## Description

SM5103 is a dedicated lithium battery charge and discharge management IC.
During charging, it charges 3.7V lithium-ion batteries with a maximum configurable charging current of 1A, and supports an input voltage up to 28V.
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.
SM5103 features ultra-low power consumption technology, with quiescent current under no-load condition as low as 6μA.
SM5103 provides indicator signals for charging, full-charge, and short-circuit states.
The NTC function monitors battery temperature in real time to guarantee battery safety and reliability.

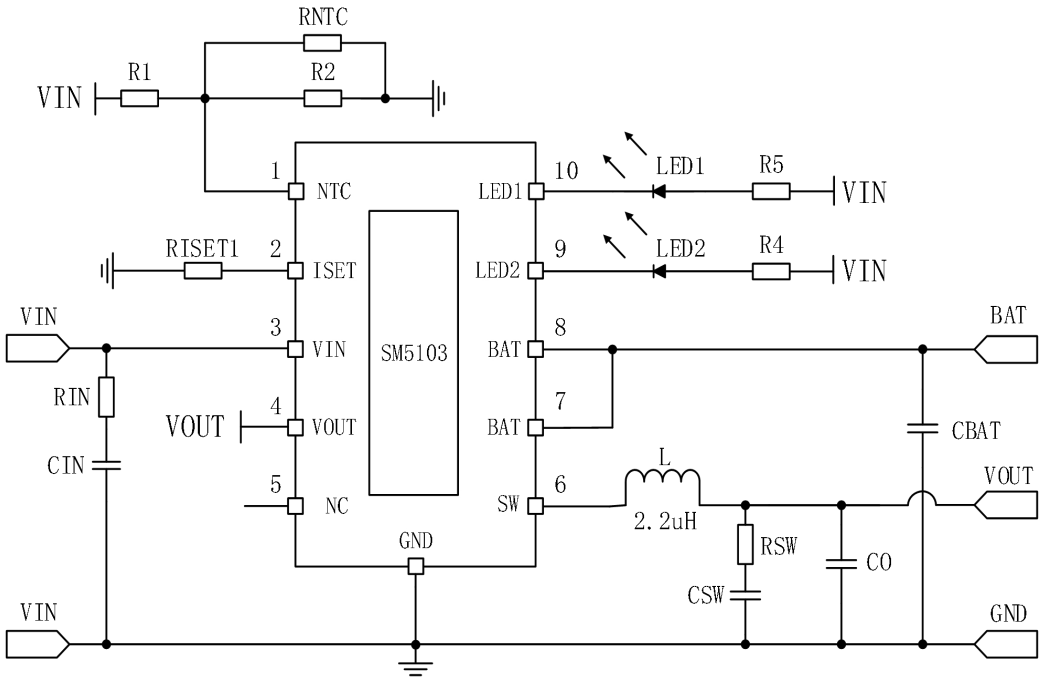
## Application

- **Replaces traditional 1.5V dry cell**

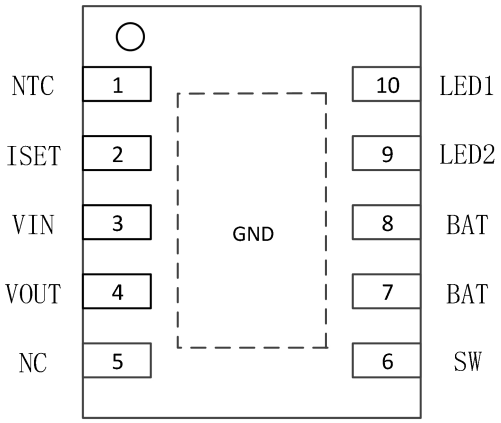
## Features

- Integrated charging and step-down discharge management
- Adjustable charging current up to 1A
- Integrated charging indicator
- Max input voltage is 28V
- 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: DFN3X3-10

## Typical Application Circuit



## PIN CONFIGURATION




DFN3x3-10

## Pin Definition

| Pin | Pin NO. | Description |
|---|---|---|
| NTC | **1** | Battery Temperature Detection Input Port |
| ISET | **2** | Constant Current Charging Current Settings and Charging Current Monitoring Port |
| VIN | **3** | Input |
| VOUT | **4** | Adapter Voltage Input : 1.5 V; Battery Output : 1.5 V |
| NC | **5** | No Connection |
| SW | **6** | Power switching transistor output, connected to an inductor |
| BAT | **7,8** | Charging Current Output Pin |
| LED2 | **9** | Full-charge indicator LED |
| LED1 | **10** | Charging Status Indicator Port |
| GND | | Power Ground |

