550mA Linear Li-ion Battery Charger IC

Features

- Recommended operating voltage: 4.5V to 5.5V
- Absolute maximum input voltage: 33V
- 28V hot-plug capability with input RC snubber
- Overvoltage protection: 6.8V (typ.)
- Programmable charge current: 550mA
- Preset 4.20V or 4.35V charge voltage with ±1% accuracy
- No external MOSFET, sense resistor or blocking diode required
- Constant-current/constant-voltage operation
- Charge, charge-complete, no-battery and fault status indication
- Standby quiescent current: 1.0μA (typ.)
- Supports charging a 0V battery
- Reverse battery protection at BAT
- 2.9V trickle charging at C/5
- Charge termination current: C/10
- Automatic recharge
- Soft start limits inrush current
- Thermal current regulation starts at 130°C junction temperature; charging shuts down at 155°C
- Operating temperature: -40°C to +105°C
- Package: SOT23-6

Applications

- Massage guns and electronic cigarettes
- Bluetooth headsets, GPS and wearables
- Digital cameras, mini speakers, electronic toys and other portable devices
- Hair clippers, shavers and other chargers

General Description

HCR4057H is a linear Li-ion battery charger with a 33V absolute maximum input voltage and a maximum charging current of 800mA. It uses trickle, constant-current and constant-voltage charging. The charging voltage is preset to 4.2V or 4.35V, and an external resistor programs the charging current. After the battery reaches 4.2V or 4.35V, charging stops when the current falls to C/10 of the programmed value, and the device enters standby mode. When the input supply is removed, the device automatically enters low-power standby.

HCR4057H operates from USB or adapter supplies. Its internal PMOSFET architecture and reverse-current blocking circuit eliminate the need for an external sense resistor or blocking diode.

SOT-23-6

Figure 1. Appearance Diagram of HCR4057H

Pin Configuration

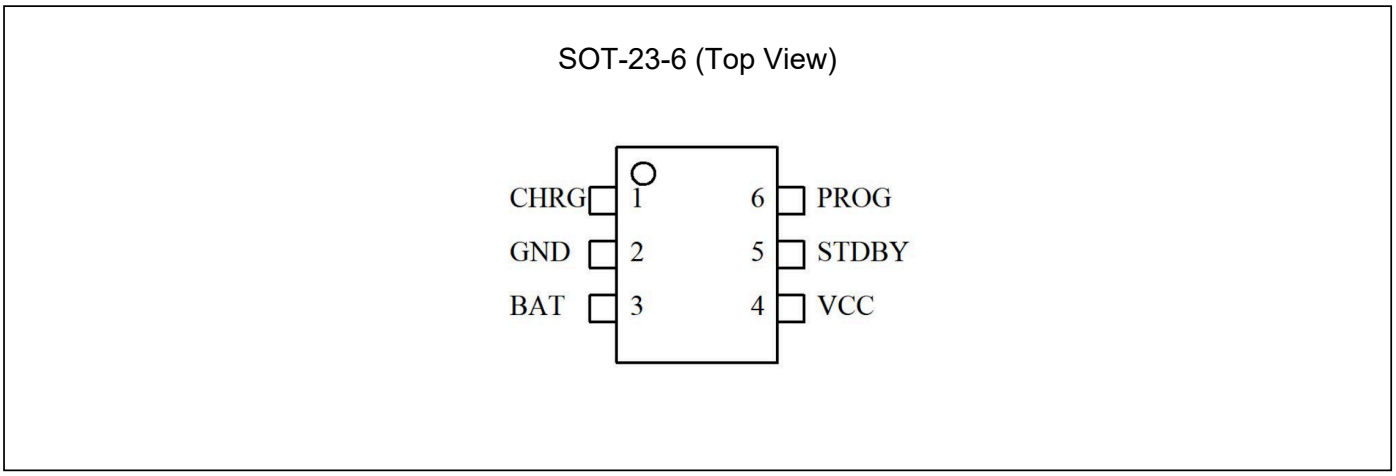


Figure 2. Pin Configuration (Top View)

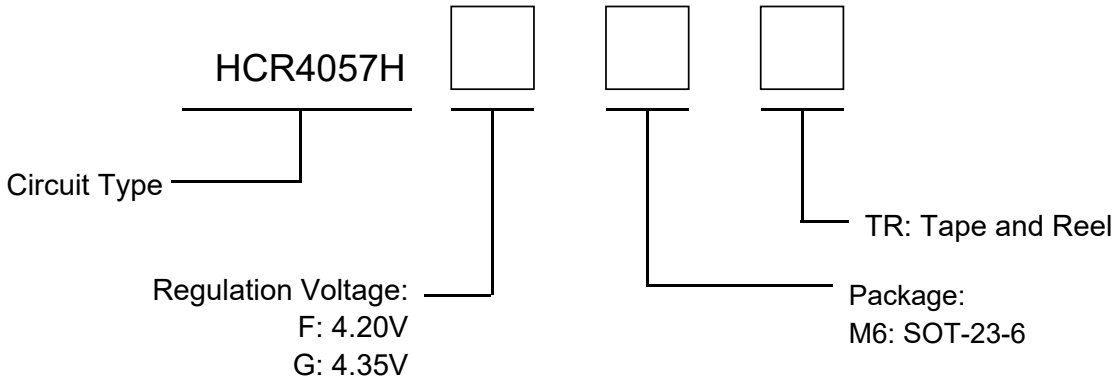
Pin Descriptions

Pin No.	Name	Description
1	$\overline{\text{CHRG}}$	Battery charging status indication.
2	GND	Ground.
3	BAT	Connect to the positive battery terminal.
4	VCC	Power supply.
5	$\overline{\text{STDBY}}$	Battery charge-complete indication.
6	PROG	Programmable charging-current setting pin.

