

Linear Lithium-Ion Battery Charger

Features

- Programmable Charge Current Up to 600mA
- Standalone Li-Ion Charger with Thermal Regulation
- No Sense Resistor or Blocking Diode Required
- Preset Charge
- Voltage with $\pm 0.6\%$ Accuracy
- Suitable for USB-Powered Charging
- 6.2V Input Over Voltage Protect
- C/10 Charge Termination
- 12V Absolute Maximum Input Voltage
- Low Battery Charging Conditioning
- Automatic Recharge
- Negligible Battery Drain Current in Shutdown
- Protection Against Battery Reverse Connection
- Self-protection for Overcurrent /Overtemperature
- Available in SOT23-5 Package

Applications

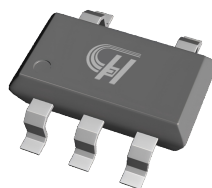
- Cellular Telephones, PDAs, MP3 Players
- Charging Docks and Cradles
- Bluetooth Applications

General Description

The HCR4054D is a low cost, Single-cell, constant-current/constant-voltage Li-Ion battery charger. With a few external components, the HCR4054D is very small stand alone charger for single Lithium-Ion batteries.

Charge current is set externally with a single resistor, no blocking diode is required due to the internal MOSFET architecture. The HCR4054D charges to a final float voltage accurate to $\pm 0.6\%$, The HCR4054D automatically terminates the charge cycle when the charge current drops to 1/10th the programmed value after the final float voltage is reached and automatically puts into a sleep mode while removing input power.

The output is both current and thermally protected to prevent operating outside of safe limits. UVLO, Thermal, OVP and reverse connection protection are also available.



SOT23-5

Figure 1. Package Type of HCR4054D

Linear Lithium-Ion Battery Charger

Pin Configuration

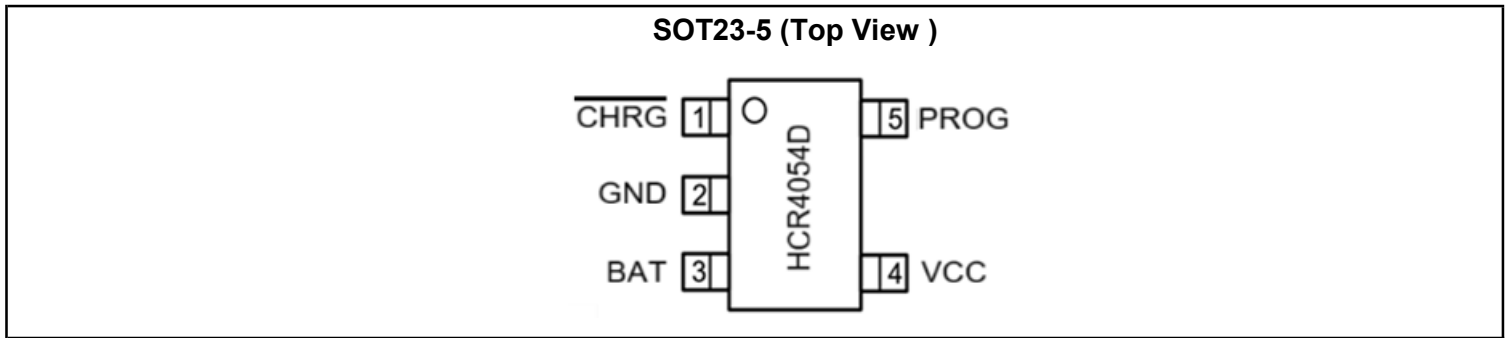
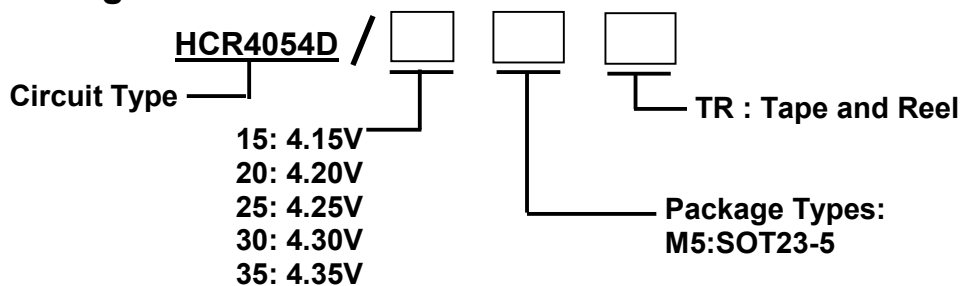


Figure 2. Pin Configuration of HCR4054D(Top View)

Pin Function Table

Pin Number	Pin Name	Pin Function
SOT23-5		
1	$\overline{\text{CHRG}}$	Open-Drain Charge Status Output
2	GND	Ground
3	BAT	Charing Current Output.
4	VCC	Positive Input Power Voltage
5	PROG	Charge Current Program, Charge Current Monitor and Shutdown Pin.

Ordering Information



Ordering Code

Part Number	Marking ID ^{note2}	Float Voltage	Packages	Quantity per Reel
HCR4054D/15M5TR	4054D15XX	4.15V	SOT23-5	3000pcs/Tape&Reel
HCR4054D/20M5TR	4054D20XX	4.20V	SOT23-5	3000pcs/Tape&Reel
HCR4054D/25M5TR	4054D25XX	4.25V	SOT23-5	3000pcs/Tape&Reel
HCR4054D/30M5TR	4054D30XX	4.30V	SOT23-5	3000pcs/Tape&Reel
HCR4054D/35M5TR	4054D35XX	4.35V	SOT23-5	3000pcs/Tape&Reel

Note 2. The 'XX' is date code.

