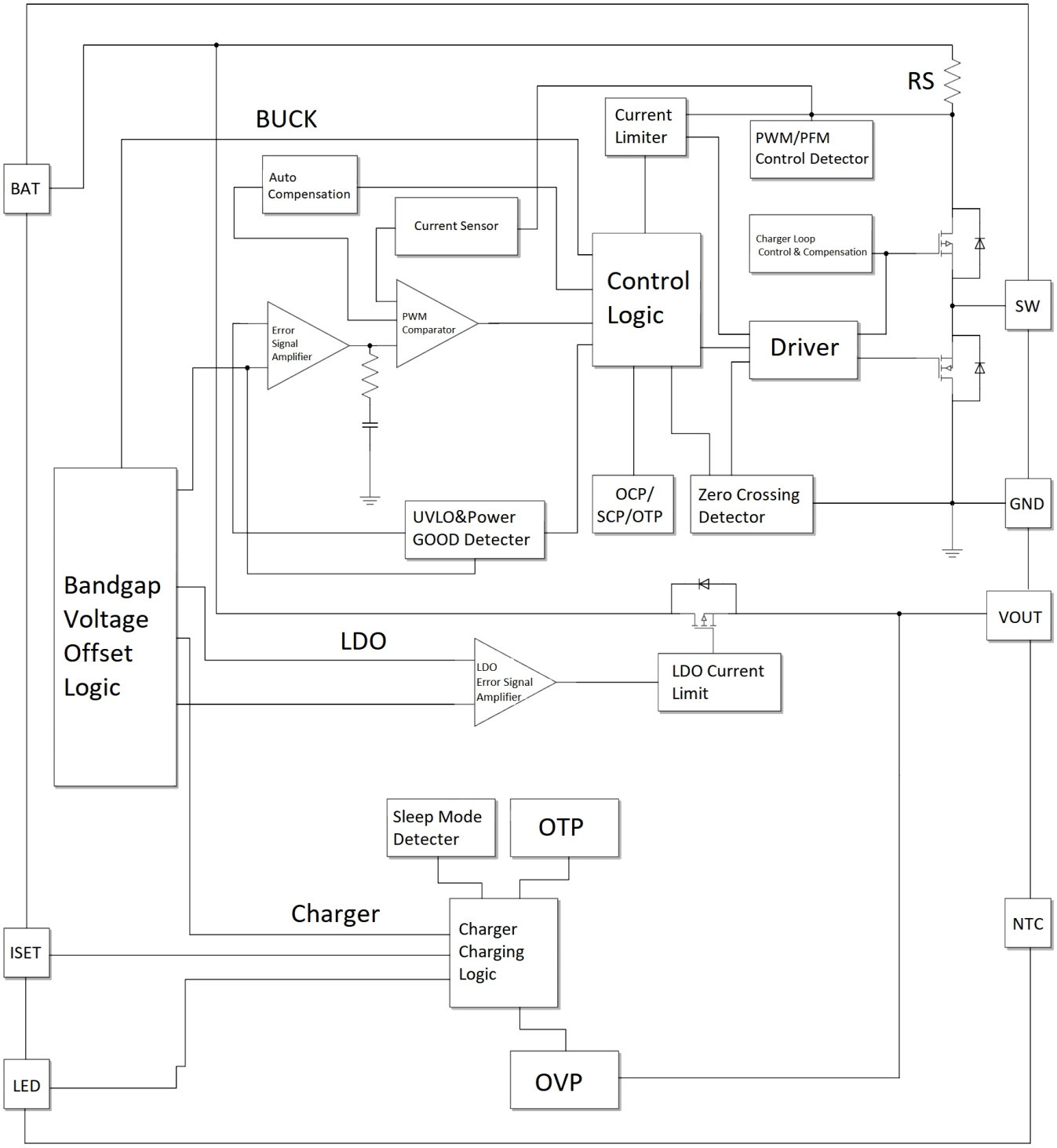
VIN.....-0.3~6V
Juntion temprature.....-40℃ ~ +85℃
Storage temprature.....-60 ℃ ~ +150℃
ESD(Mechanical Mode-MM).....200V
ESD (Human Body Mode-HBM).....2000V

