0.1mA-300mA Single Cell Li-ion Battery Charger， 45nA Battery Leakage Current

GENERAL DESCRIPTION

The PW4054T series of devices are highly integrated Li-Ion and Li-Pol linear chargers targeted at small capacity battery for portable applications. It is a complete constant-current/ constant voltage linear charger. No external sense resistor is needed, and no blocking diode is required due to the internal MOSFET architecture. It can deliver up to 300mA of charge current (using a good thermal PCB layout) with a final float voltage accuracy of ±1%. The charge voltage is fixed at 4.2V or 4.35V, and the charge current can be programmed externally with a single resistor. The charger function has high accuracy current and voltage regulation loops and charge termination

The PW4054T automatically terminates the charge cycle when the charge current drops to 1/10 the programmed value after the final float voltage is reached.When the input supply (wall adapter or USB supply) is removed, the PW4054T will shut off, only 40nA leakage current coming from battery at sleep mode when ambient temperature is 85℃, so it can save energy and improve standby time.

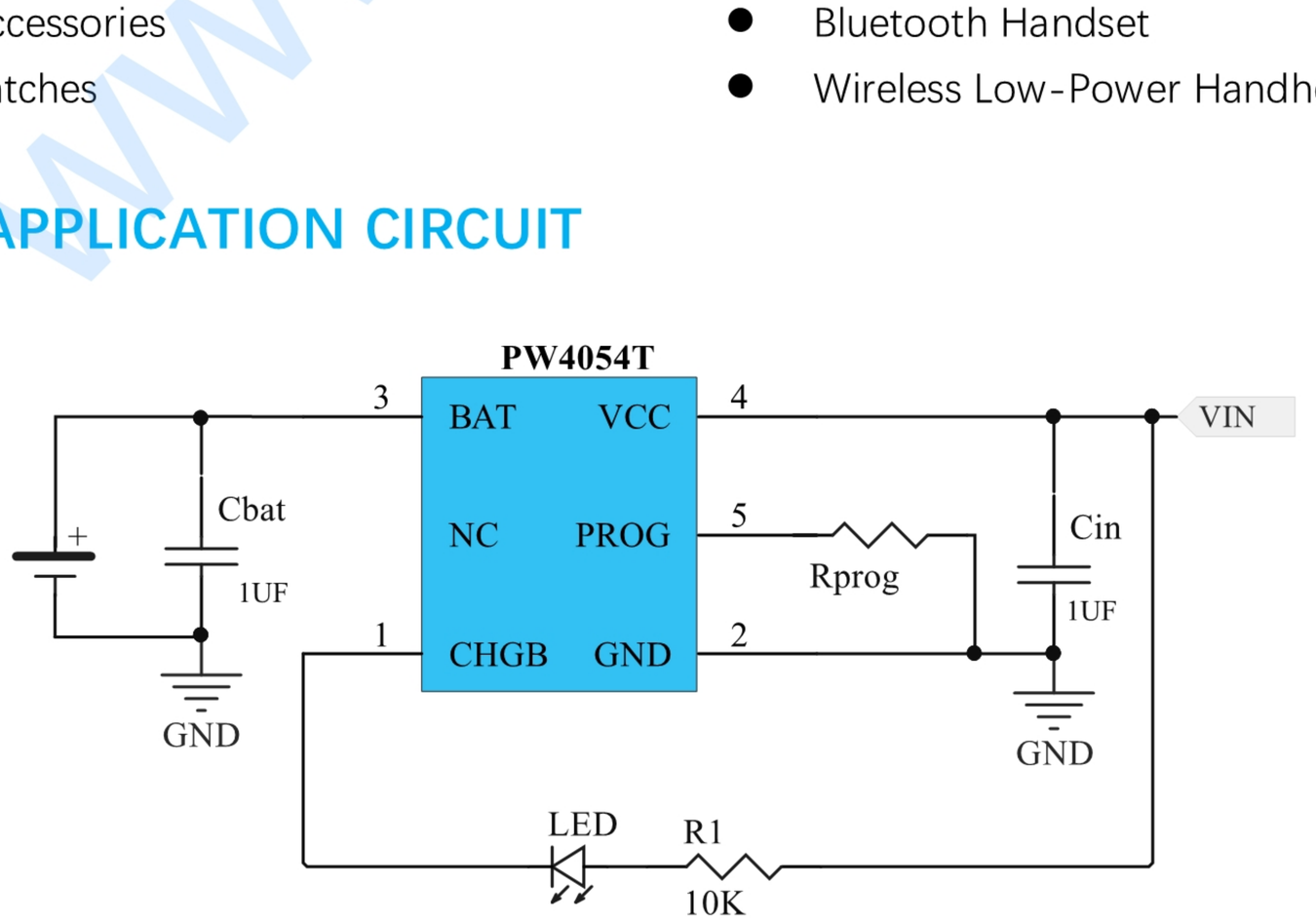
FEATURE

- 1% Charge Voltage Accuracy
- 5% Charge Current Accuracy