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Block Diagram

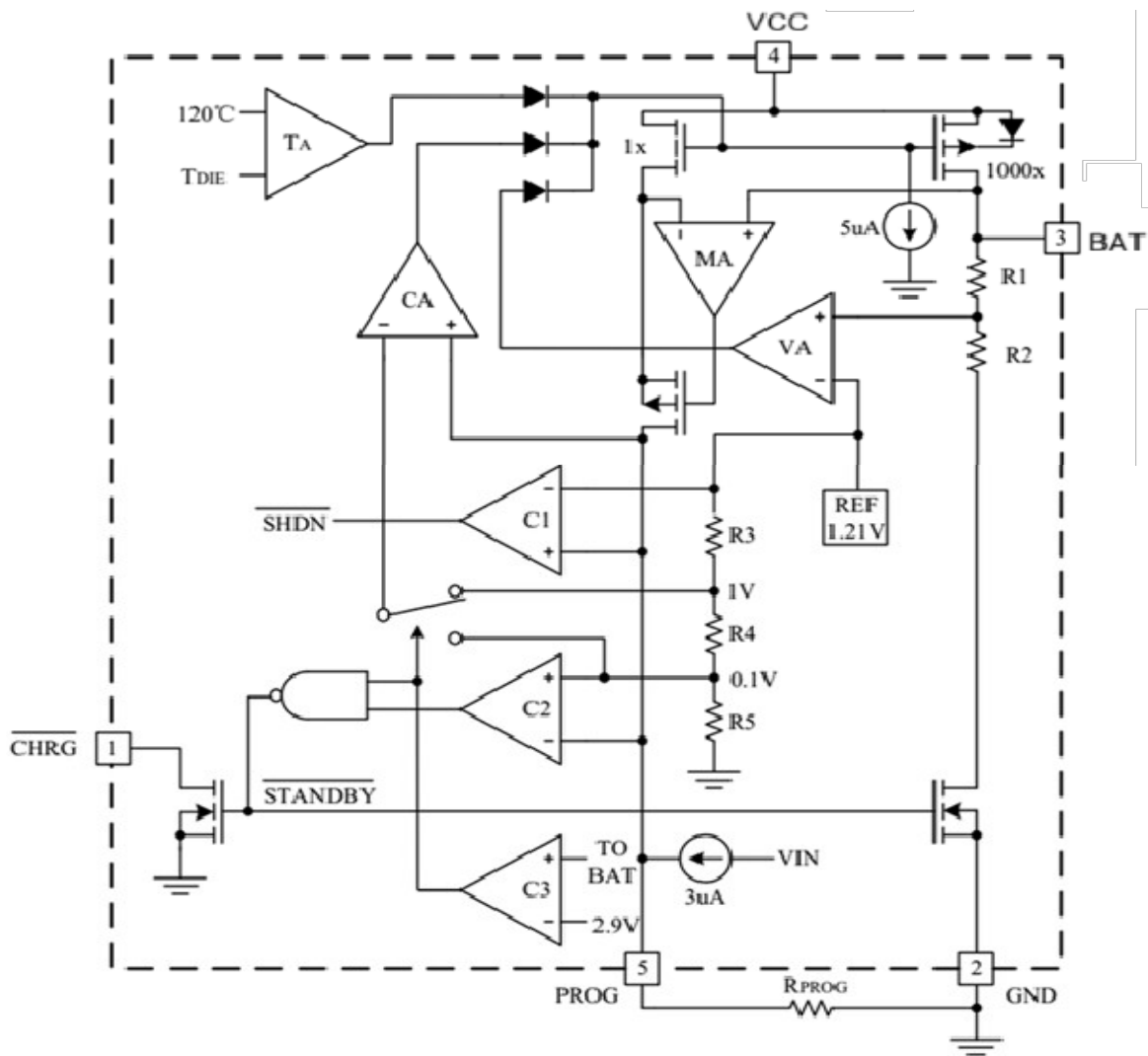
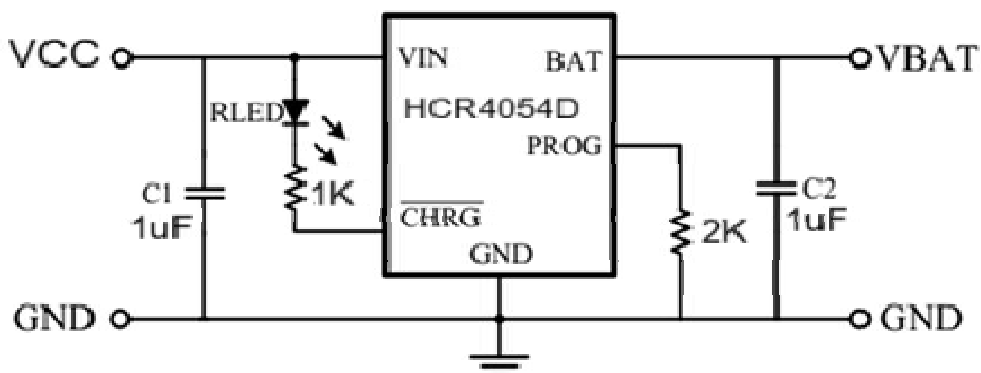


Figure 3. Pin Configuration of HCR4054D (Top View)

Typical Application Circuit^{note3}



Note 3: $C1=4.7\mu F$, $C2=10\mu F$, $I_{BAT}=(V_{PROG}/R_{PROG}) \times 1000$

Figure 4. Typical Application Circuit of HCR4054D

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Absolute Maximum Ratings ^{Note 1}

Parameter		Symbol	Value	Unit
VCC Input Supply Voltage		VCC	-0.3 to +12	V
PROG Pin Voltage		Vprog	-0.3 to +8.5	V
BAT Pin Voltage		Vbat	-4.5 to +5.5	V
CHRG Pin Voltage		Vchrg	-4.5 to +5.5	V
Maximum Power Dissipation	SOT23-5	PD	600	mW
BAT Pin Current		Ibat	800	mA
PROG Pin Current		Iprog	800	uA
Storage Temperature Range		TSTG	-65 to +150	'C
Operating Junction Temperature		TJ	-40 to +150	'C
Lead Temperature (Soldering, 10s)		TLEAD	260	'C

Thermal Information

Parameter	Symbol	Ratings	Unit
Junction-to-Ambient Thermal Resistance	RθJA	170	'C/W
Junction-to-Case(top) Thermal Resistance	RθJC	130	'C/W

Recommend Operating Conditions ^{note1}

Input Supply Voltage	VCC	+4.15 to +6.2	V
Ambient Operting Temp	Topa	-40 to +85	'C

Note 1: the "Absolute maximum Ratings" is rated values exceeding which the product could suffer physical damage.