Selection Guide

Model	Float Voltage	Trickle Current	Termination Current	Package
HCR4057HF	4.20V	C/5	C/10	SOT23-6
HCR4057HG	4.35V	C/5	C/10	SOT23-6

Ordering Information



Variant: F: 4.20V; G: 4.35V

Ordering Code

Part Number	Marking ID (Note 2)	Temperature Range	Package	Quantity per Reel
HCR4057HFM6TR	4057HFxx	-40 to +105°C	SOT-23-6	3000pcs/Reel
HCR4057HGM6TR	4057HGxx	-40 to +105°C	SOT-23-6	3000pcs/Reel

Note 2: The marking consists of the variant model followed by ”xx”, the date code.

Typical Application Circuit

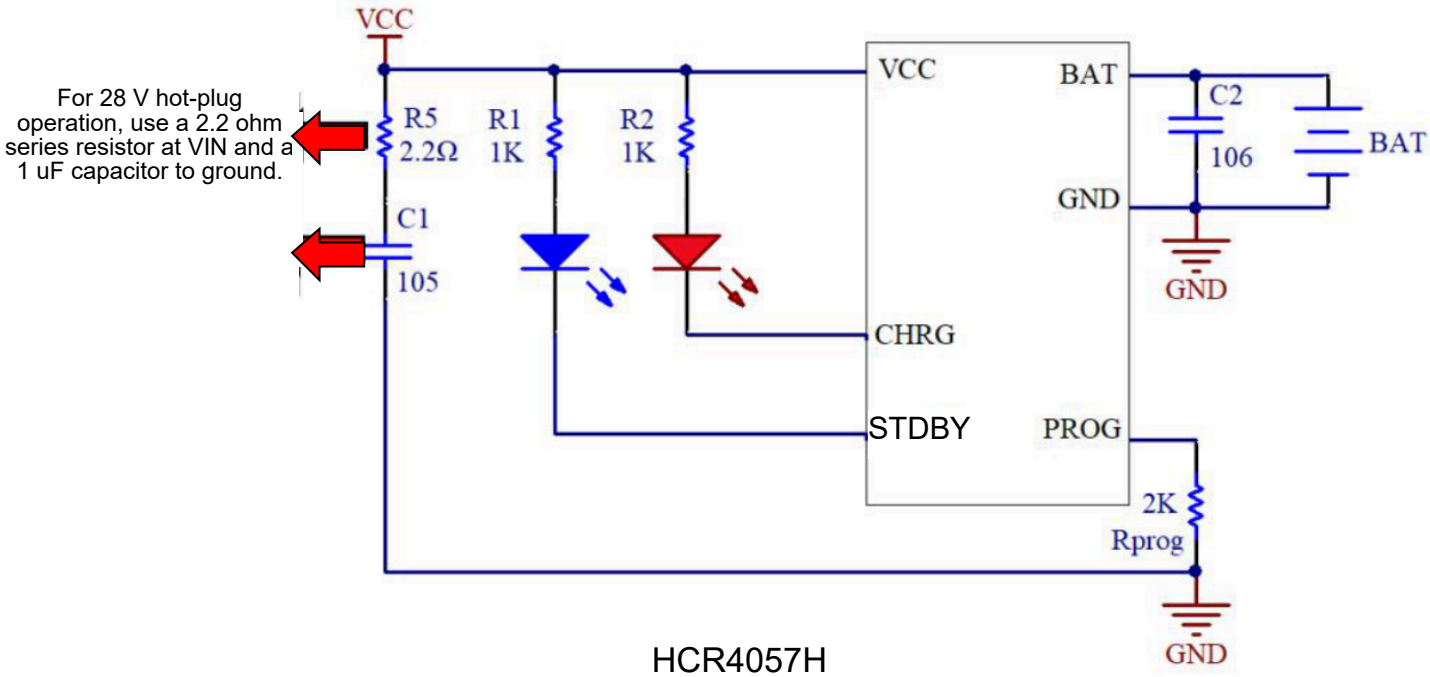


Figure 3. Typical Application Circuit

For 28V hot-plug operation, the input filter shown in the circuit is required: connect a 2.2Ω resistor in series with a 1μF capacitor from V_{IN} to ground.