Operating Range

VAP.....4.5V~5.5V
ICHG.....1A
IOUT（discharge Current）.....3A

(1) Operation beyond absolute maximum ratings may cause device damage. Operation at or above these ratings is not advised, as continuous use will degrade reliability. Absolute maximum ratings define maximum stress limits only

Block Diagram



Electrical Characteristics

(Unless otherwise specified, VBUS=5V, TA=25℃.)

Parameter	Symbol	Test conditions	Min.	Typ.	Max	Unit
Charge						
Input Voltage	VAP		4.5	5.0	5.5	V
	OVP	RSET = 1K		6.0		V
Constant-voltage floating charging voltage	VCV	3.7V, when charging current drops to ICHG 1/10	4.16	4.20	4.24	V
Charging current	ICHG	RSET = 1K		1000		mA
Trickle Charging Current	ITRIKL	VBAT < VTRIKL , RSET = 1K		100		mA
Trickle Charge Threshold Voltage	VTRIKL	RSET = 1K, VBAT Rasing		3.0		V
Trickle Charge Hysteresis Voltage	VTRHYS	RSET = 1K, 3.7V		200		mV
VCC - VBAT Threshold Voltage	VASD	VCC Rasing		94		mV
		VCC falling		36		V
ISET Voltage	VSET	RSET = 1K during charge		1.0		V
Charge Over-Temperature Protection Threshold (Internal Chip Temperature)	OTP1	Reduce charging current once junction temperature reaches this threshold.		130		℃
Discharge						
Discharge Mode Judgment	Iout>25mA	Enter Buck mode		25		mA
	Iout<3mA	Enter LDO mode		5		mA
Operating Current at Battery Terminal	IQ	No loading（LDO Mode）		6		uA
	IQ	Buck mode		500		uA
	ISD	UVLO（Shutdown Mode）		6		uA
Output Voltage	VOUT	No loading		1.56		V
	VOUT	IOUT> 0.1mA, LDO mode		1.56		V
	VOUT	BUCK mode	1.46	1.5	1.54	V
Switching Frequency	fSW	500mA loading		1		MHz
Under Voltage Protection	UVLO	3.7V Li-ion Battery voltage		2.75		V
Load Capability	Iout			3.0		A
Cycle-by-Cycle Peak Current Limit	ILMT		4.0			A
Over-Temperature Protection Threshold	OTP2	Operation shuts down when junction temperature rises to this value.		150		℃
Over-Temperature Protection Recovery Threshold	OTP2-HYS	Operation restarts when junction temperature drops to this threshold.		25		℃
LED Current	LED			3		mA
NTC Current	INTC			20		uA

Order information

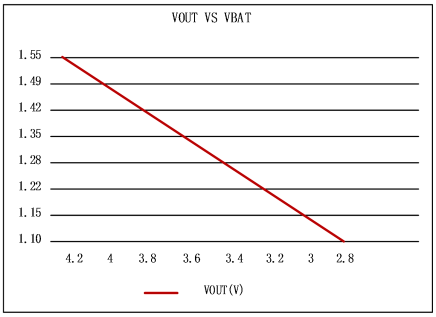
Voltage	Description
V42	Simulated dry battery version
V35	Constant Voltage Version

