SK64556

1A Single-cell Linear Lithium-ion Battery Charger

GENERAL DESCRIPTION

The SK64556 is a complete constant current/ constant voltage linear charger suitable for single lithium batteries. Its compact package and fewer external components make the SK64556 highly suitable for portable applications. It adopts an internal MOSFET architecture and anti-backflow circuit, so there is no need for external detection resistors and isolation diodes. Thermal feedback can adjust the charging current, thereby limiting the power consumption of the chip under high-power operation or high-temperature environmental conditions. The charging voltage is fixed at 4.2V, 4.35V, and 4.4V, and the charging current can be programmed and set through an external resistor connected to the ISET.

When the final floating voltage is reached and the charging current drops to 1/10 of the set current, the SK64556 will automatically terminate the charging cycle. When the input voltage source is removed, the SK64556 automatically enters A low-power state, and the leakage current at the port connected to the battery drops below 1μA.

Other features include a charging current monitor, under-voltage locking, automatic charging and status pins.

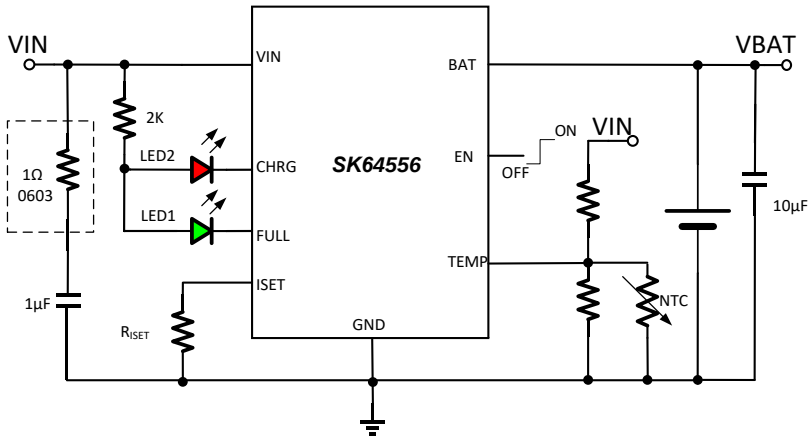
FEATURE

- Maximum Input Voltage Rating up to 30V
- The maximum withstand voltage of the BAT terminal is 13V
- Input overvoltage protection: 7V
- Short-circuit protection
- Programmable charging current up to 1A
- The preset charging termination voltage of 4.2V/4.35V/4.4V with an accuracy of 1%
- Prevent reverse connection of batteries
- No MOSFET, detection resistor or isolation diode is required
- DFN2x2-8/DFN3x3-8 packages

APPLICATIONS

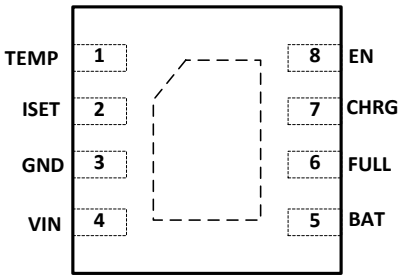
- Electronic Cigarette
- Electronic Toys
- Bluetooth applications
- Lithium-ion battery-powered equipments

TYPICAL APPLICATION CIRCUIT



PIN CONFIGURATION

TOP VIEW



DFN2x2-8/DFN3x3-8

PIN DESCRIPTION

PIN NO.	Name	Description
7	CHRG	The charging state indicator of open-drain output
3	GND	Ground Pin
5	BAT	Charging current output pin
4	VIN	Power input pin connected to the adapter
6	FULL	The charging end of the open-drain output is indicated
2	ISET	Charge Current Program. The charge current is programmed by connecting a 1% resistor (R_{ISET}) to ground. $I_{BAT}=1000/R_{ISET}$
1	TEMP	Temperature detection pin. The temperature detection function is cancelled by grounding it, and the charging function is normal.
8	EN	Chip enable pin. Connect this pin to VIN or high level to enable the charger, and connect it to GND or low level to disable it. EN cannot be suspended, so it is recommended to connect it to a fixed level.