Functional Block Diagram

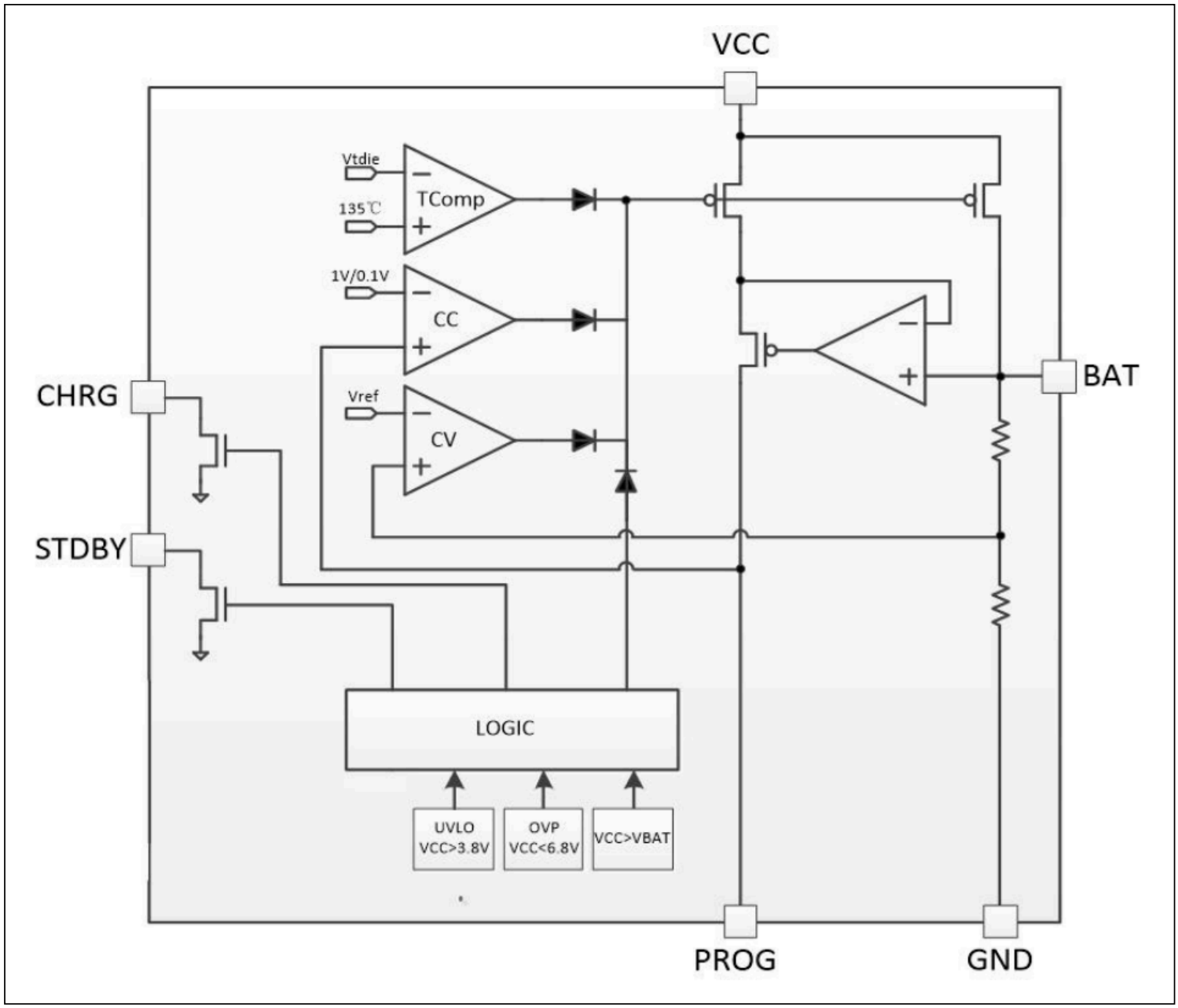


Figure 4. Functional Block Diagram

Absolute Maximum Ratings

Parameter	Symbol	Range	Unit
Input voltage	V_{IN}	-0.3 to 33	V
$\overline{CHRG}$ and $\overline{STDBY}$ pin voltage	V_{CHRG}, V_{STDBY}	-0.3 to 33	V
BAT pin voltage	V_{BAT}	-0.3 to 12	V
PROG pin voltage	V_{PROG}	-0.3 to 10	V
Maximum BAT pin current	I_{BAT}	800	mA
Maximum PROG pin current	I_{PROG}	1	mA
Power dissipation at T_A = +25°C	P_D (SOT23-6)	0.5	W
Storage temperature	T_{STG}	-65 to +150	°C
Maximum operating junction temperature	TJ(MAX)	155	°C
Lead soldering temperature (10s)	T_{LEAD}	260	°C
ESD (Human Body Model)	VDD to GND	≥5K	V

Note: Exceeding the absolute maximum ratings may damage the device.

Recommend Operating Conditions

Parameter	Symbol	Min.	Max.	Unit
Input voltage	V_{IN}	4.5	5.5	V
Ambient operating temperature	T_{OP}	-40	+105	°C
Charging current	I_{BAT}	30	550	mA

Electrical Characteristics

Parameter	Symbol	Test Conditions	Min.	Typ.	Max.	Unit
Input supply voltage	V_{IN}		4.5	5.0	5.5	V
Input overvoltage lockout threshold (OVP)	V_{OVLO}	V_{CC} rising	6.6	6.8	7.0	V
OVP hysteresis	V_{OVLO}-HYS	V_{CC} falling		500		mV
Input supply current	I_{CC}	Charging mode, R_{PROG} = 2kΩ		200	350	μA
Input supply current	I_{CC}	Standby mode (charge terminated)		100	150	μA
Input supply current	I_{CC}	Shutdown mode (R_{PROG} disconnected); V_{CC} < V_{BAT}, or V_{CC} < V_{OVLO}		55	100	μA
Regulated output (float) voltage	V_{FLOAT}	0°C ≤ T_A ≤ 85°C; I_{BAT} = 40mA	4.158	4.20	4.242	V
Regulated output (float) voltage	V_{FLOAT}	0°C ≤ T_A ≤ 85°C; I_{BAT} = 40mA	4.306	4.35	4.393	V
BAT pin charging current	I_{BAT}	Constant-current mode, R_{PROG} = 2kΩ	480	550	600	mA
BAT pin charging current	I_{BAT}	Standby mode, V_{BAT} = 4.20V		1.0		μA
BAT pin charging current	I_{BAT}	Shutdown mode (R_{PROG} disconnected)		1.0		μA
BAT pin charging current	I_{BAT}	Sleep mode, V_{CC} = 0V		0.1		μA
Trickle charging current	I_{TRIKL}	V_{BAT} < V_{TRIKL}; R_{PROG} = 2kΩ; C/5		100		mA
Trickle charging threshold	V_{TRIKL}	R_{PROG} = 2kΩ; V_{BAT} rising	2.8	2.9	3.0	V
Trickle charging hysteresis	V_{TRHYS}	R_{PROG} = 2kΩ; V_{BAT} falling	40	80	120	mV
V_{CC} undervoltage protection threshold	V_{UVLO}	V_{CC} rising	3.6	3.8	4.0	V
V_{CC} undervoltage lockout hysteresis	V_{UVHYS}	V_{CC} falling	150	200	250	mV
Manual shutdown threshold	V_{MSD}	PROG voltage	1.3			V
V_{CC} - V_{BAT} lockout voltage	V_{ASD}	V_{CC} rising		250		mV

Electrical Characteristics (Continued)