- Support Application for Very Low Charge Currents –1mA to 300mA
- Output Short-Circuit Protection
- Soft-Start Limits Inrush Current
- Charge Status Output Pin
- Automatic Recharge
- Support minimum 0.1mA Charge Termination Current
- 45nA Maximum Battery Output Leakage Current @ 0℃~85℃
- High Voltage Chemistry Support: up to 4.35V
- SOT23-5L

APPLICATIONS

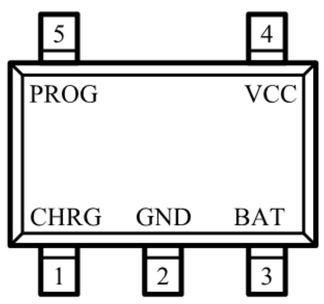
- Fitness Accessories
- Smart Watches
- Bluetooth Handset
- Wireless Low-Power Handheld Devices

TYPICAL APPLICATION CIRCUIT



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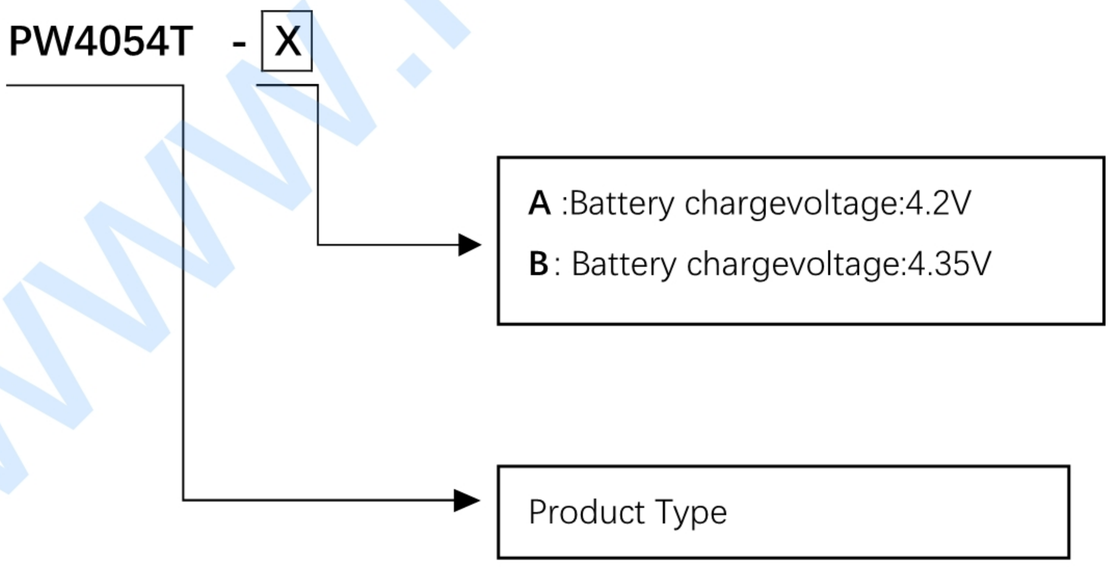
PIN ASSIGNMENT/DESCRIPTION



SOT-23-5L
(TOP VIEW)

Pin No	Pin Name	Functions
1	CHGB	Open-Drain Charge Status Output. When the battery is charging, the CHGB pin is pulled low. When the charge cycle is completed or VCC is removed, the CHGB is forced high impedance.
2	GND	Ground
3	BAT	Charge Current Output. Provides charge current to the battery and regulates the final float voltage to 4.2V or 4.35V.
4	VCC	Power Supply
5	PROG	Charge current setting, charge current monitor. The charging current is given by I_{BAT}= 100/R_{PROG}(A). Please choose 1% precision resistor for RPROG. For fixed charge current part, this pin is no bonding wire.