ORDERING INFORMATION

Model	Package	Operation Temperature	Ordering Number	Tape & Reel
SK64556	DFN2X2-8L	-40°C to +85°C	SK64556D8-42	3000 PCS
	DFN2X2-8L	-40°C to +85°C	SK64556D8-435	3000 PCS
	DFN2X2-8L	-40°C to +85°C	SK64556D8-44	3000 PCS
	DFN3x3-8L	-40°C to +85°C	SK64556DC8-42	6000 PCS
	DFN3x3-8L	-40°C to +85°C	SK64556DC8-435	6000 PCS
	DFN3x3-8L	-40°C to +85°C	SK64556DC8-44	6000 PCS

ABSOLUTE MAXIMUM RATINGS

Description		Value / Range	Units
Supply Input Voltage (VIN)		-0.3 ~ 30	V
Battery Pin (BAT)		-0.3~13	V
CHRG/FULL to GND		-0.3 ~ 30	V
EN/TEMP to GND		-0.3 ~ 30	V
ISET to GND		-0.3 ~ 6.5	V
Storage Temperature Range		-55 ~ +150	°C
Lead Temperature (10s)		260	°C
ESD Rating	HBM (Human Body Mode)	±2000	V
	MM (Machine Mode)	±200	V

THERMAL INFORMATION

Description		Value / Range	Units
Package Thermal Resistance (θ_{JA})	DFN2x2-8	118	°C/W
	DFN3x3-8	84	°C/W
Power Dissipation P_D (@T_A=25°C)	DFN2x2-8	0.97	W
	DFN3x3-8	1.37	W

RECOMMENDED OPERATION CONDITION

Description	Value / Range	Units
Operating Junction Temperature	-40 ~ +125	°C
Operating Ambient Temperature	-40 ~ +85	°C
Supply Input Voltage	4.5 ~ 6.0	V

ELECTRICAL CHARACTERISTICS

T_A = 25°C, V_{IN}= 5.0V, C_{IN}=1μF, C_{BAT}=10μF, unless otherwise specified.

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
INPUT VOLTAGE AND CURRENT						
Input Voltage Range	V_{IN}		4.5	5	6	V
Input Supply Current	I_{IN}	Standby Mode, V_{BAT}=4.3V, V_{EN}=5V		130		μA
Input Shutdown Current	I_{SD}	V_{EN}=0V		50		μA
VIN Undervoltage Lockout Threshold	V_{UV}	VIN Rising, V_{BAT}=2.5V		3.5		V
VCC Undervoltage Lockout Hysteresis	V_{UVHYS}	VIN Falling		160		mV
Input Voltage OVP	V_{OVP}	VIN Rising		7		V
OVP Hysteresis	V_{OVPHYS}	VIN Falling		300		mV
BATTERY CHARGER						
Regulated Output (Float) Voltage	V_{FLOAT}	SK64556-42	4.158	4.20	4.242	V
		SK64556-435	4.307	4.35	4.393	V
		SK64556-44	4.356	4.40	4.444	V
BAT Pin Current	I_{BAT}	RISET= 1k, Current Mode		1000		mA
		RISET= 2k, Current Mode		500		mA
		Standby Mode, V_{BAT} = 4.5V		1		μA
		Shutdown mode(V_{BAT}=4.5V, RISET not connected or V_{IN}=0, EN=0)		0.1		μA
		Battery reverse connection (V_{BAT}=-4.2V,VIN=0)		2		mA
Trickle Charge Current	I_{TRIKL}			10		%I_{BAT}
Termination Current Threshold	I_{EOC}			10		%I_{BAT}
Trickle Charge Threshold Voltage	V_{TRIKL}	VBAT Rising		2.9		V
Trickle Charge Hysteresis Voltage	$V_{TRIKLHYS}$			250		mV
Recharging hysteresis voltage	$\triangle V_{RECH\ RG}$	VFLOAT-VRECHRG		150		mV
VIN – BAT Lockout Threshold Voltage	V_{ASD}	V_{BAT} = 3.6V, V_{IN}: 3.5V → 4V		140		mV
		V_{BAT} = 3.6V, V_{IN}: 4V → 3.5V		120		mV

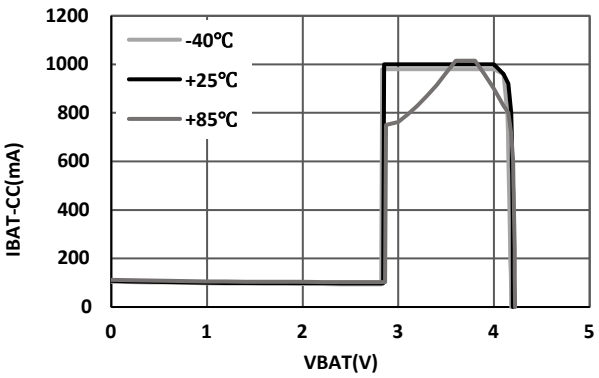
ELECTRICAL CHARACTERISTICS

T_A = 25°C, V_{IN}= 5.0V, C_{IN}=1μF, C_{BAT}=10μF, unless otherwise specified.