Functional Description

Work Mode Determination

SM5102 determines its operating mode by comparing the voltage VOUT at the OUT pin with the voltage VBAT at the BAT pin.
When VOUT exceeds VBAT +100mV, SM5102 operates in charge mode, using the voltage at the OUT terminal as the power source to perform linear charging on each lithium battery cell connected to the BAT terminal.
When VOUT < VBAT, the SM5102 operates in discharge mode (Buck DC/DC mode or LDO mode), converting the voltage of a single lithium battery cell from the BAT terminal to the output voltage of 1.0 V for a dry cell and delivering it via the OUT terminal. Under heavy load conditions, the Buck DC/DC mode enables high-current output capability; under light load conditions, the LDO mode ensures optimal efficiency during no-load operation.
V42 : The output voltage of the dry cell exhibits a linear relationship with that of the lithium battery. When the lithium battery voltage is 4.2 V, the dry cell's output voltage is 1.55 V; as the lithium battery voltage gradually decreases during discharge, the dry cell's output voltage also declines accordingly, simulating the characteristics of a dry cell as shown in the table below.

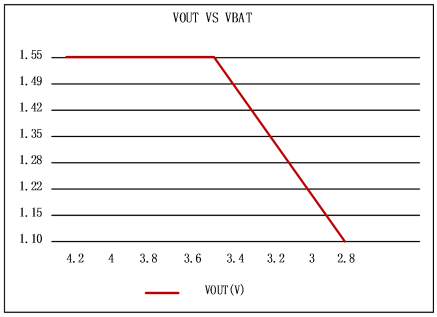
VBAT	VOUT
4.2V	1.55
4.0V	1.49
3.8V	1.42
3.6V	1.35
3.4V	1.28
3.2V	1.22
3.0V	1.15
2.8V	1.10



Under normal operation, SM5102 operates in PWM mode, where the working frequency remains constant. Equipped with an internal current-based feedback compensation circuit, the chip eliminates the need for external compensation components. Additionally, it incorporates a feedforward circuit to

V35 : When the battery pack (BAT) voltage exceeds 3.5V, the output dry-cell voltage remains constant at 1.5V; when the BAT voltage falls below 3.5V, the output dry-cell voltage exhibits a linear relationship with the lithium battery voltage, as shown in the table below.

VBAT	VOUT
4.2V	1.5
4.0V	1.5
3.8V	1.5
3.6V	1.5
3.4V	1.45
3.2V	1.34
3.0V	1.29
2.8V	1.18



Discharge Operation Mode

After the system enters discharge management mode, SM5102 first switches to BUCK DC/DC mode. When the load current falls below 3 mA, it detects this condition and switches to LDO mode after a 4-second delay. If the system enters LDO mode, it switches back to BUCK DC/DC mode when the load current exceeds 25 mA.

BUCK DC/DC Operation Mode

The SM5102 achieves voltage reduction through coordinated switching between the internal P-MOS main switch and N-MOS synchronous rectifier, combined with external inductors and output capacitors.

enhance transient voltage response performance. During the falling edge of the sawtooth wave generated by the internal waveform generator, the P-MOS transistor turns on; when the PWM comparator switches, overvoltage protection is triggered, or current limitation conditions occur, the P-MOS transistor turns off, and the N-MOS transistor turns on. When the P-MOS transistor reactivates or reverse current is detected, the N-MOS transistor turns off. If a reverse current is detected and the inductor's maximum current falls below 500 mA, SM5102 will enter PFM mode, thereby reducing the operating current under light load conditions.

1) Overcurrent Protection (OCP)

When operating in DC/DC mode, the SM5102's internal overcurrent protection circuit continuously monitors the current flowing through the P-MOS transistor. If this current exceeds the current limit value (ILIM), the P-MOS transistor is turned off to prevent further inductor current buildup; upon the next pulse, if the P-MOS transistor current falls below ILIM, the chip returns to normal operation from the overcurrent protection state. However, should an overcurrent condition recur, the P-MOS transistor is promptly turned off and reactivates the overcurrent protection mechanism.

2) Short-Circuit Protection

When the OUT terminal shorts to ground, the SM5102 enters a hiccup mode, activating every 100 ms to detect whether the short circuit has been resolved, thereby significantly reducing the input current at the battery end and effectively minimizing circuit heating. After the short-circuit fault is removed, the circuit will immediately enter the normal DC/DC operating mode.