These values must therefore not be exceeded under any conditions.

Linear Lithium-Ion Battery Charger

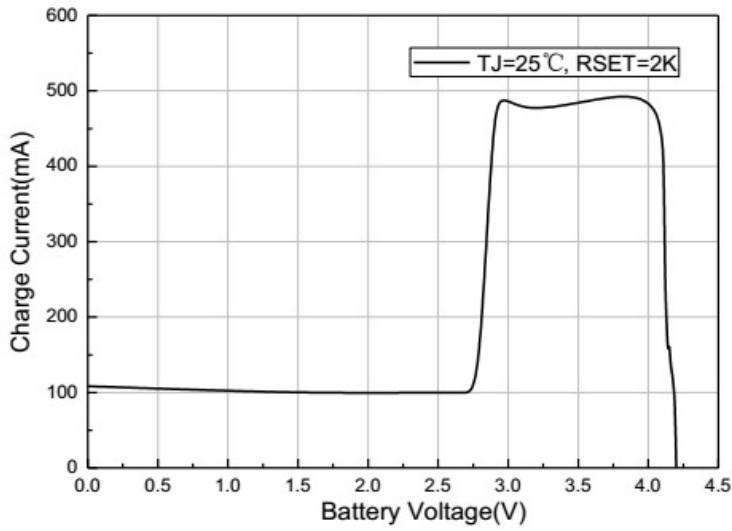
Electrical Characteristics (Ta=25°C; Vin=5V, unless otherwise specified)

Parameter	Symbol	Test Condition	Min	Type	Max	Unit
Input Supply Voltage	VCC		4.5	-	6.2	V
Input Supply Current	ICC	Standby mode	-	150	-	uA
Regulated Output(Float) Voltage	Vfloat	0°C<TA<85°C, IBAT=40mA	-0.6	-	+0.6	%
BAT pin Current	Ibat	Rprog=2K,Current mode	460	500	540	mA
		Rprog=10K,Current mode	90	100	110	mA
		Standby mode, Vbat=4.2V	0	-2.5	-6.0	uA
		Shutdown mode	-	1	2	uA
		Sleep mode, Vcc=0V	-	1	2	uA
Trickle charge current	Itrikl	Rprog=2K	-	50	-	mA
		Rprog=10K	-	10	-	mA
Trickle charge Threshold Voltage	Vtrikl	Rprog=10K,Vbat Rising	2.8	2.9	3.0	V
C/10 Termination Current Threshold	Iterm	Rprog=10K	0.085	0.10	0.115	mA/mA
		Rprog=2K	0.085	0.10	0.115	mA/mA
PROG pin Voltage	Vprog	Rprog=10K, Current mode	0.93	1.0	1.07	V
Recharge Battery threshold voltage	ΔVrecg	VFLOAT-VRECHRG	-	100	200	mV
CHRG pin weak pull-down current	Ichrg	Vchrg=5V	-	3	-	mA
PROG pin pull-up current	Iprog		-	3	-	uA
Recharge Comparat or Filter time	tRECHGE		-	2	-	mS
Soft-Start time	tss		-	700	-	uS
Junction Temperature in Constant Temperature Mode	TLIM		-	120	-	°C
Power FET On resistance	-		-	600	-	mΩ