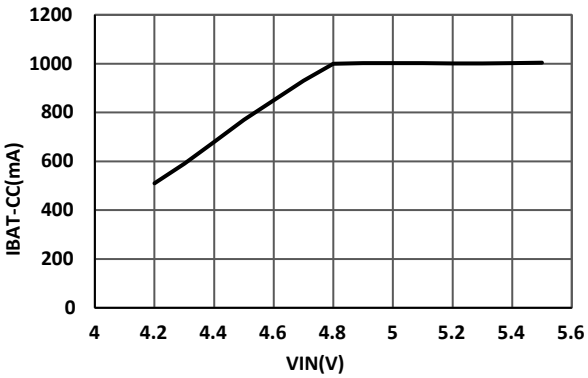
Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
Junction Temperature in Constant Temperature Mode	T_{LIM}			140		℃
MOS On-Resistance	R_{DS}	I_{BAT}=500mA		600		mΩ
Recharge filtering time	$T_{RECHARGE}$	VIN Falling		1		ms
Charging end filtering time	T_{TERM}	IBAT decreased to I_{CHG}/10		3.8		ms
ISET/CHRG/FULL PIN						
ISET Pin Voltage	V_{ISET_CC}	Constant current mode		1		V
	V_{ISET_TR}	Trickle current mode		0.1		V
CHRG/FULL Pin Output Low Voltage	V_{CHRG}	I_{CHRG}=5mA		0.5		V
CHRG/FULL Pin pull-down current	I_{CHRG}	V_{CHRG}=5V			5	μA
EN PIN						
EN Low Threshold	V_{EN_OFF}	VEN Falling			0.4	V
EN High Threshold	V_{EN_ON}	VEN Rising	1.4			V
EN Pin Leakage Current	I_{EN}	V_{EN}=5V or V_{EN}=0V	-1		1	μA
TEMP PIN						
TEMP High Flip Level	V_{TEMP_COLD}	VTEMP Rising	78	80	82	%V_{IN}
TEMP Low Flip Level	V_{TEMP_HOT}	VTEMP Falling	43	45	47	%V_{IN}
TEMP Ground Charging Level	V_{TEMP_GND}	VTEMP Falling			0.2	V

TYPICAL PERFORMANCE CHARACTERISTICS

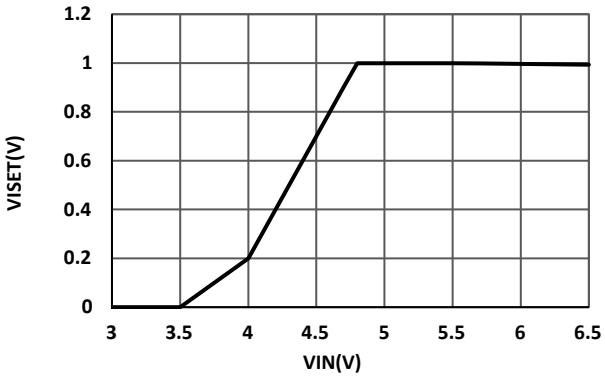
V_{IN}=5V, V_{BAT}=3.6V, R_{ISET}=1kΩ, DFN3X3 package, T_A= 25°C, unless otherwise noted