3) Synchronous Rectifier Tube

SM5102 incorporates an internal N-MOS synchronous rectifier, eliminating the need for an external Schottky rectifier diode. Moreover, the N-MOS transistor exhibits a lower on-resistance than conventional Schottky rectifier diodes, thereby enhancing circuit efficiency.

4) Over-temperature protection (OTP)

When the internal temperature of the SM5102 circuit exceeds the overheat protection threshold (TOTP), the circuit turns off both the P-MOS and N-MOS transistors, preventing output voltage generation. When the chip's operating temperature drops to the overheat protection recovery threshold (TOTP–TOTP–HYS), the circuit returns to normal operation, and the P-MOS transistor automatically activates in the next cycle.

LDO Operating Mode

When the load current is below 3 mA, the system enters LDO mode. The SM5102 generates a 1.5 V output from a dry cell by alternately switching between on/off states via an internal P-MOS transistor and an external output capacitor. Its built-in compensation circuit eliminates the need for external compensation components, while achieving a power consumption of only 6μA under no-load conditions for high efficiency. The SM5102 incorporates an internal N-MOS synchronous rectifier, eliminating the need for an external Schottky rectifier diode. Moreover, the N-MOS transistor exhibits a lower on-resistance than conventional Schottky rectifier diodes, thereby enhancing circuit efficiency.

Charging Management Mode

When the output voltage (VOUT) at the OUT terminal is greater than the battery voltage by 100 mV (VOUT > VBAT + 100 mV), the SM5102 initiates a charging cycle. If the voltage at the BAT terminal is less than the trickle charge threshold voltage (VTRIKL), the battery enters the trickle charge state. In this state, the battery is charged with a current equal to 1/10 of the set charging current (ICHG) for safe preconditioning. If trickle charging raises the battery voltage above VTRIKL, the battery enters a pre-charging state. In this state, the battery's charging current is set to 1/10 of the specified charging current, allowing the battery voltage to rise to a safe level for full-current charging. After the trickle charge completes, the charger enters constant-current charging mode and supplies the programmed charging current to the battery. When the voltage at the BAT pin approaches the constant charge voltage (VCV), the SM5102 switches to constant-voltage charging mode, and the charging current begins to decrease. Once the charging current drops to 1/10 of the programmed charging current, the circuit outputs a charge completion signal on the VLED pin to indicate a fully charged battery. At this point, one full charging cycle is completed.

1) Set Charge Current

The charging current is set using a resistor connected between the ISET pin and ground. The battery charging current is 1000 times the output current of the ISET pin. The charging current sourced from the BAT pin can be determined at any time by monitoring the voltage at the ISET pin, as given by the following formula:

$$I_{BAT} = \frac{1}{R_{iset}} \times 1000$$

It indicates the corresponding charging states as shown in the table below.

2) Charge complete

NTC (For IC Junction Temperature Only)

SM5102 integrates an NTC function for battery temperature detection. During operation, the SM5102 sources a 20 μA current to the NTC pin and monitors the voltage on the NTC pin to determine the current battery temperature.

Status	LED
During charge	1 Hz blinking
Charge complete	on
Charging State: No Battery Connected (BAT connected to 10uF)	High-speed blinking (about 20 Hz)
Discharge	off
Discharge Short-Circuit	10 Hz High-Speed Blinking
DischargeUnder-Voltage	Flashes 8 times at 1 Hz, then turns off.

When charging: When the NTC PIN detects a voltage of 0.29V, it represents a battery temperature of 75 degrees, and charging of the battery is stopped. In discharge mode: when the voltage detected at the NTC pin reaches 0.21 V, it indicates the battery's high temperature of 85°C, and the device stops discharging to the load.

LED Light Status

SM5102 provides an open-drain output LED pin. An indicator LED is externally connected to the high supply rail, with a constant LED current of 3 mA. The

When the voltage at the BAT terminal reaches the constant-voltage float charge voltage (VCV), and the charging current drops to 1/10 of the set charging current, it can be considered that a charging cycle has ended.