Selection Guide



RECOMMENDED OPERATING CONDITION

SYMBOL	ITEMS	MIN	NOM	MAX	UNIT
V_{CC}	Input operating voltage range	4.5	5	5.5	V
I_{BAT}	Battery charge current range	1	50	250	mA
T_J	Junction temperature	0		125	℃
R_{PROG}	CC mode charge current programming resistor	1	2	100	KΩ

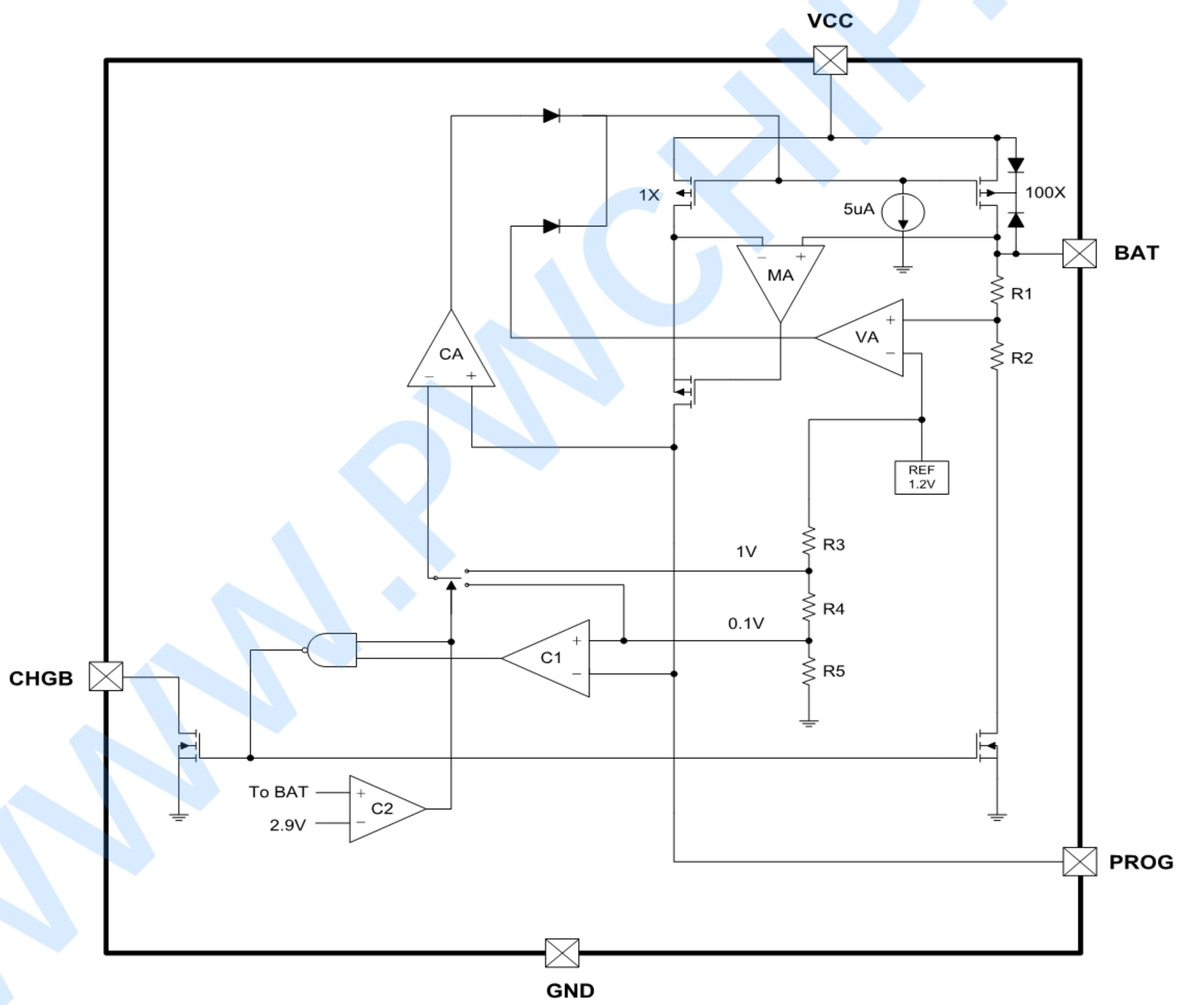
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Absolute Maximum Ratings (note 1)