Parameter	Symbol	Test Conditions	Min.	Typ.	Max.	Unit
V_{CC} - V_{BAT} lockout voltage	V_{ASD}	V_{CC} falling		200		mV
Termination current threshold	I_{TERM}	R_{PROG} = 2kΩ; C/10		50		mA
PROG pin voltage	V_{PROG}	Constant-current mode, R_{PROG} = 2kΩ	0.9	1.0	1.1	V
$\overline{CHRG}$ output low voltage	V_{CHRG}	I_{CHRG} = 5mA		0.35	0.5	V
$\overline{STDBY}$ output low voltage	V_{STDBY}	I_{STDBY} = 5mA		0.35	0.5	V
Recharge battery threshold	V_{RECHG}	IFLOAT - V_{RECHG}	100	150	200	mV
Recharge delay	t_{RECHG}	V_{BAT} falling		1.2		ms
Charge termination delay	t_{TERM}	I_{BAT} falls below I_{CHRG}/10		1.6		ms
PROG pull-up current	I_{PROG}			2.0		μA
Power FET on-resistance	R_{ON}			500		mΩ
Soft-start time	t_{SS}	I_{BAT} = 0 to I_{BAT} = 1000/R_{PROG}		450		μs
Junction temperature in temperature-limit mode	T_{LIM}			155		°C

Note: Some parameters may vary slightly between production batches.

Typical Performance Characteristics

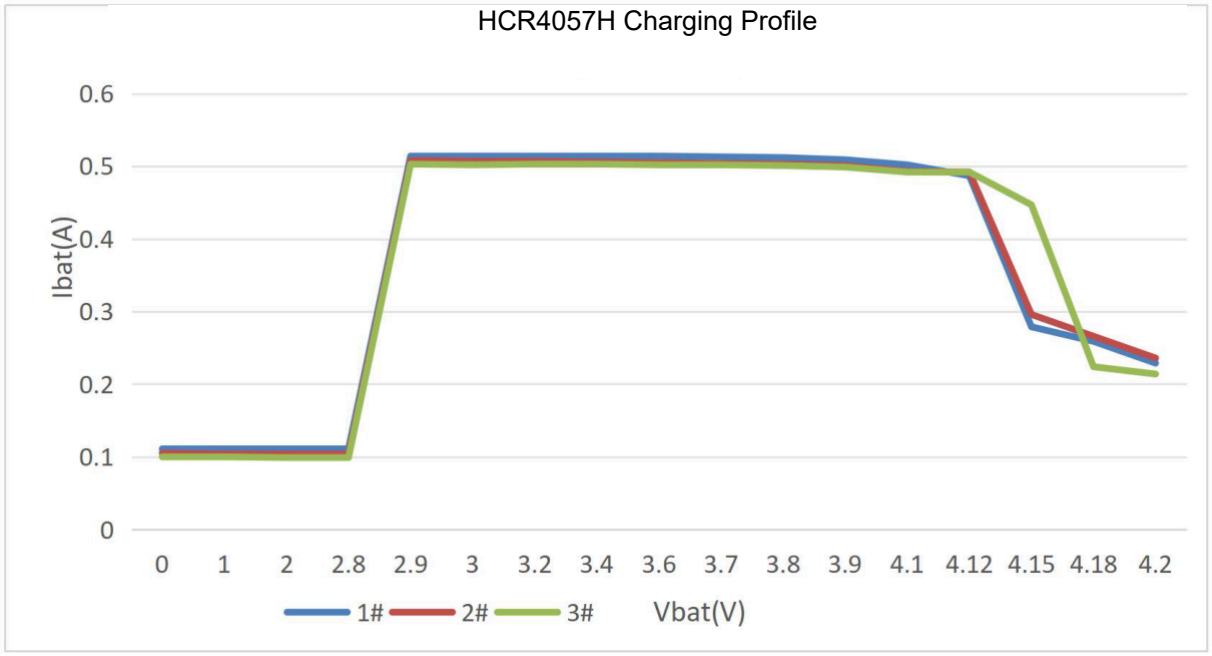


Figure 5. Charging Characteristics (V_{IN} = 5V, PROG = 2kΩ, SOT23-6)

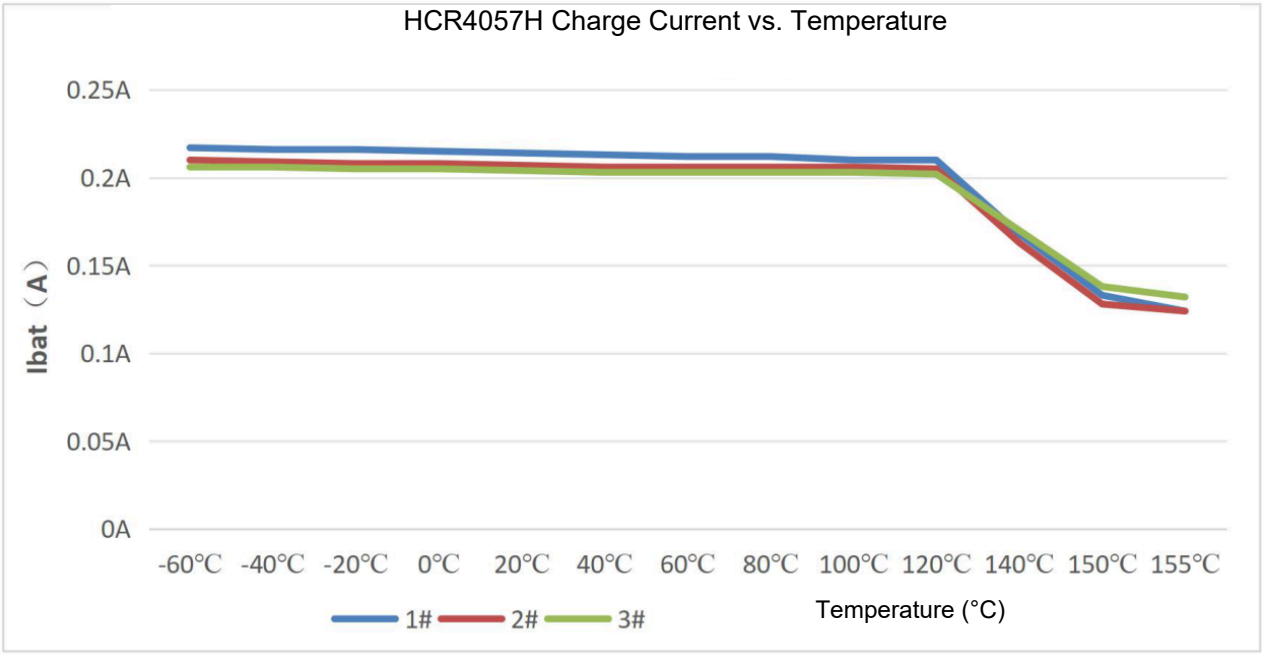


Figure 6. Charging Current vs. Temperature (V_{IN} = 5V, PROG = 5.1kΩ, SOT23-6)