3) Overheat Protection (OTP1) (for chip internal temperature only)

In charging mode, if the internal junction temperature of SM5102 exceeds the over-temperature protection threshold (OTP1), the IC will gradually reduce the charging current to lower power dissipation and prevent device damage. When the IC operating temperature drops back below the OTP1 threshold, the charging current will recover to its normal value

IC controls the states of the LED pin (high impedance, low level, square wave) according to different charging conditions to drive the external LED

PCB Layout Note

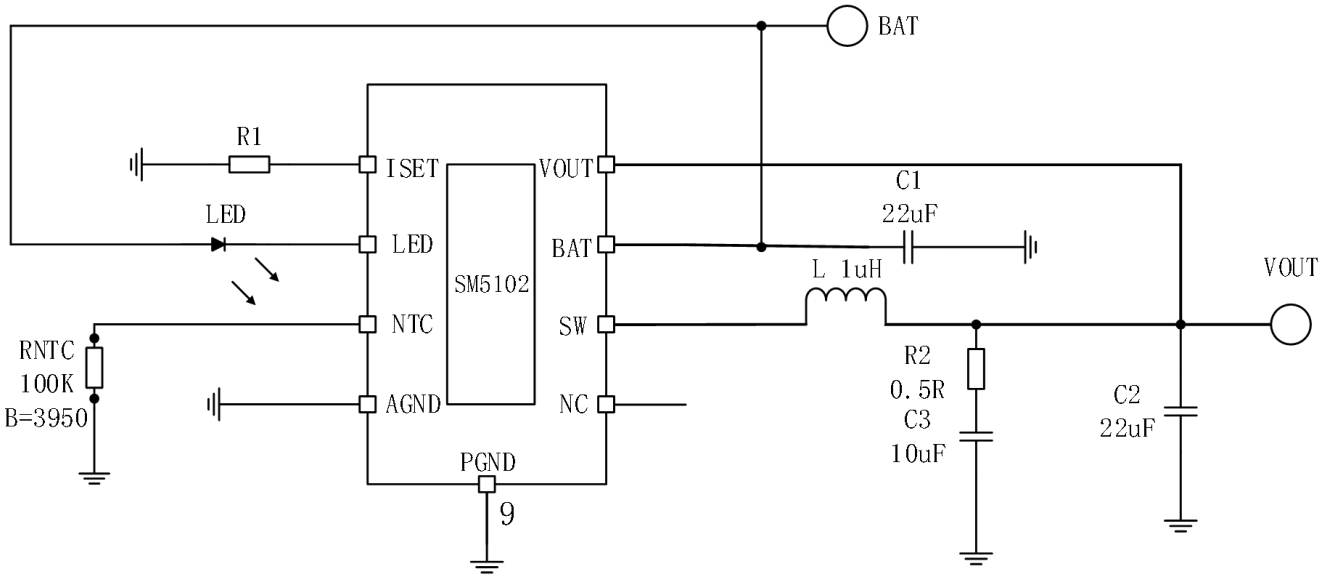
1. For high-current loops such as BAT and GND traces, use the widest possible track width; the entire bottom layer can be filled with ground copper.
2. Place the capacitor of the power supply pin BAT as close to the IC as possible.
3. Place the inductor close to the SW pin.

4. Place feedback resistors near the IC, and connect the ground terminal of the feedback resistors to the IC ground close by.
5. Arrange plenty of vias for ground connections to the bottom layer to reduce ground loop impedance.