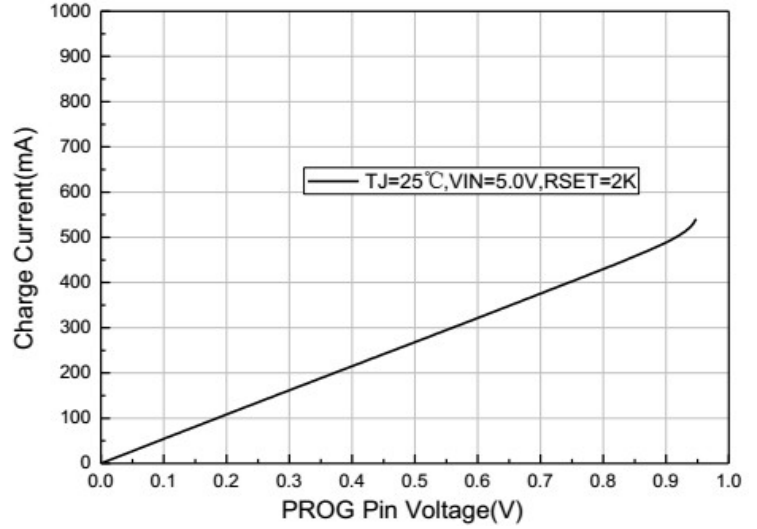
Linear Lithium-Ion Battery Charger

Typical Performance Characteristics

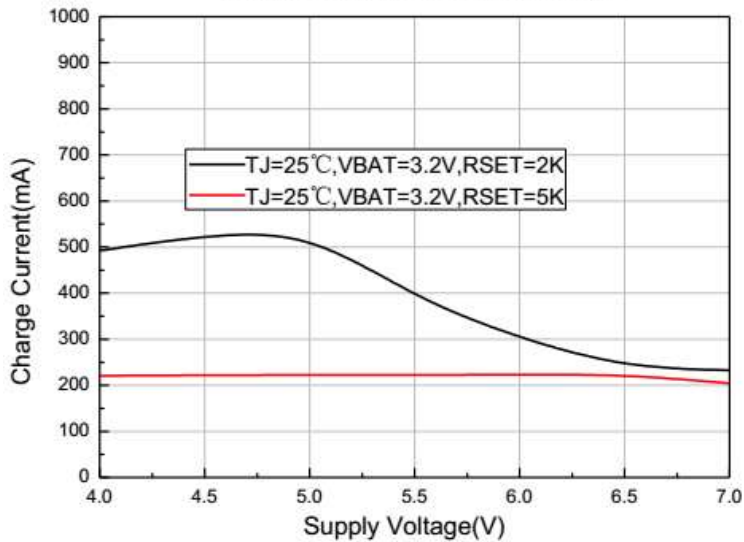
Charge Current VS Battery Voltage



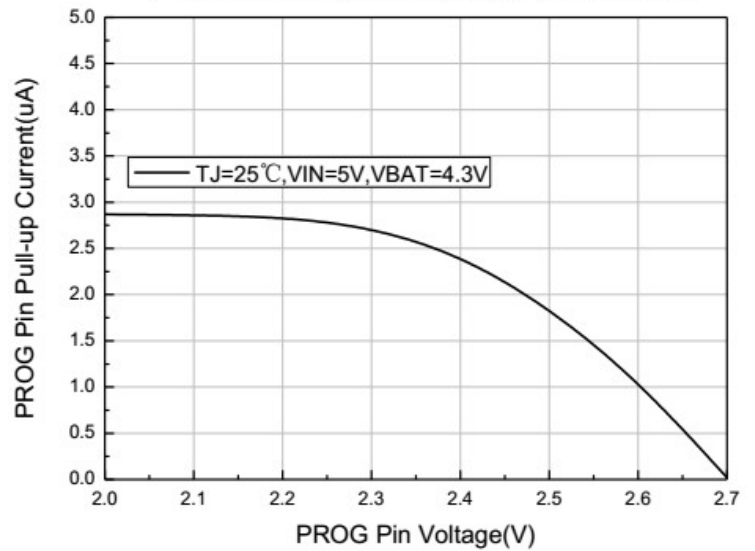
Charge Current VS PROG Pin Voltage



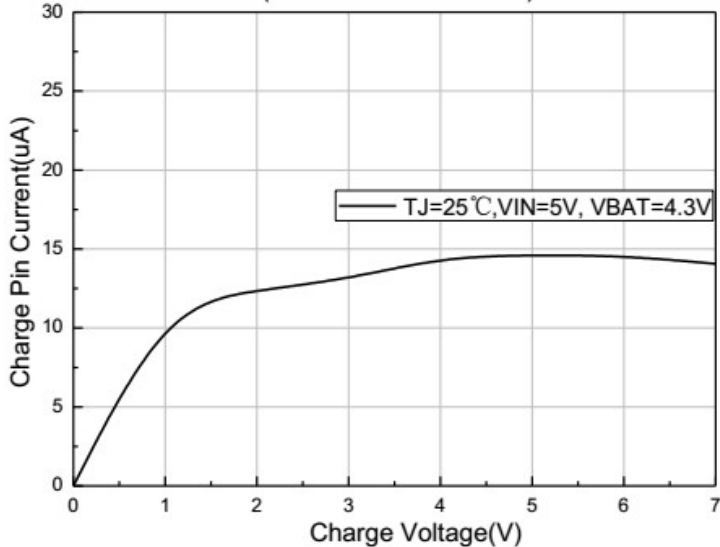
Charge Current VS Supply Voltage



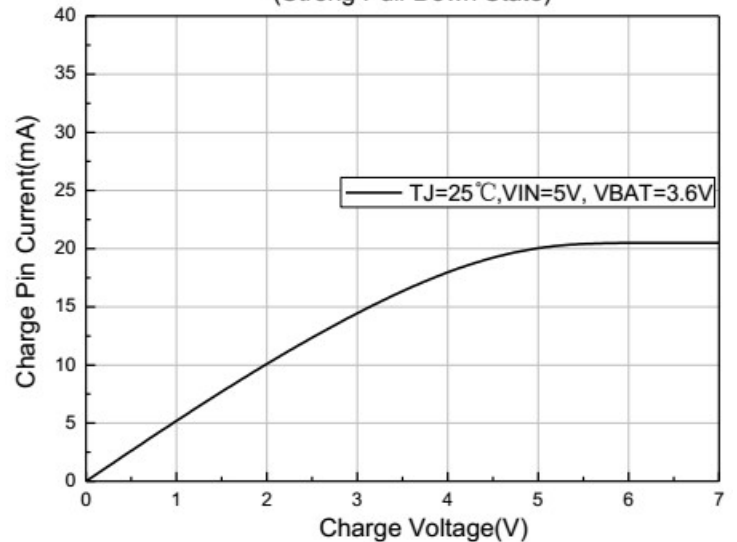
PROG Pin Pull-up Current VS PROG Pin Voltage



Charge Pin Current VS Charge Voltage
(Weak Pull-Down State)



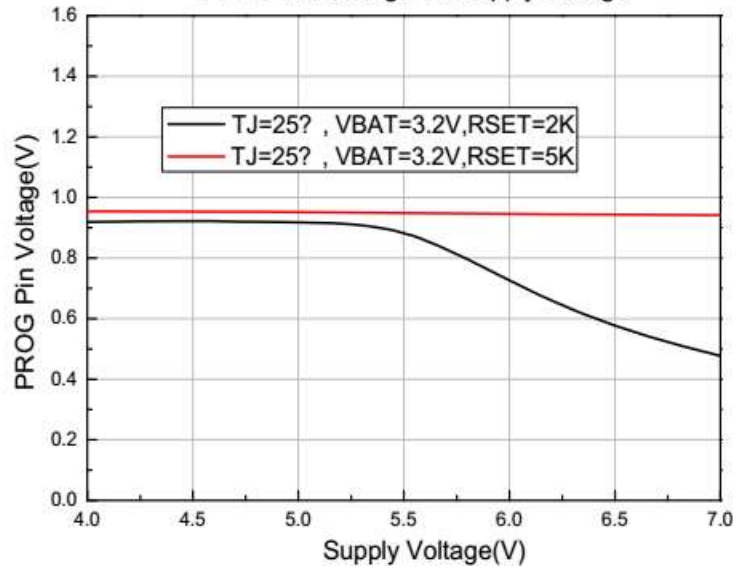
Charge Pin Current VS Charge Voltage
(Strong Pull-Down State)