## Max. Rating(1)

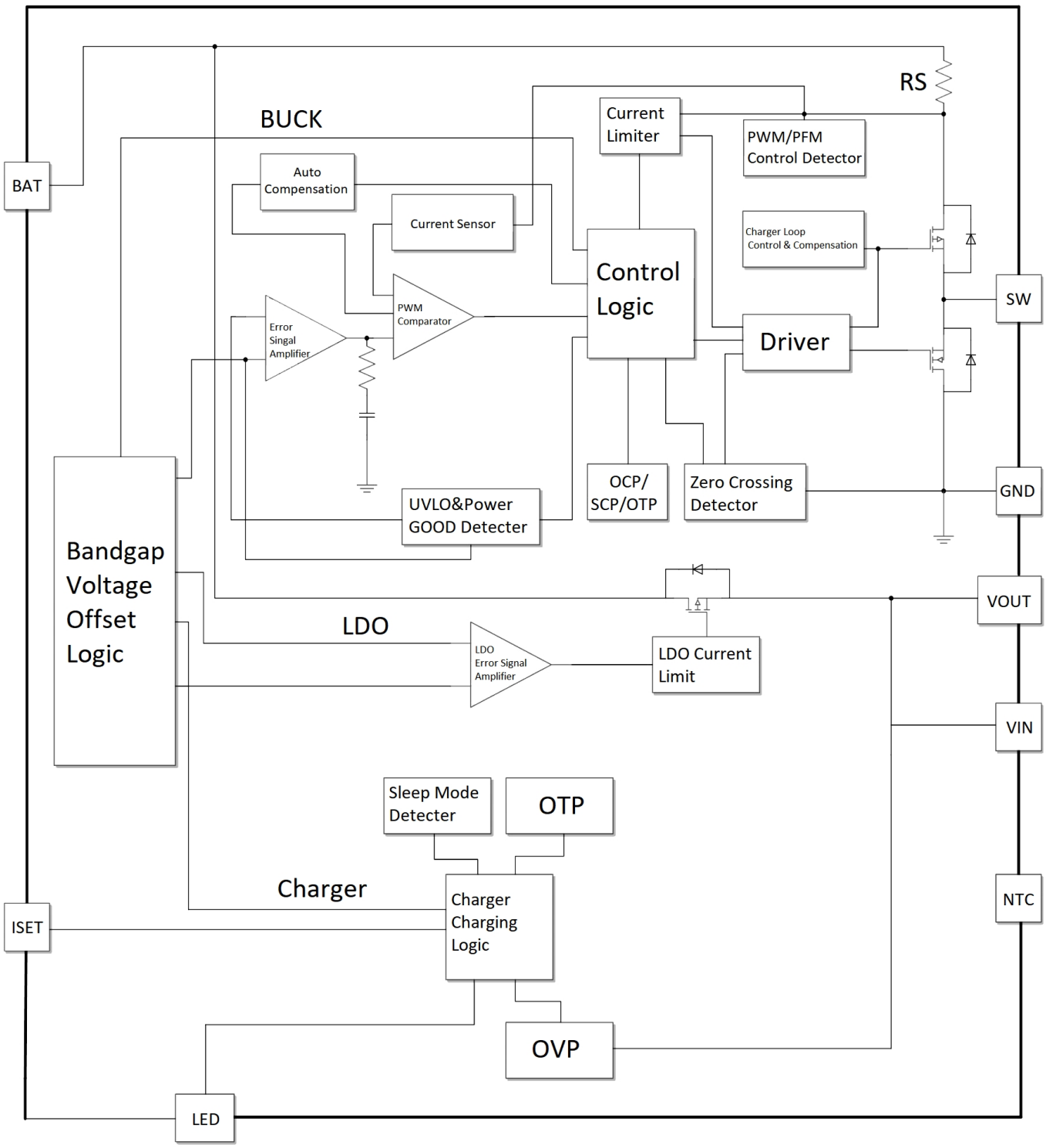
VIN.....-0.3~28V
Juntion temprature.....-40℃ ~ +85℃
Storage temprature.....-60 ℃ ~ +150℃
ESD(Mechanical Mode-MM).....200V
ESD (Human Body Mode-HBM).....2000V