SYMBOL	ITEMS	VALUE	UNIT
VCC	Input Voltage	-0.3~7	V
VPROG	PROG Voltage	-0.3~7	V
VBAT	BAT Voltage	-0.3~7	V
VCHGB	CHGB Voltage	-0.3~7	V
IBAT	Battery Charge Current	300	mA
PDMAX	Power Dissipation	0.3	W
TJ	Junction Temperature	-40~125	℃
TSTG	Storage Temperature	-55 to 150	℃
TSOLDER	Package Lead Soldering Temperature 10s	260	℃

Note 1: Exceed these limits to damage to the device. Exposure to absolute maximum rating conditions may affect device reliability.

SIMPLIFIED BLOCK DIAGRAM



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ELECTRICAL CHARACTERISTICS

The following specifications apply for V_{CC}=5V T_A=25℃, unless specified otherwise.

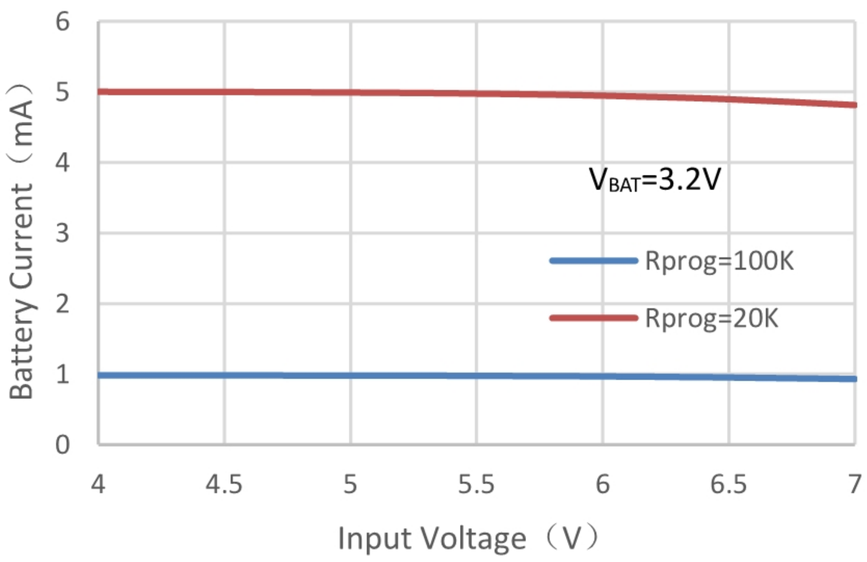
SYMBOL	ITEMS	CONDITIONS	MIN	TYP	MAX	UNIT
$I_{SPLYCHRG}$	Charge Mode GND Current	R_{PROG}=1kΩ,V_{CC}=5V		89		μA
$I_{BATCHRG}$	Charge Mode Battery Current	R_{PROG}=1kΩ	95	100	105	mA
		R_{PROG}=2kΩ	45.5	50	52.5	
		R_{PROG}=4kΩ	23.7	25	26.3	
		Iset > 25mA,Fixed current	0.95 *Iset	Iset	1.05 *Iset	
		Iset ≤ 25mA,Fixed current	Iset - 2	Iset	Iset + 2	
$I_{SPLYSTBY}$	Standby Mode Supply Current	Charge Terminated		70		μA
$I_{BATSTBY}$	Standby Mode Battery Current	Charge Terminated		2.4		μA
$I_{SPLYASD}$	Shutdown Mode Supply Current	Vcc<V_{BAT}<Vcc+0.3V / Vcc<UVLO, no battery		27		μA
I_{BATASD}	Shutdown Mode BAT Pin Current	V_{BAT} - V_{CC}>0.3V		0.52		μA
$I_{BATSLEEP1}$	Sleep Mode BAT Pin Current	V_{CC}=0 or V_{CC} Floating Ta=25℃		0		μA
$I_{BATSLEEP2}$	Sleep Mode BAT Pin Current	V_{CC}=0 or V_{CC} Floating Ta=0℃~85℃, Note 5		40	45	nA
V_{FLOAT}	Float Voltage		4.158	4.2	4.242	V
			4.306	4.35	4.394	V
I_{TRIKL}	Trickle and Terminal Charge Current	R_{PROG}=1kΩ	8	10	12	mA
		R_{PROG}=2kΩ	4	5	6.5	mA
		R_{PROG}=4kΩ	2	2.5	3.5	mA
		Fixed current	0.08 * Iset	0.1 * Iset	0.12 * Iset	mA
V_{TRIKL}	Trickle Charge Voltage Threshold	V_{BAT} from low to high	2.8	2.9	3.0	V
$V_{TRIKL, HYS}$	Trickle Charge Voltage Hysteresis	V_{BAT} from high to low		100		mV
V_{UVLO}	UVLO Threshold	V_{CC} from Low to High	3.6	3.8	4.0	V
$V_{UVLO, HYS}$	UVLO Hysteresis	V_{CC} from high to low		270		mV
V_{ASD}	V_{CC}-V_{BAT} Lockout Threshold Voltage	V_{CC} from High to Low		80		mV
		V_{CC} from Low to High		130		mV
ΔV_{RECHRG}	Auto Recharge Battery Voltage	V_{BAT} from high to low	100	150	200	mV
V_{CHGB}	CHGB Pin Output Low Voltage	I_{CHGB}=1mA		0.14	0.3	V
T_{SS}	Soft-Start Time	Note		190		us
T_{RECHRG}	Recharge Comparator Filter Time	Note		2		ms
T_{TERM}	Charge Terminated Filter Time	Note		1		ms