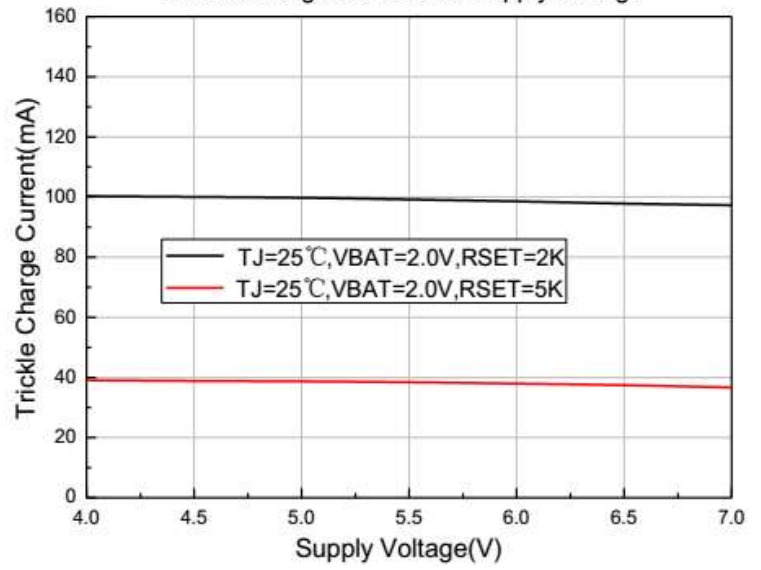
Linear Lithium-Ion Battery Charger

Typical Performance Characteristics (continued)

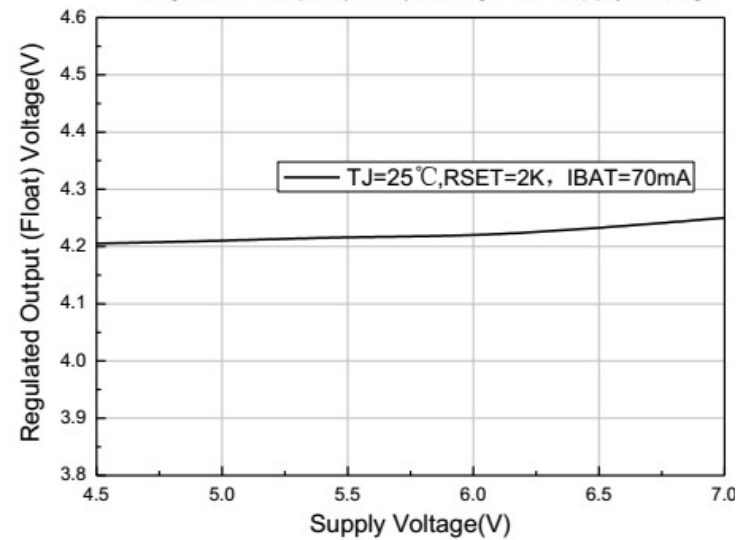
PROG Pin Voltage VS Supply Voltage



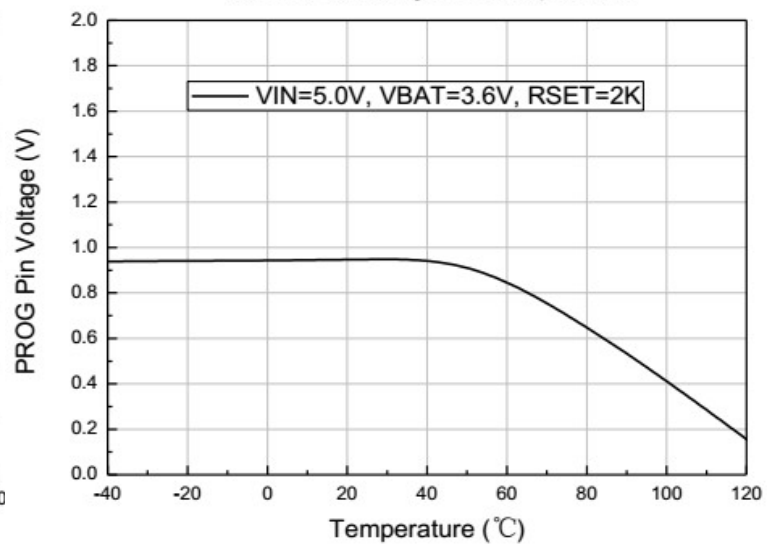
Trickle Charge Current VS Supply Voltage



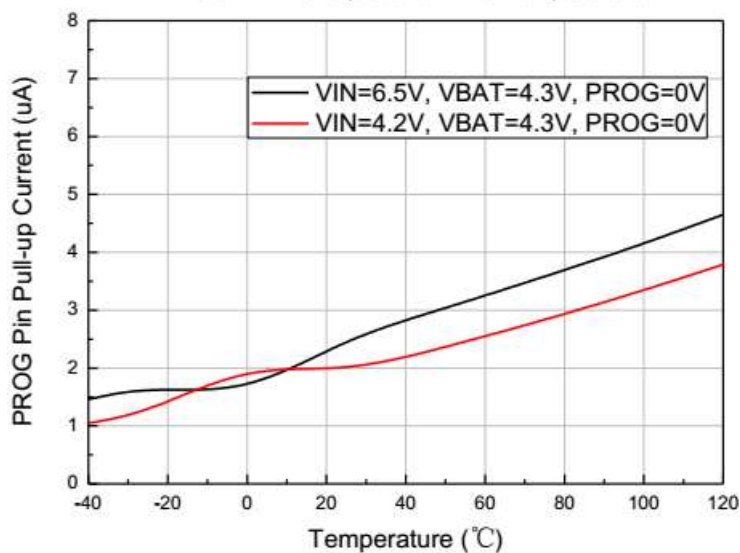
Regulated Output (Float) Voltage VS Supply Voltage