Typical Performance Characteristics

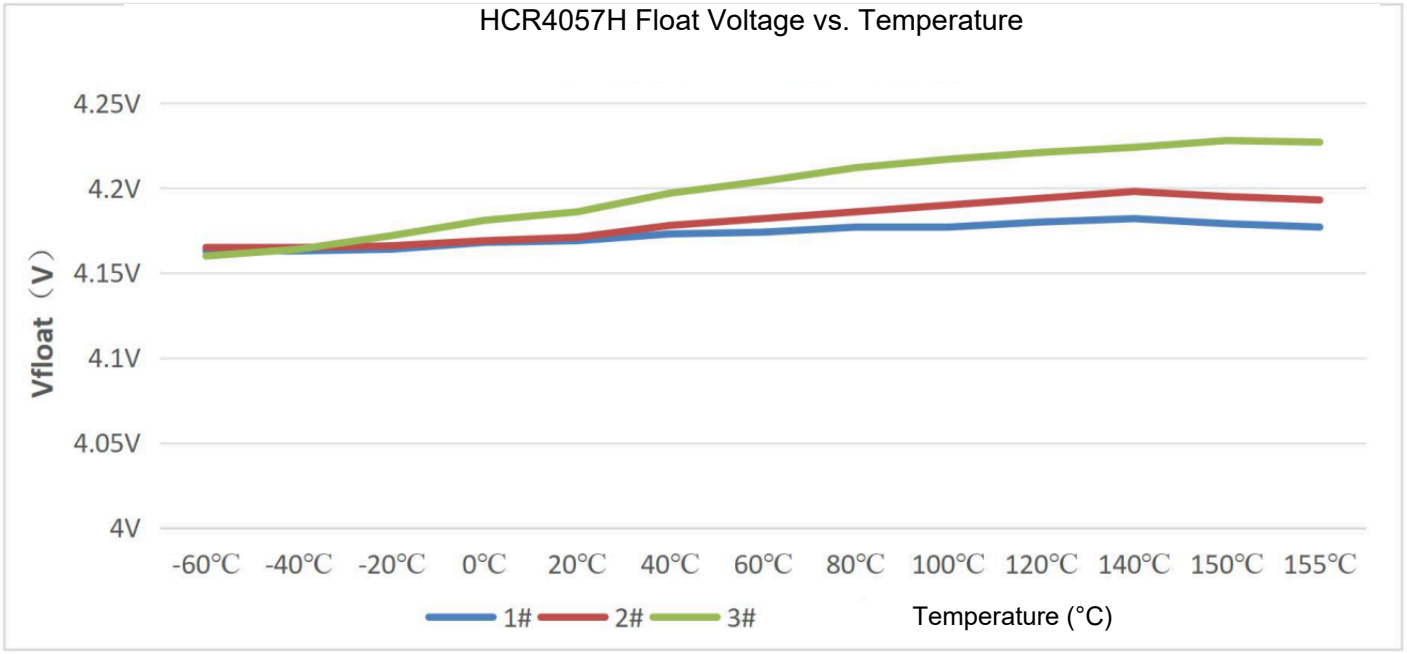


Figure 7. Float Voltage vs. Temperature (V_{IN} = 5V, PROG = 5.1kΩ, SOT23-6)