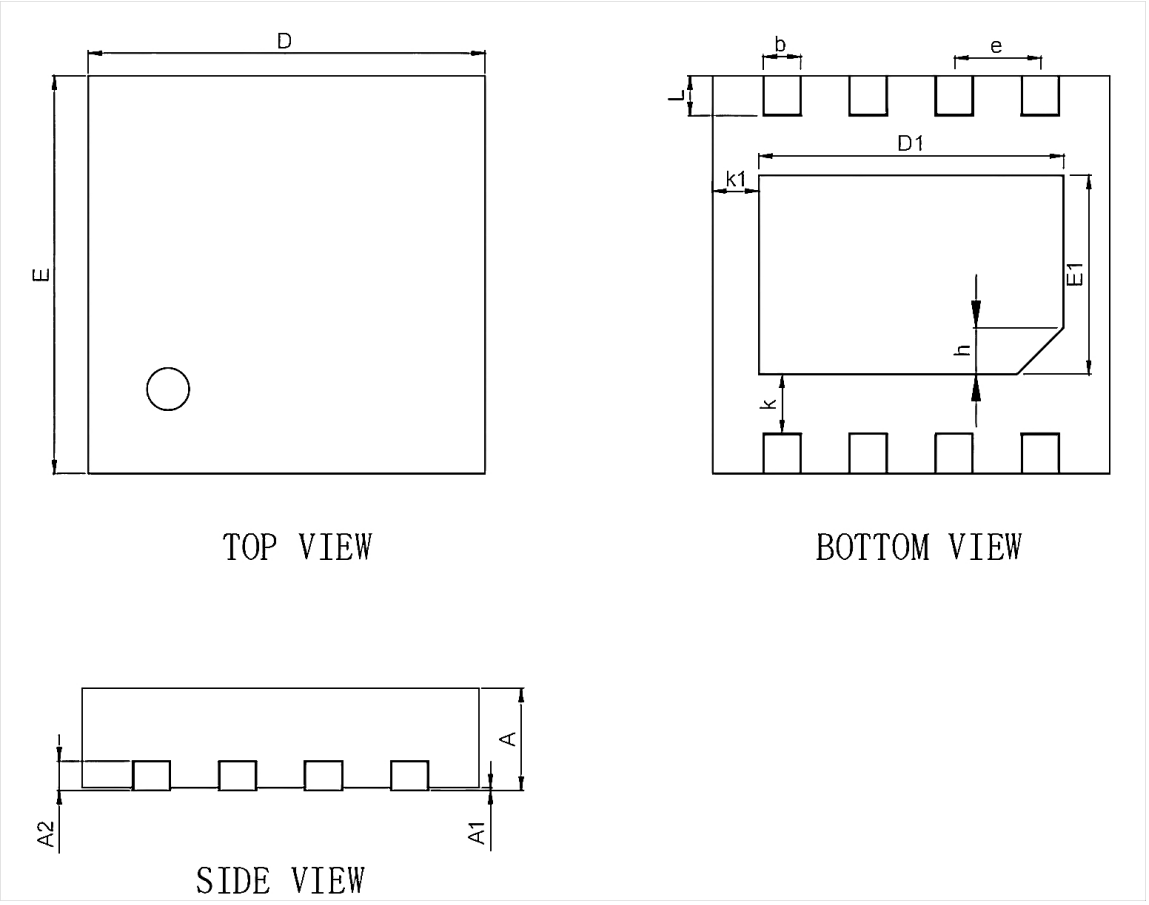
Application Notes

Connect the power ground to the battery and keep it as short as possible, preferably less than 3 cm.

Typical Application



Package size : DFN3X3-8



symbol	dimensions		
	millimeters		
	min	nom	max
A	0.70	0.75	0.80
A1	0.00	0.02	0.05
b	0.25	0.280	0.31
A2		0.203BSC	
D	2.90	3.00	3.10
E	2.90	3.00	3.10
E1	1.45	1.50	1.55
D1	2.25	2.30	2.35
e		0.65REF	
L	0.25		0.35
h		0.49REF	
k1	0.30	0.35	0.40
k	0.40	0.45	0.50