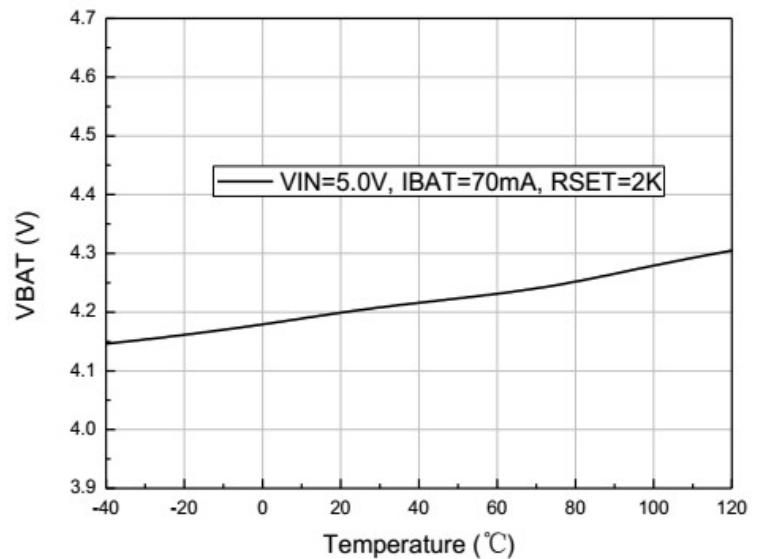
PROG Pin Voltage VS Temperature



PROG Pin Pull-up Current VS Temperature

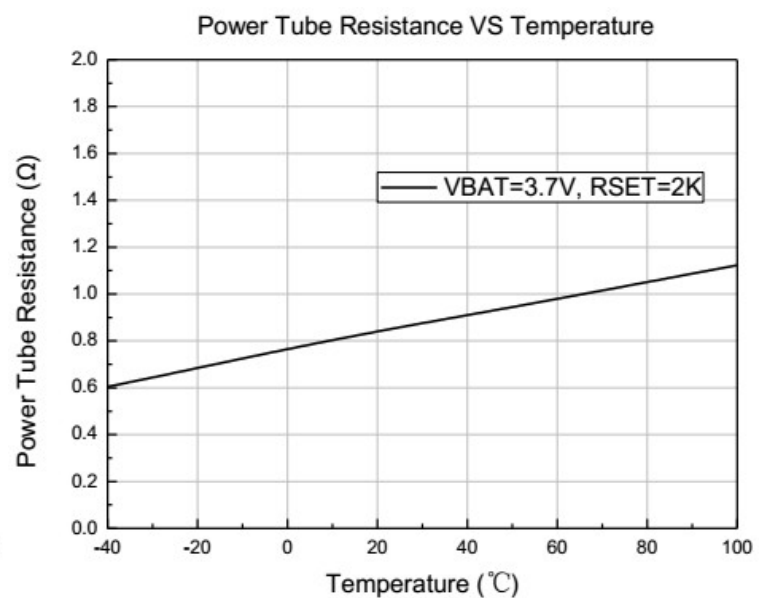
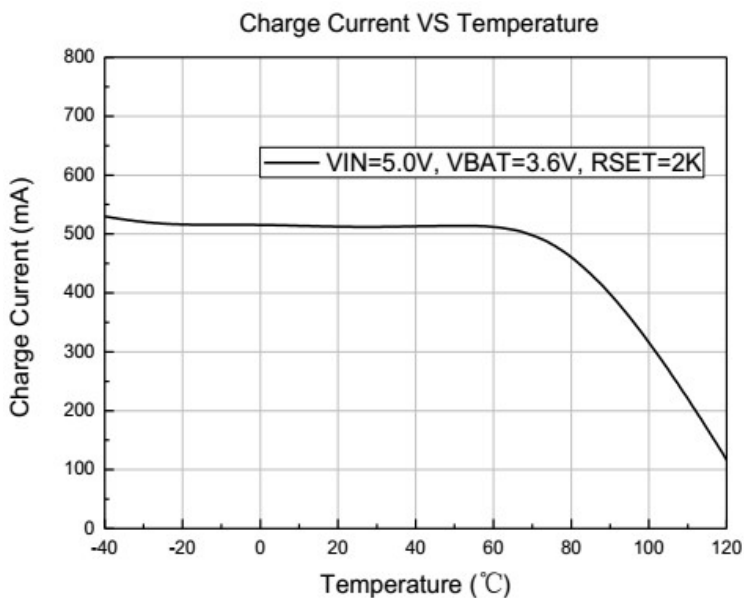
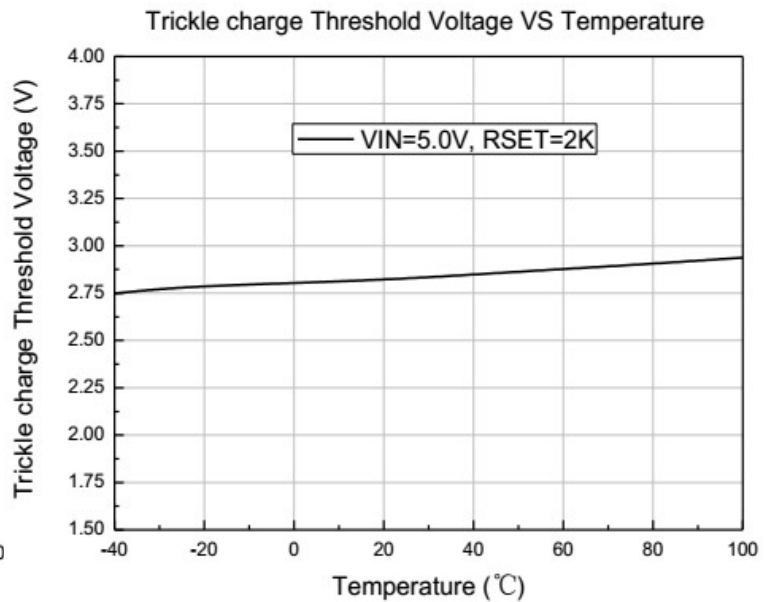
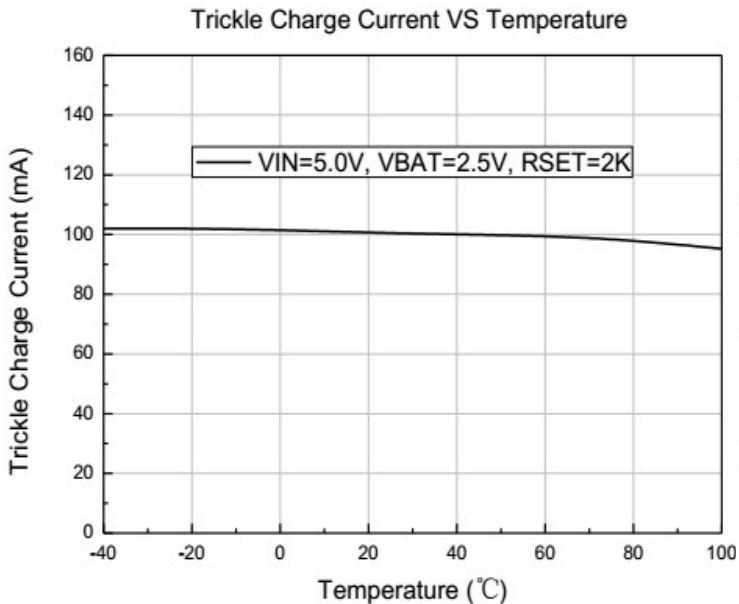
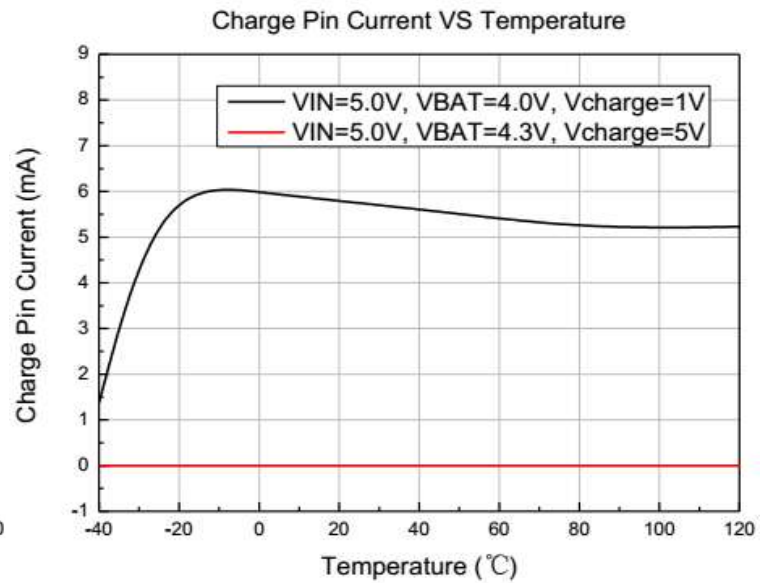
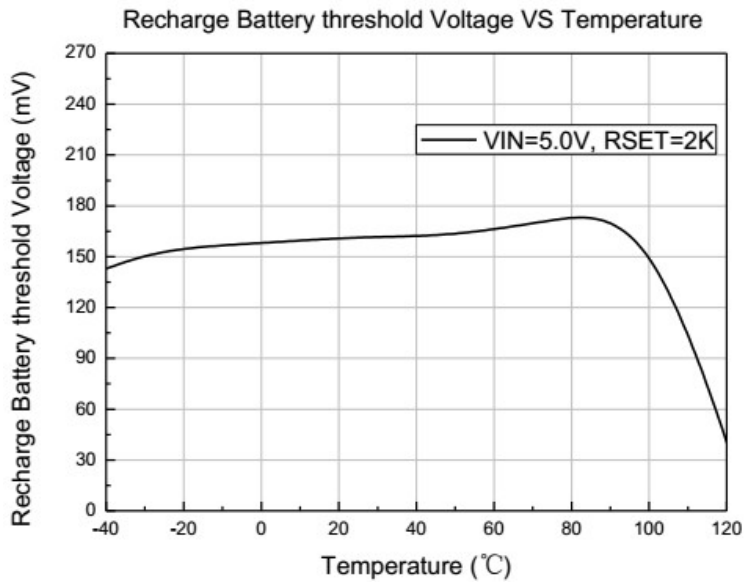