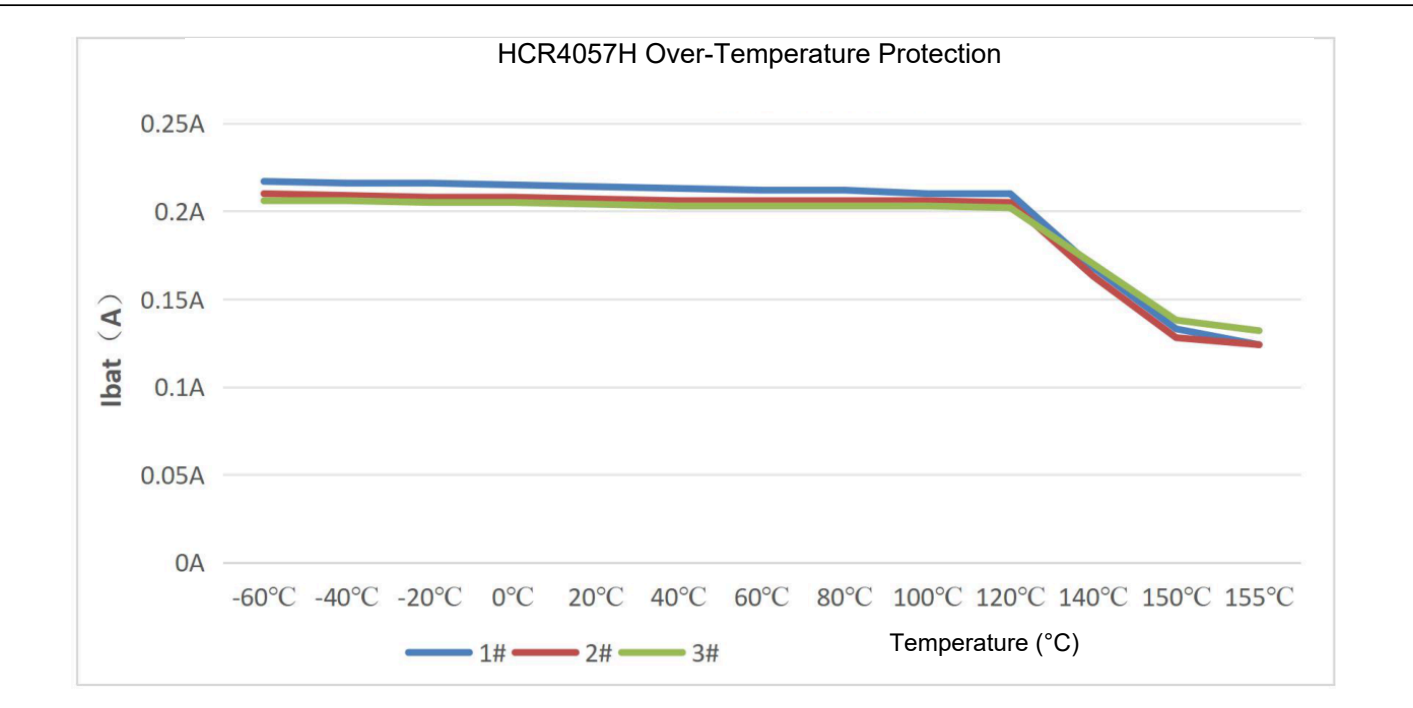


Figure 8. Overtemperature Protection (V_{IN} = 5V, PROG = 5.1kΩ, SOT23-6)

Detailed Description and Application Information

Operating Principle

HCR4057H is a linear charger for a single-cell Li-ion or Li-polymer battery. An internal power MOSFET charges the battery in constant-current/constant-voltage mode. An external resistor programs the charging current, which can reach a maximum of 800mA. The device provides $\overline{CHRG}$ charging-status and $\overline{STDBY}$ charge-complete outputs. The internal power circuit automatically reduces charging current when the junction temperature exceeds 130°C, allowing maximum use of the charging capability. Charging shuts down at 155°C to protect the device and external components from overheating. Input overvoltage protection protects the device in demanding input-supply conditions.

Normal Charging

A charging cycle begins when V_{CC} rises above the UVLO threshold and a 1%-accuracy programming resistor is connected between PROG and ground. If the BAT voltage is below the 2.9V trickle charging threshold, HCR4057H enters trickle charging mode and supplies approximately C/5 of the programmed charging current to raise the battery voltage to a safe level. When BAT rises above the trickle threshold, the charger enters constant-current mode and supplies a constant current to the battery. When BAT reaches the final float voltage of 4.2V or 4.35V, the device enters constant-voltage mode and the charging current begins to decrease. The charging cycle ends when the current falls to C/10 of the programmed value.

Programming the Charging Current

A resistor connected between PROG and ground sets the charging current. The charging current is 1000 times the current at PROG. The programming resistor and charging current are calculated as follows:

$$R_{PROG} = \frac{1000}{I_{BAT}} \quad \text{or} \quad I_{BAT} = \frac{1000}{R_{PROG}}$$

The charging current delivered from BAT can be determined at any time by monitoring the PROG voltage:

$$I_{BAT} = \frac{V_{PROG}}{R_{PROG}} \times 1000$$

When the programmed current exceeds 550mA, the device generates more heat and thermal protection reduces the charging current. Measured current under different operating conditions may therefore differ from the theoretical value calculated by the equation. Select a suitable R_{PROG} for the application. Recommended values are listed below.

Recommended Programming Resistor

R_{PROG} (kΩ)	I_{BAT} (mA)
1.6	600
2	550
3.3	300

Charge Termination

The charging cycle terminates when the current falls to C/10 of the programmed value after the final float voltage has been reached. An internal filtered comparator detects this condition by monitoring PROG. When the PROG voltage falls below 100mV (C/10), charging terminates and HCR4057H enters standby mode. The input supply current then drops to approximately 100μA.

Detailed Description and Application Information

Charging Status Indication

HCR4057H has two open-drain status outputs, $\overline{CHRG}$ and $\overline{STDBY}$. $\overline{CHRG}$ is pulled low while the battery is charging and is high impedance in other states. When no battery is connected, $\overline{CHRG}$ outputs pulses to indicate the absence of a battery. With a 1µF external capacitor at the battery terminal, the $\overline{CHRG}$ flashing period is approximately 0.1 to 0.8 seconds. With a 10µF external capacitor at BAT, the flashing period is approximately 1 to 2 seconds. Connect any unused status output to ground when status indication is not required. The indicator states are listed below.

Charging State	$\overline{CHRG}$ Level (LED)	$\overline{STDBY}$ Level (LED)
Charging	Low (on)	High impedance (off)
Battery fully charged	High impedance (off)	Low (on)
Input undervoltage, input overvoltage or reverse battery	High impedance (off)	High impedance (off)
10µF at BAT; no battery	Flashes, 1 to 2s	Low (on)

Thermal Limiting

If the device temperature rises above 130°C, an internal thermal feedback loop reduces the programmed charging current. Above 155°C, the output shuts down. This function prevents HCR4057H from overheating and allows the user to make greater use of the power-handling capability of a given circuit board while reducing the risk of device damage.

Undervoltage Lockout

An internal undervoltage lockout circuit monitors the input voltage and holds HCR4057H in shutdown until V_{CC} rises above the undervoltage lockout threshold. The UVLO circuit keeps the charger in shutdown. If the UVLO comparator changes state, the charger will not leave shutdown until V_{CC} is 250mV higher than the battery voltage.

Automatic Recharge

After the battery reaches the float voltage and the charging cycle terminates, HCR4057H immediately monitors BAT. A new charging cycle begins when BAT falls below approximately 4.05V for the 4.20V float-voltage option or 4.20V for the 4.35V option. This keeps the battery near full charge without requiring periodic initiation of a charging cycle.