## Operating Range

VAP.....4.5V~5.5V
ICHG.....1 A
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 | VIN | Absolute Maximum Voltage | | | 28 | V |
| Constant-voltage floating charging voltage | VCV | 3.7V, when charging current drops to ICHG 1/10 | 4.16 | 4.20 | 4.24 | V |
| Recharge Voltage | VRCHG | 3.7 V li-ion battery | 4.00 | 4.05 | 4.10 | V |
| Charging current | ICHG | RSET = 1.2K | | 1000 | | mA |
| Trickle Charging Current | ITRIKL | VBAT < VTRIKL , RSET = 1.2K | | 100 | | mA |
| Trickle Charge Threshold Voltage | VTRIKL | RSET = 1.2K, VBAT Raising | | 3.0 | | V |
| Trickle Charge Hysteresis Voltage | VTRHYS | RSET = 1.2K, 3.7V | | 200 | | mV |
| VCC - VBAT Threshold Voltage | VASD | VCC Raising | | 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** | | | | | | |
| Operating Current at Battery Terminal | IQ | Buck mode | | 500 | | uA |
| | ISD | UVLO (Shutdown Mode) | | 6 | | uA |
| Output Voltage | VOUT | BUCK mode | 1.46 | 1.50 | 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

SM5103 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 + 100 mV, SM5103 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. VIN pin max withstand voltage: 28V, which prevents chip damage.

When VOUT < VBAT, the SM5103 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. When the voltage of a single-cell lithium battery at the BAT pin is low, the output voltage drops to 1.1V under discharge mode. The device operates with ultra-low power consumption under light load conditions, drawing only 6μA quiescent current at full no-load to improve operating efficiency.

## Discharge mode = BUCK DC/DC mode

SM5103 achieves step-down conversion by alternately turning on and off the internal main P-MOS switch and synchronous rectifier N-MOS, in conjunction with an external inductor and output capacitor. Under normal operation, SM5103 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 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, SM5103 will enter PFM mode, thereby reducing the operating current under light load conditions.

## 1) Overcurrent Protection (OCP)

When operating in DC/DC mode, the SM5103'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 SM5103 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

SM5103 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 SM5103 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.

## Charging Management Mode

When the input voltage (VIN) at the input terminal is greater than the battery voltage by 100 mV (VIN > VBAT + 100 mV), the SM5103 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 SM5103 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:

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

### 2) Charge complete

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. 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 SM5103 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.

## Battery Temperature Detection

Connect the NTC pin to the output of the battery NTC sensor. If the voltage on the NTC pin is less than 45% of the input voltage or higher than 80% of the input voltage, it indicates an excessively low or high battery temperature, and charging will be suspended. If the NTC pin is tied directly to GND, the battery temperature detection function is disabled, while all other charging functions remain operational.