V_{BAT} VS Temperature



Linear Lithium-Ion Battery Charger

Typical Performance Characteristics (continued)



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Operation

The HCR4054D is a single cell lithium-ion battery charger using a constant-current constant-voltage algorithm. It can deliver up to 600mA of charge (using a good thermal PCB layout) with a final float voltage accuracy of $\pm 1\%$. The HCR4054D includes an internal P-channel power MOSFET and thermal regulation circuitry. No blocking diode or external current sense resistor is required; thus, the basic charger circuit requires only two external components. Furthermore, the HCR4054D is capable of operating from a USB power source.

Normal Charge Cycle

A charge cycle begins when the voltage at the VCC pin rises above the UVLO threshold level and a 1% program resistor is connected from the PROG pin to ground or when a battery is connected to the charger output. If the BAT pin is less than 2.9V, the charger enters trickle mode. In this mode, the HCR4054D supplies approximately 1/10 the programmed charge current to bring the battery voltage up to a safe level for full current charging. When the BAT pin voltage rises above 2.9V, the charger enters constant-current mode, where the programmed charge current is supplied to the battery. When the BAT pin approaches the final float voltage (4.2V), the HCR4054D enters constant-voltage mode and the charge current begins to decrease. When the charge current drops to 1/10 of the programmed value, the charge cycle ends.

Programming Charge Current

The charge current is programmed using a single resistor from the PROG pin to ground. The battery charge current is 1000 times the current out of the PROG pin. The program resistor and the charge current are calculated using the following equations:

$$R_{\text{PROG}} = \frac{1000V}{I_{\text{CHG}}} \quad I_{\text{PROG}} = \frac{1000V}{R_{\text{PROG}}}$$

Programming Charge Current(con.)