Detailed Description and Application Information

Reverse Battery Protection

HCR4057H includes reverse Li-ion battery protection. If a battery is connected in reverse to BAT, the device shuts down and indicates a fault. The reverse-connected battery leakage current is approximately 0.1mA. Correcting the battery connection automatically starts a charging cycle. If the reverse-connected battery is removed, the BAT capacitor initially remains at a negative voltage, so the charging indicator does not immediately return to its normal state. Correctly connecting a battery automatically activates charging. Alternatively, after the negative charge on the BAT capacitor dissipates and BAT rises above 0V, the normal no-battery indication returns.

Charging Current Soft Start

HCR4057H includes a soft-start circuit that minimizes inrush current at the beginning of a charging cycle. When a cycle begins, the charging current rises from zero to its full-scale value in approximately 450μs. This minimizes transient loading of the power supply during startup.

Input Overvoltage Protection (OVP)

HCR4057H provides input overvoltage protection. When V_{CC} reaches 6.8V, OVP shuts down the device and stops charging the battery. The device resumes operation when the supply voltage falls to 6.2V.

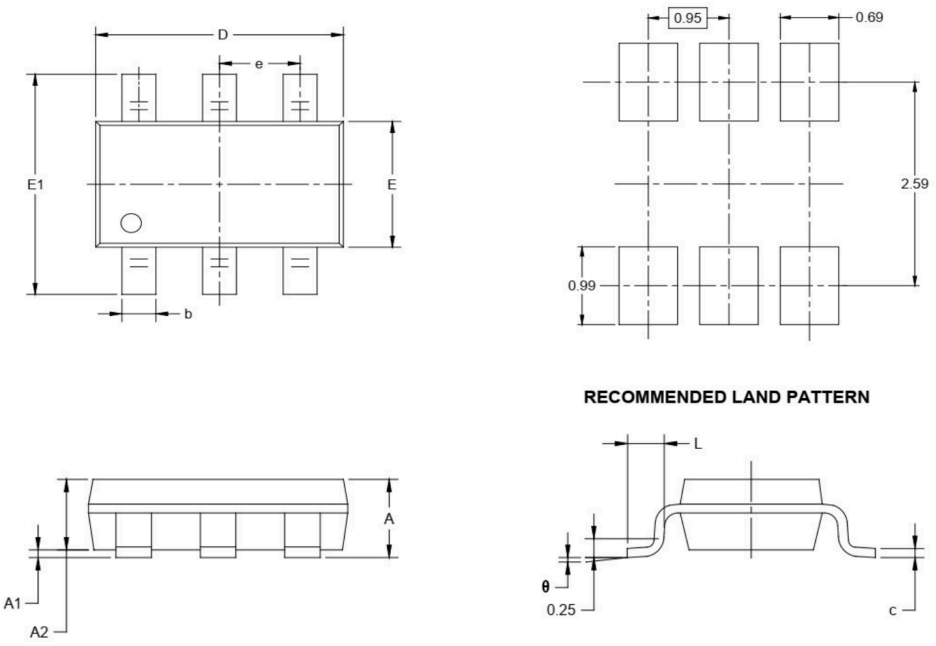
Input/Output Capacitors, Resistors and PCB Layout

For reliable operation and to prevent voltage spikes and glitches from damaging the device, an input RC filter is recommended; refer to the typical application circuit. Capacitor values are C_1 = 105 and C_2 = 106. Place the capacitors as close as possible to the device pins.

Recommended resistor values are R_1 = R_2 = 1kΩ. These resistors must not be omitted, to prevent incorrect LED status indication.