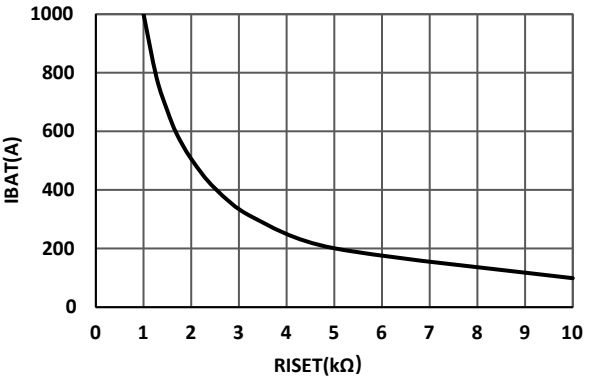
V_{BAT} VS I_{BAT}



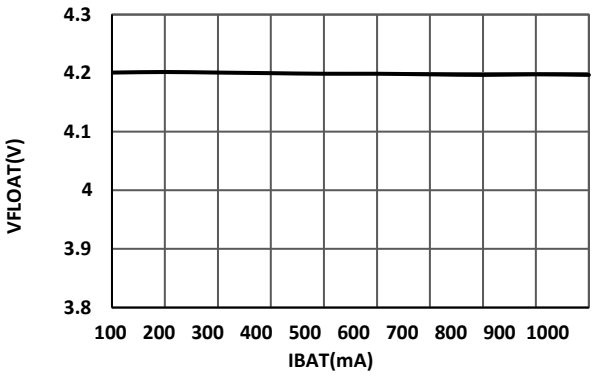
V_{IN} VS I_{BAT}-CC



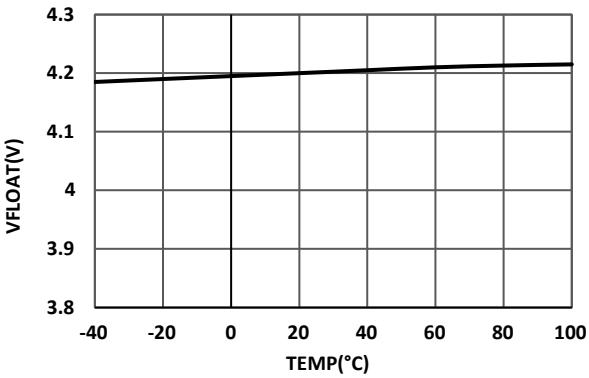
V_{IN} VS V_{ISET}



I_{BAT} VS R_{ISET}



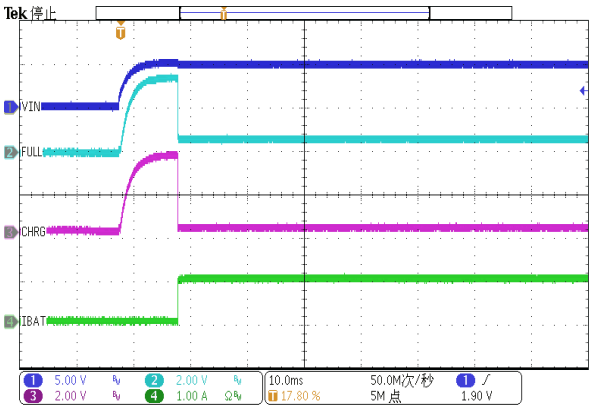
I_{BAT} VS V_{FLOAT}



TEMP VS V_{FLOAT}

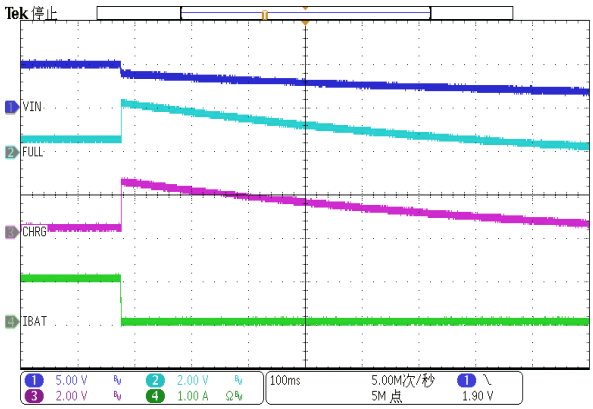
TYPICAL PERFORMANCE CHARACTERISTICS

V_{IN}=5V, V_{BAT}=3.6V, R_{ISET}=1kΩ, I_{BAT}=1A, T_A= 25°C, unless otherwise noted