Note : Guaranteed by Design.

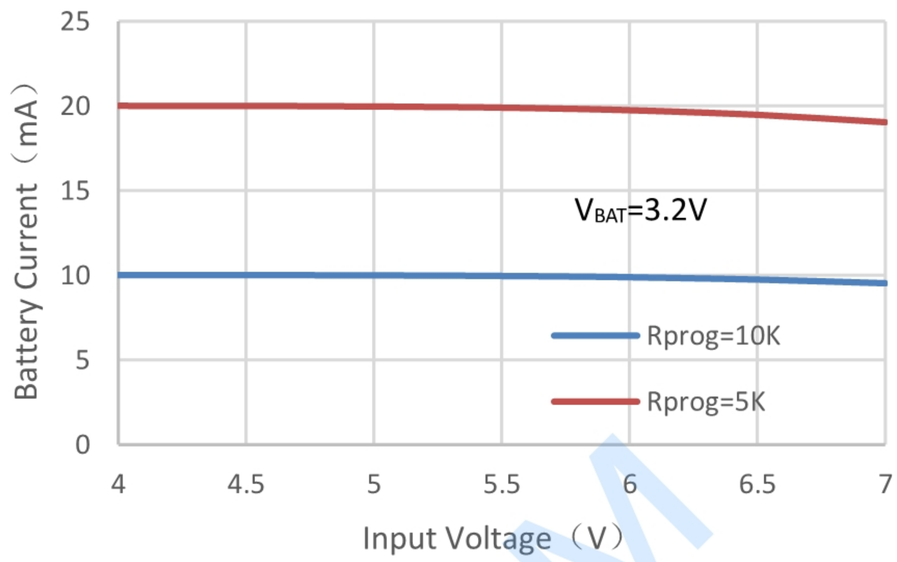
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TYPICAL CHARACTERISTICS