## LED Status

Charging: LED1 ON, LED2 OFF; Full charge: LED1 OFF, LED2 ON

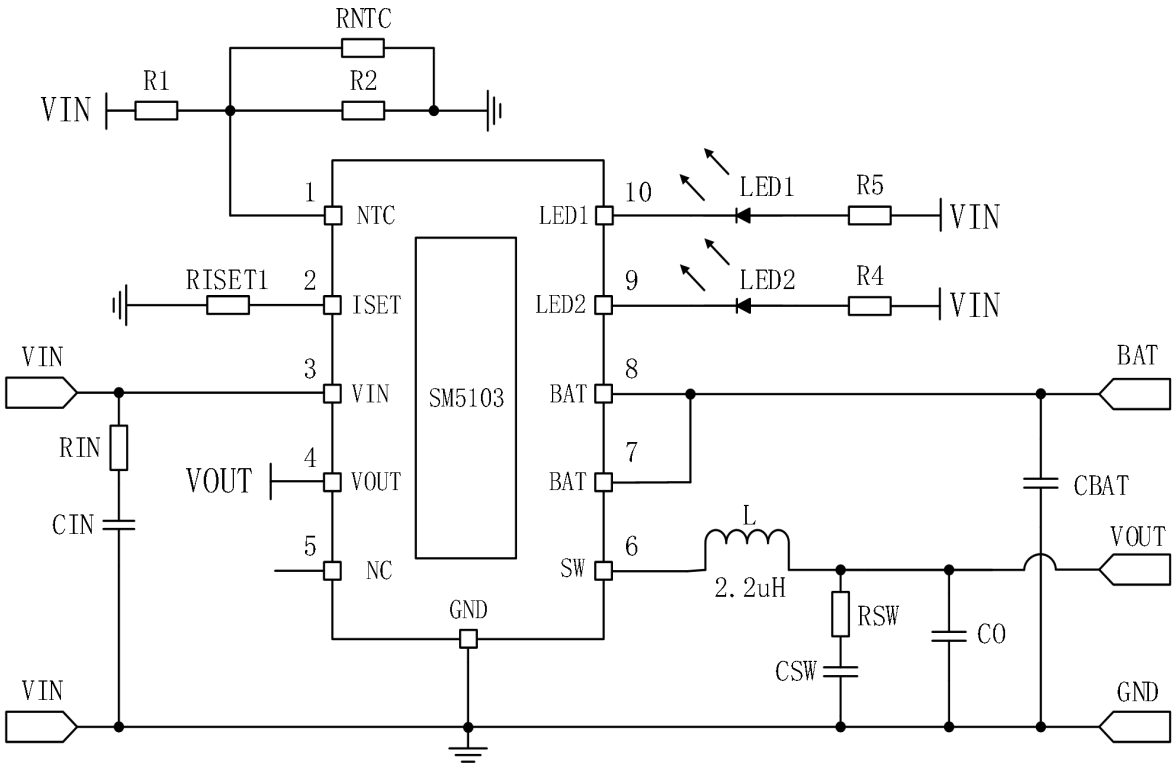
## PCB Layout Note

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.

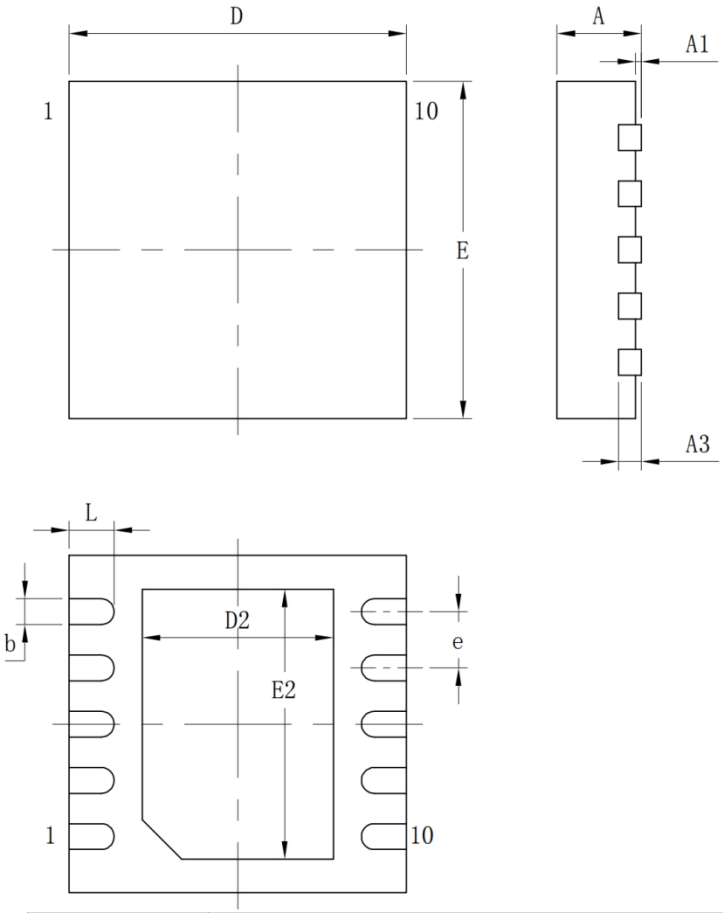
Application Notes

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

## Typical Application



## Package size : DFN3X3-10




| symbol | dimensions | | |
|---|---|---|---|
| | millimeters | | |
| | min | nom | max |
| A | 0.70 | 0.75 | 0.80 |
| A1 | | | 0.05 |
| A3 | | 0.203REF | |
| b | 0.18 | 0.23 | 0.28 |
| D | 2.90 | 3.00 | 3.10 |
| E | 2.90 | 3.00 | 3.10 |
| D2 | 1.6 | 1.7 | 1.8 |
| E2 | 2.3 | 2.4 | 2.5 |
| e | | 0.5REF | |
| L | 0.35 | 0.4 | 0.45 |

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