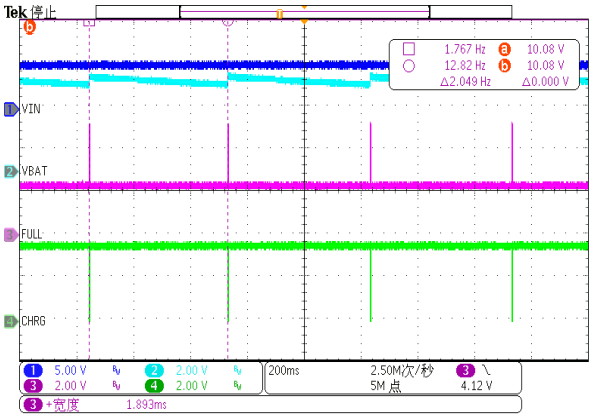
ON/OFF Startup

CH1:VIN CH2:FULL CH3:CHRG CH4:IBAT



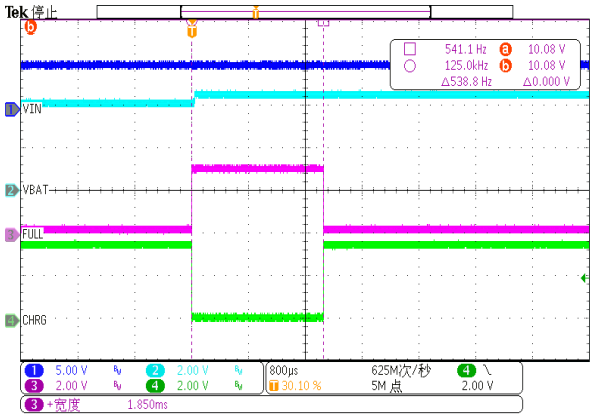
ON/OFF Shutdown

CH1:VIN CH2:FULL CH3:CHRG CH4:IBAT



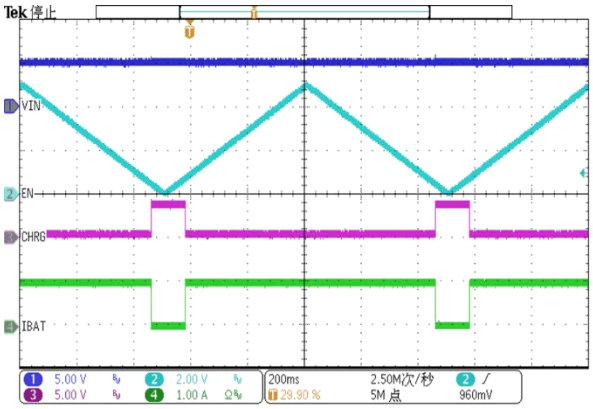
Light Status (Battery is not connected)

CH1:VIN CH2:VBAT CH3:FULL CH4:CHRG



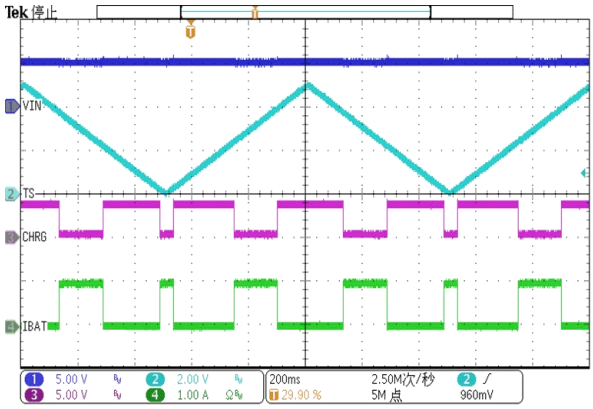
Light Status (Battery is not connected)