Mechanical Dimensions

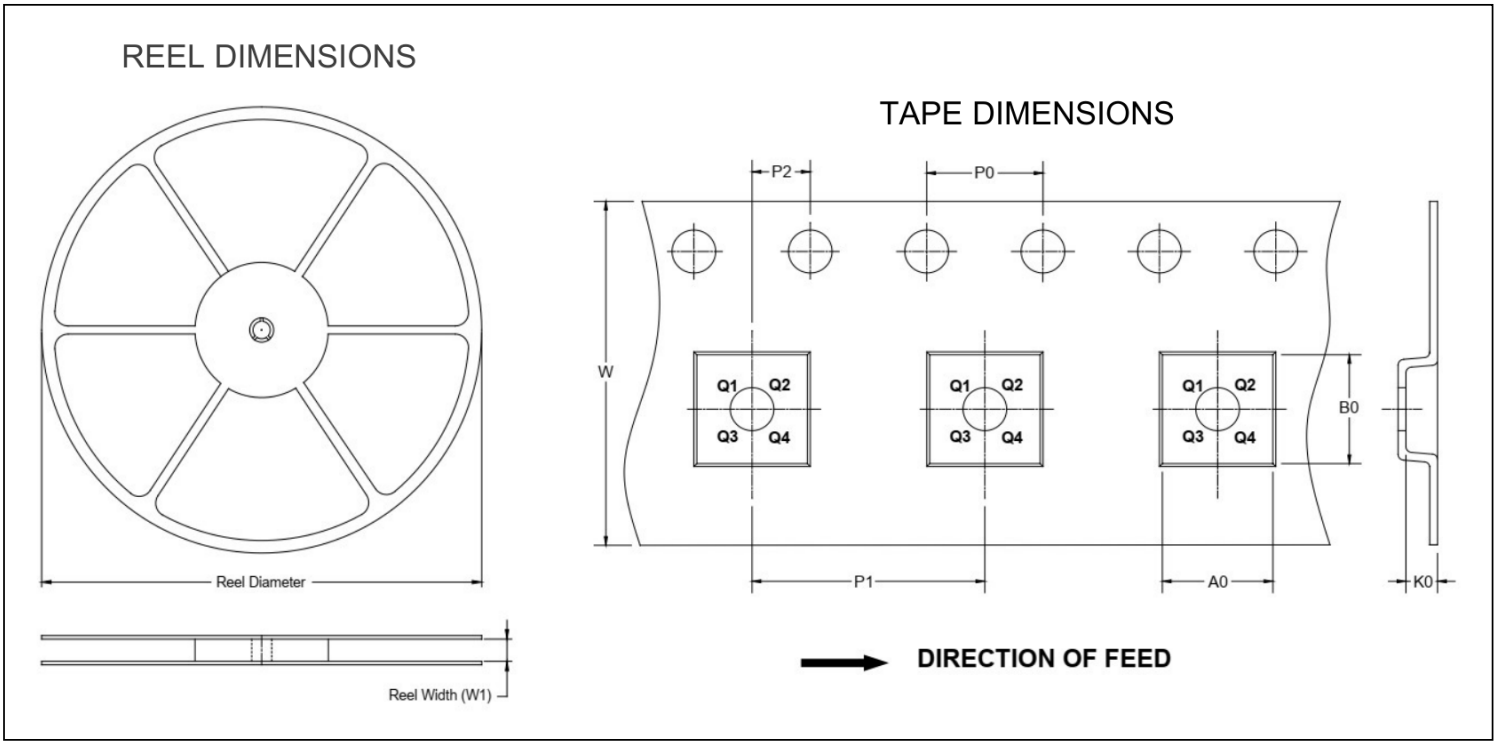
M6L PKG: SOT-23-6 Unit: mm



Symbol	MIN (mm)	MOD (mm)	MAX (mm)
A	-	-	1.100
A1	0.000	-	0.100
A2	0.700	-	1.000
b	0.300	-	0.500
c	0.080	-	0.200
D	2.820	-	3.050
E	1.550	-	1.700
E1	2.650	-	2.950
e	0.950 BSC		
L	0.300	-	0.600
θ	0°	-	8°

1. Body dimensions do not include mode flash or protrusion.
2. This drawing is subject to change without notice.

Tape and Reel Information



Reel and Tape Dimensions

NOTE: The picture is only for reference. Please make the object as the standard.

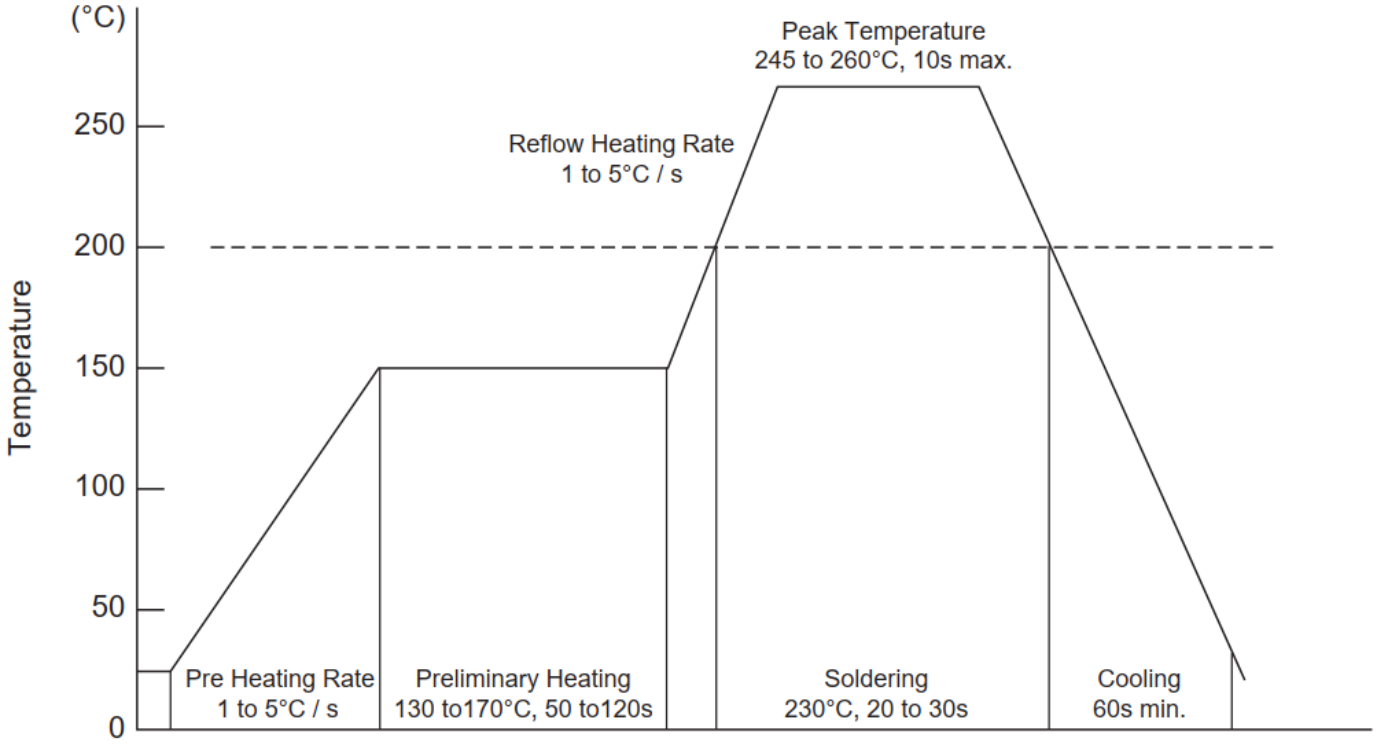
Key Parameter List of Tape and Reel

Package	Reel Diameter	W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	P1 (mm)	P2 (mm)	W (mm)	Pin1 Quadrant
SOT-23-6	7”	9.5	3.20	3.20	1.40	4.0	4.0	2.0	8.0	Q3

Quantity per Reel: SOT-23-6 - 3000pcs

Conditions of Soldering and Storage

Recommended Condition of Reflow Soldering



Recommended peak temperature is over 245°C. If peak temperature is below 245°C, you may adjust the following parameters:

- Time length of peak temperature (longer)
- Time length of soldering (longer)
- Thickness of solder paste (thicker)

Conditions of Hand Soldering

- Temperature: 300°C
- Time: 3s max
- Times: one time

Storage Conditions

- Temperature: 5 to 40°C
- Humidity: 30 to 80% RH
- Recommended period: One year after manufacturing