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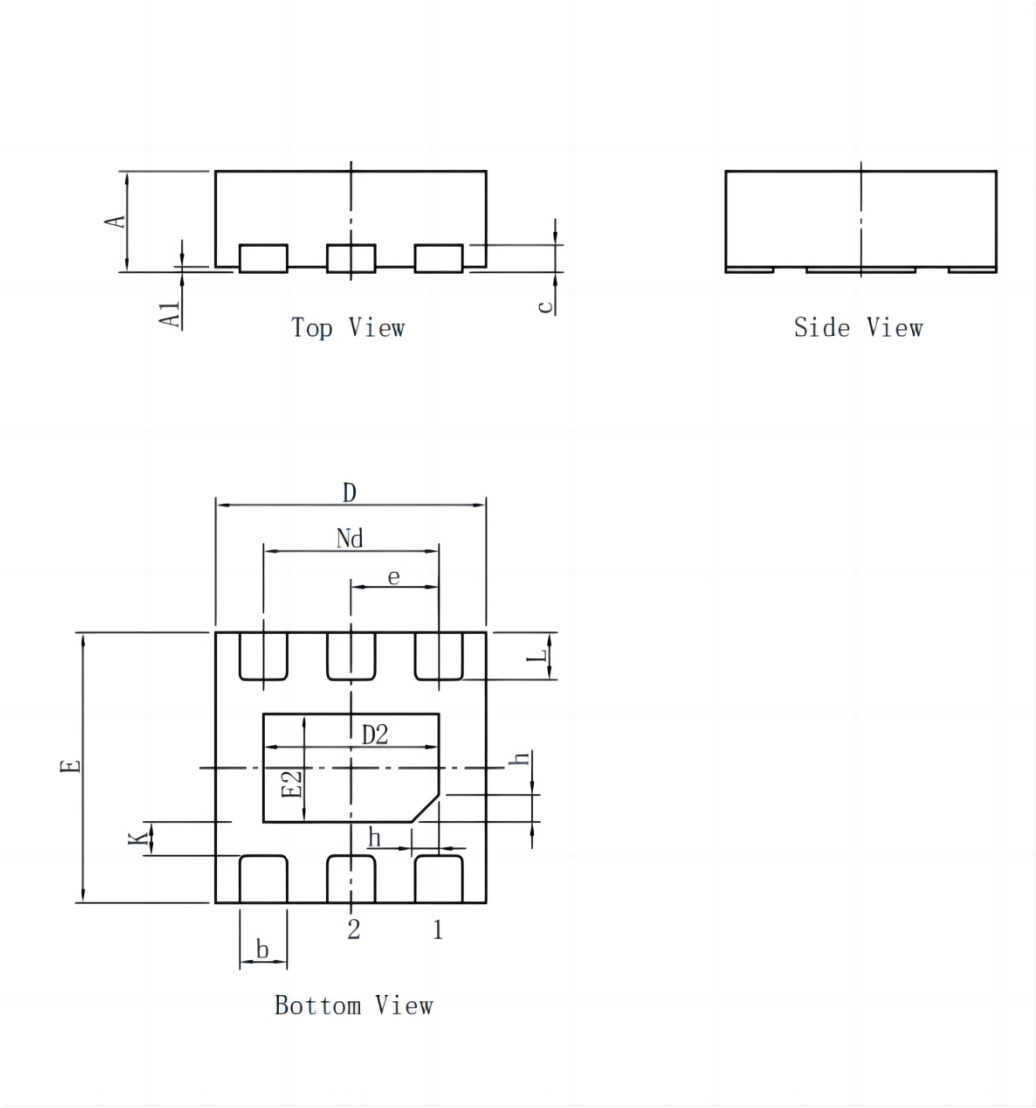
Package size : DFN2x2-6



Symbol	Dimensions		Symbol	Dimensions	
	Min	Max		Min	Max
A	0.70	0.80	E2	0.75	0.85
A1	0.00	0.05	e	0.650BSC	
b	0.30	0.40	Nd	1.300BSC	
c	0.18	0.25	K	0.20	-
D	1.95	2.05	L	0.28	0.38
D2	1.25	1.35	h	0.15	0.25
E	1.95	2.05			

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