CH1:VIN CH2:VBAT CH3:FULL CH4:CHRG



EN Control

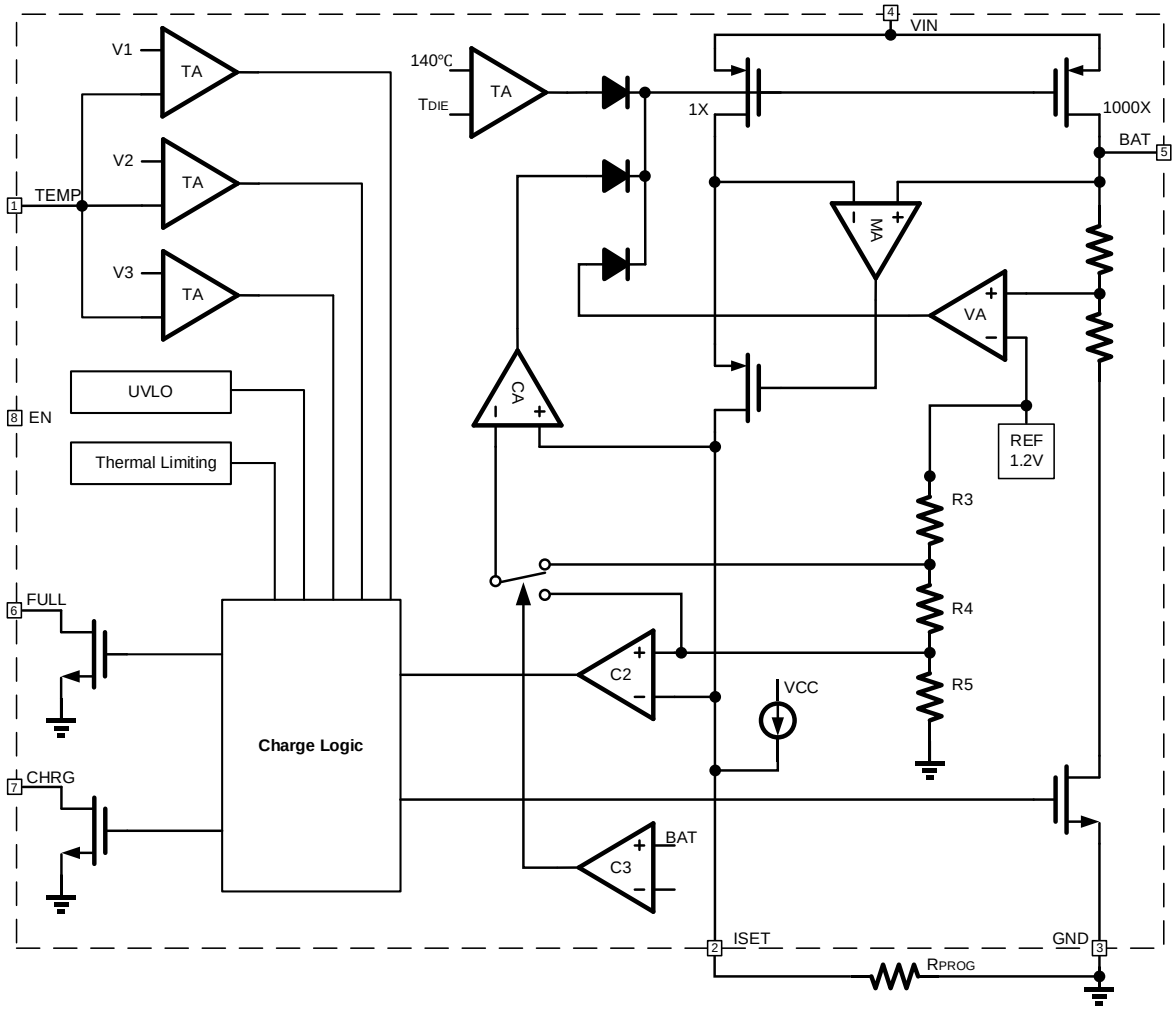
CH1:VIN CH2:EN CH3:CHRG CH4:IBAT



TEMP Detection

CH1:VIN CH2:TEMP CH3:CHRG CH4:IBAT

BLOCK DIAGRAM



FUNCTIONAL DESCRIPTION

Input Voltage Range

When the input voltage is lower than 3.3V or higher than 7V, the charger IC will be automatically disabled. If the voltage at the BAT pin is lower than 2.9V, the chip is in trickle charging mode when charging. In this mode, SK64556 provides about 1/10 of the ISET programming charging current until the battery voltage reaches the safe level of full current charging. When the voltage at the BAT pin rises above 2.9V, the charger enters the constant current mode (CC), and the charging current programmed by ISET is supplied to the battery. When the voltage of BAT pin approaches the final floating voltage, SK64556 enters constant voltage mode (CV), and the charging current gradually decreases. When the charging current in CV mode decreases to 1/10 of the programming current, the battery is fully charged.

Charge Termination

The charging cycle is terminated when the charging current drops to 1/10 of the set value after reaching the final floating charging voltage. This condition is detected by monitoring the ISET pin with an internal filter comparator. When the ISET pin voltage drops below 100mV for more than T_{TERM} (generally 1ms), the charge is terminated.

ISET Programmable Charging Current

The charging current is set by a resistor connected between the ISET pin and the ground. The set resistance and charging current are calculated by the following formula.

$$I_{BAT} = \frac{1000}{R_{ISET}}$$

Automatic Recharge

Once the charging cycle is terminated, the SK64556 continuously monitors the voltage on the BAT pin. When the battery voltage drops below 4.05V (roughly corresponding to 80% to 90% of the battery capacity), the charging cycle begins again. It ensures that the battery is maintained at (or close to) a fully charged state, and eliminates the need to start a periodic charging cycle.

Undervoltage Lockout (UVLO)

The built-in undervoltage lockout circuit monitors the input voltage and keeps the charger in shutdown mode until VIN rises above the undervoltage lockout threshold. The UVLO circuit will keep the charger in shutdown mode. If the UVLO comparator jumps, the charger will not exit the shutdown mode until VIN rises to 160mV higher than the battery voltage.

Battery Reverse Protection

SK64556 is integrated with a battery reverse connection protection circuit, which can effectively prevent the chip damage caused by battery reverse connection in assembly or application. When the BAT pin voltage is lower than the GND voltage by 300mV, close the internal charging loop; When the BAT pin voltage rises to 80mV lower than the GND voltage, it is considered that the battery is connected normally, and the charging cycle restarts.