The charge current out of the BAT pin can be determined at any time by monitoring the PROG pin voltage using the following equation:

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

Charge Termination

A charge cycle is terminated when the charge current falls to 1/10th the programmed value after the final float voltage is reached. This condition is detected by using an internal, filtered comparator to monitor the PROG pin. When the PROG pin voltage falls below 100mV for longer than 1ms, charging is terminated. The charge current is latched off and the HCR4054D enters standby mode, where the input supply current drops to 170uA. when charging, transient loads on the BAT pin can cause the PROG pin to fall below 100mV for short periods of time before the DC charge current has dropped to 1/10th the programmed value. The 1ms filter time on the termination comparator ensures that transient loads of this nature do not result in premature charge cycle termination. Once the average charge current drops below 1/10th the programmed value, the HCR4054D terminates the charge cycle and ceases to provide any current through the BAT pin. In this state, all loads on the BAT pin must be supplied by the battery. The HCR4054D constantly monitors the BAT pin voltage in standby mode. If this voltage drops below the 4.1V recharge threshold(VRECHRG), another charge cycle begins and current is once again supplied to be battery. To manually restart a charge cycle when in standby mode, the input voltage must be removed and reapplied, or the charger must be shut down and restarted using the PROG pin.

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Charge Status Indicator

The CHRГ charge status output has two different states: strong pull-down and high impedance. The CHRГ strong pull-down state indicates that the HCR4054D is in a charge cycle. Once the charge cycle has terminated, the CHRГ pin state is change to High impedance.

Charging Status	CHRГ
Charging	Bright
Charge Complete	Snuffed Out
No Battery	Flashing
Undervoltage	Snuffed Out
Reverse Battery Connection	Snuffed Out

Thermal Limiting

An internal thermal feedback loop reduces the programmed charge current if the die temperature attempts to rise above a preset value of approximately 120°C. This feature protects the HCR4054D from excessive temperature and allows the user to push the limits of the power handing capability of a given circuit board without risk of damaging the

HCR4054D. The charge current can be set according to typical(not worst-case) ambient temperature with the assurance that the charger will automatically reduce the current in worst-case conditions.

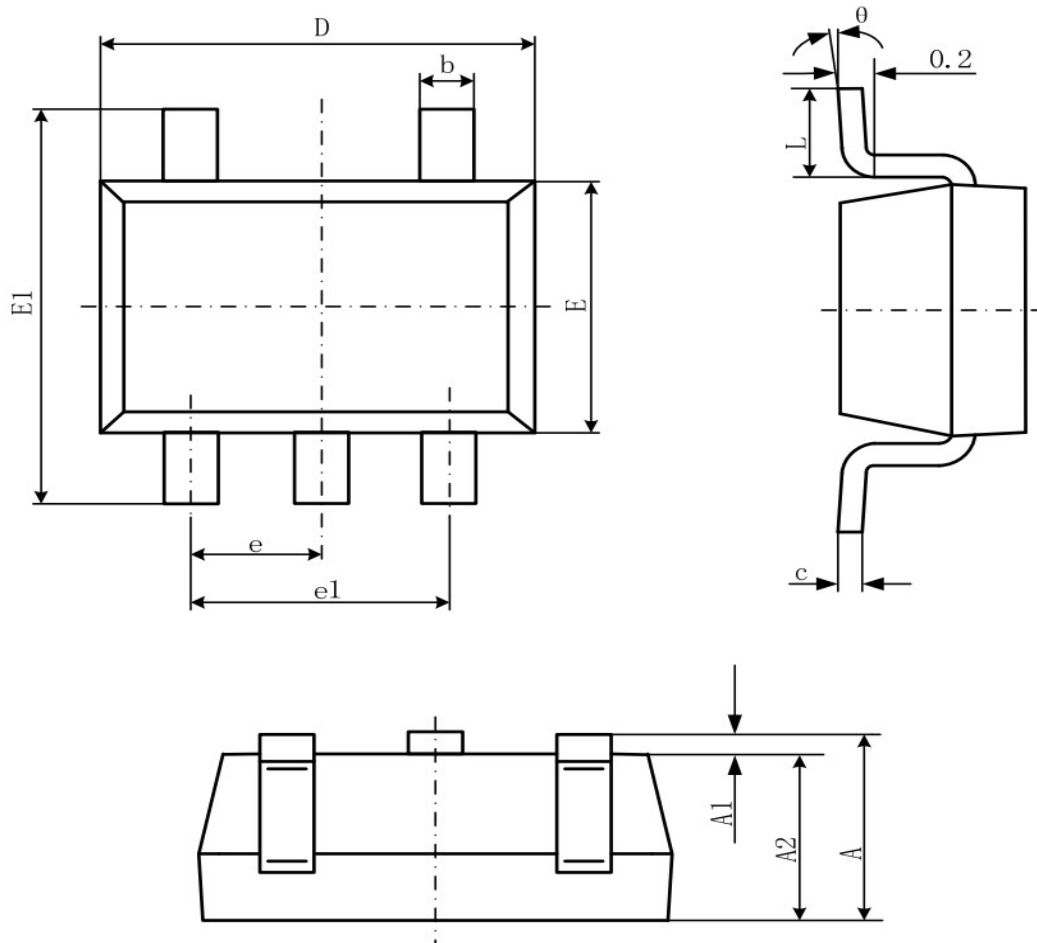
Because of the samll size of the SOT23-5 package, It is very important to use a good thermal PC board layout to maximize the avaiable charge current. The thermal path for the heat generated by the IC is from the die to the copper lead frame,through the package leads,(especially the ground lead) to the PC board copper. The PC board copper is the heat sink. The footprint copper pads should be as wide as possible and expand out to larger copper areas to spread and dissipate the heat to the surrounding ambient. Feedthrough vias to inner or backside copper layers are also useful in improving the overall thermal performance of the charger. Other heat sources on the board, not related to the charger, must also be considered when designing a PC board layout because they will affect overall temperature rise and the maximum charge current.

Linear Lithium-Ion Battery Charger

Mechanical Dimensions

PKG: SOT-23-5L(ST25L)

Unit: mm(inch)



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950(BSC)		0.037(BSC)	
e1	1.800	2.000	0.071	0.079
L	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°