Enable Function

SK64556 has the function of enabling/disabling. When the voltage on the EN pin is higher than 1.4V, the IC will be enabled. And connect EN pin to GND or low level to disable it. EN cannot be suspended, so it is recommended to connect it to a fixed level.

Charge Status Indication (CHRG and FULL)

There are two different charging states, one is charging and the other is charging completion. CHRG pin pulls low in the charging state and becomes high impedance in the charging completion state. In the opposite way, the FULL pin is pulled low after charging, and it is high impedance when charging.

Charger's Status	Red LED CHRG	Green LED FULL
Charging	Light	Dark
Charge termination	Dark	Light
UVLO, OVP , Abnormal Battery Temperature, and Battery Reverse Connection	Dark	Dark
Battery is not connected(Note 1)	Flash	Flash

Note(1): The duty cycle of the FULL indicator lamp is extremely high when the battery is not connected, which will cause human eyes to be unable to recognize the instantaneous flashing state when the indicator lamp goes out. In typical application circuit conditions, the duty ratio and frequency reference data are as follows.

Indicator Light	Signal Period	Low Level Duration (Light On)	High Level Duration (Lights Off)	Duty Cycle (Light On)
Red LED CHRG	2 Hz(500ms)	1.8ms	498.2ms	0.36%
Green LED FULL	2 Hz(500ms)	498.2ms	1.8ms	99.64%

The waveform can refer to **Light Status** pictures of the **TYPICAL PERFORMANCE CHARACTERISTICS** page.

Temperature Monitoring Of Battery

If the chip temperature rises to the preset value of 140°C, the internal thermal feedback loop will reduce the charging current. This function can prevent the SK64556 from overheating and allow users to increase the upper limit of the power handling capacity of a given circuit board without the risk of damaging the SK64556. Under the premise of ensuring that the charger will automatically reduce the current in the worst-case scenario, the charging current can be set according to the typical (rather than the worst-case) ambient temperature, and it is ensured that the charger will automatically reduce the current in the worst-case scenario.

Temperature Detection Function

SK64556 monitors the temperature by detecting the voltage at the TEMP pin, externally connects VIN through a voltage divider resistor (R1/R2), and then connects the external NTC resistor. When the temperature changes, the resistance value of NTC changes, which makes the voltage at the TEMP pin change, and compares it with the internal reference voltage threshold, and stops charging if it exceeds the range. Because both the external voltage and the internal reference voltage are reference VIN, the temperature detection circuit will not be affected by the change of VIN voltage. To start the charging cycle, the voltage of TEMP pin must be in the range of V_{TEMP_L} to V_{TEMP_H}, otherwise the charging will be stopped until the voltage of TEMP pin reaches the range of V_{TEMP_L} to V_{TEMP_H}. If the TEMP temperature detection function is not needed, the TEMP can be grounded and the charging function is normal.

In application, first determine the NTC resistance, check the resistance specification to determine the resistance value corresponding to the protection temperature, and then calculate the external resistance (R1/R2) value through the formula.

Referring to a typical application circuit, the external divider resistance R1 and R2 can be selected according to the following formula:

$$R_1 = \frac{R_{TL}R_{TH}(K_2 - K_1)}{(R_{TL} - R_{TH})K_1K_2}$$

$$R_2 = \frac{R_{TL}R_{TH}(K_2 - K_1)}{R_{TL}(K_1 - K_1K_2) - R_{TH}(K_2 - K_1K_2)}$$

In the formula:

$K_1 = V_{TEMP_L}/V_{IN}$

$K_2 = V_{TEMP_H}/V_{IN}$,

R_{TL} is the NTC resistance corresponding to low temperature

R_{TH} is the NTC resistance corresponding to high temperature.

Power Dissipation

The device's junction temperature depends on several factors such as ambient temperature, PCB layout, the load and package type. Equations that can be used to calculate power dissipation and junction temperature are found below:

$P_D = R_{DS(ON)} \times I_{OUT}^2$

To relate this PD to junction temperature, the following equation can be used:

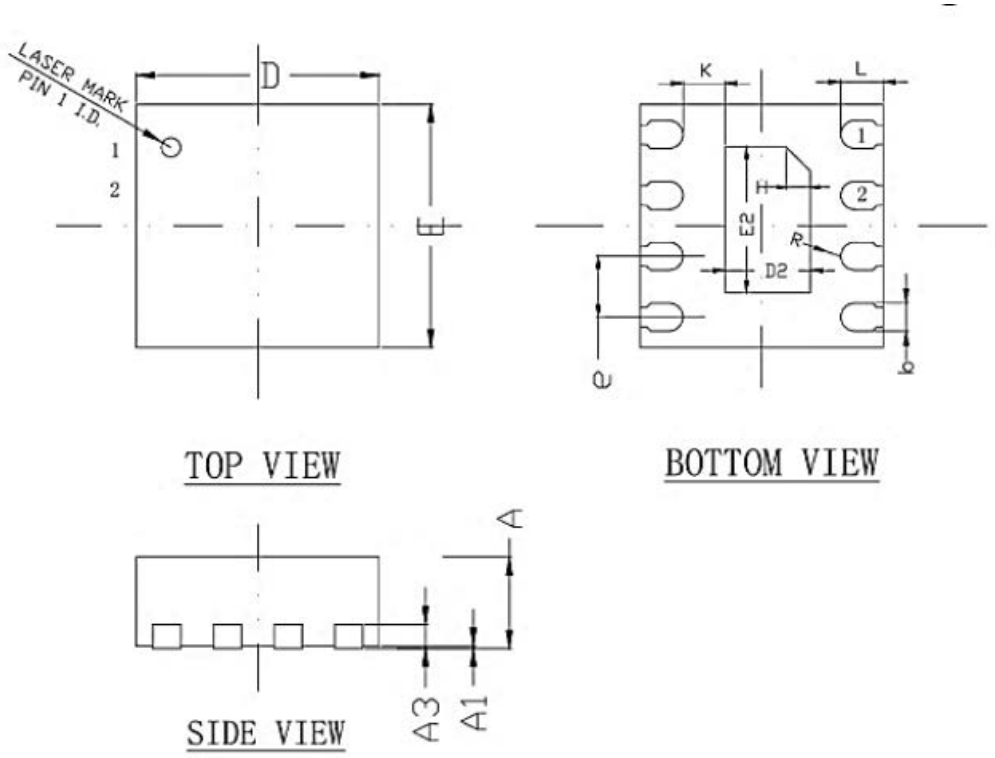
$T_J = P_D \times \theta_{JA} + T_A$

Where:

T_J is junction temperature, T_A is ambient temperature, θ_{JA} is the thermal resistance of the package type.

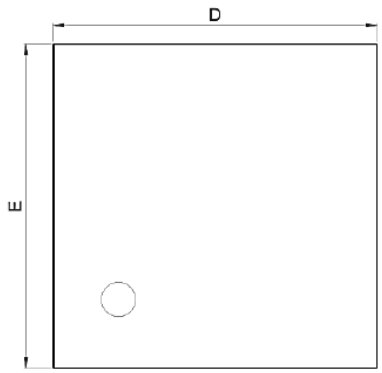
Note: The DFN2*2-8 package can only stably maintain a 1A charging current in an adequate heat dissipation environment.

PACKAGE DIMENSIONS:DFN2X2-8L

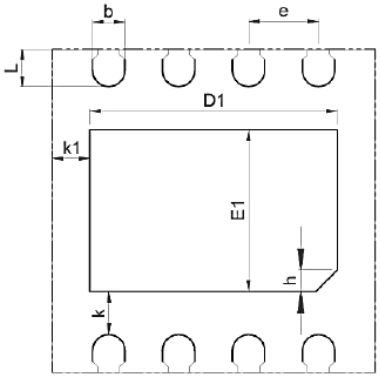


SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	0.70	0.75	0.80
A1	0.00	0.02	0.05
A3		0.20REF	
b	0.18	0.26	0.34
D	1.90	2.00	2.10
E	1.90	2.00	2.10
D2	0.55	0.70	0.85
E2	1.15	1.25	1.35
e	0.40	0.50	0.60
H		0.20REF	
K	0.30	--	--
L	0.20	0.30	0.40
R	0.115	--	--

PACKAGE DIMENSIONS:DFN3X3-8L



TOP VIEW



BOTTOM VIEW



SIDE VIEW

SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	0.70	0.75	0.80
* A1	0.00	0.02	0.05
* b	0.25	0.300	0.35
* A2		0.203 BSC	
* D	2.90	3.00	3.10
* E	2.90	3.00	3.10
* E1	1.40	1.50	1.60
* D1	2.20	2.40	2.60
* e		0.65 REF	
* L	0.30	0.35	0.40
h		0.20REF	
* k1	0.32	0.40	0.47
* k	0.35	0.40	0.45