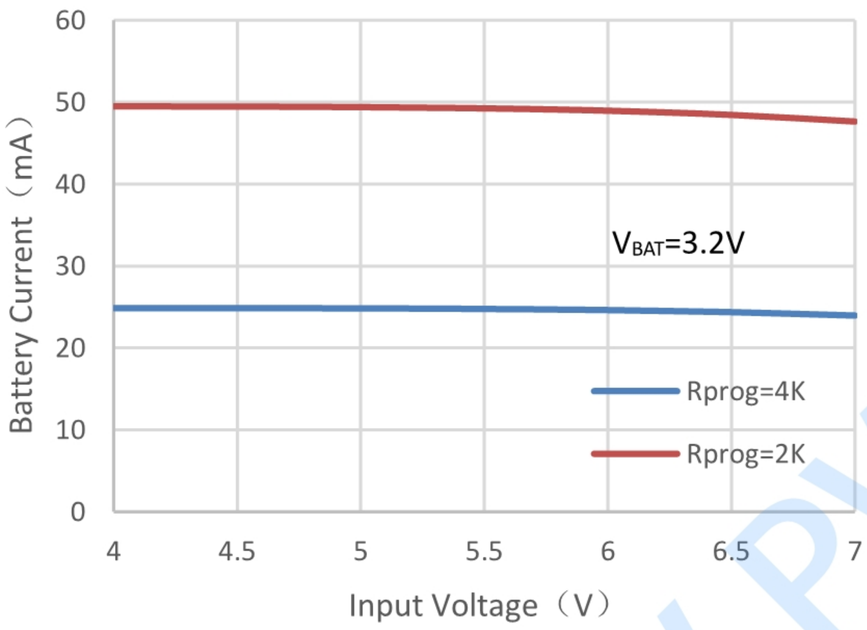
Battery Current vs. Input Voltage



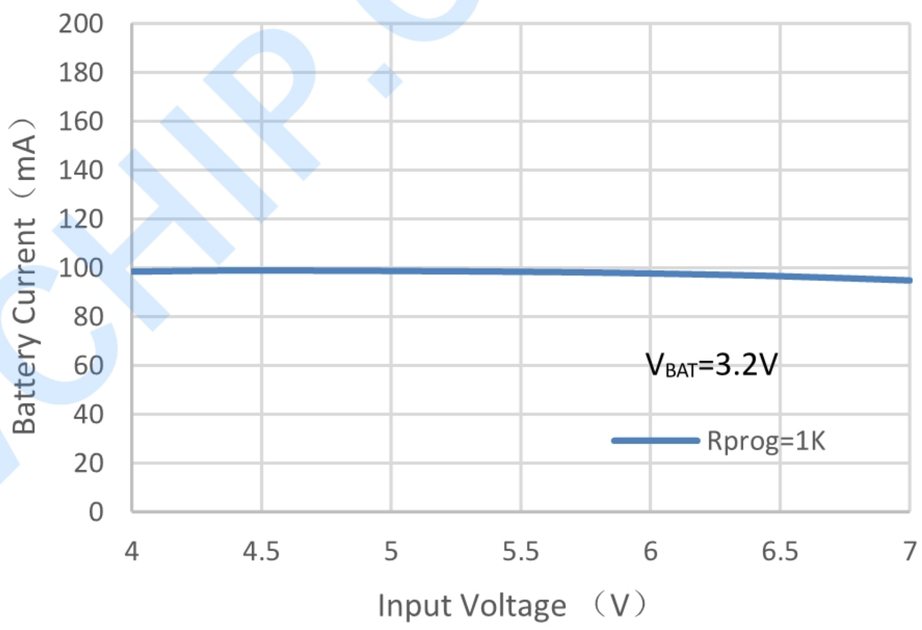
Battery Current vs. Input Voltage



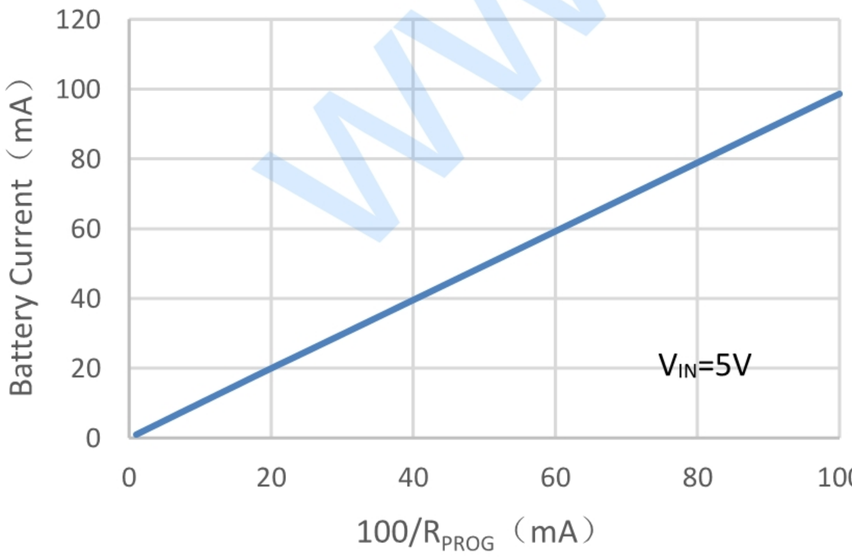
Battery Current vs. Input Voltage



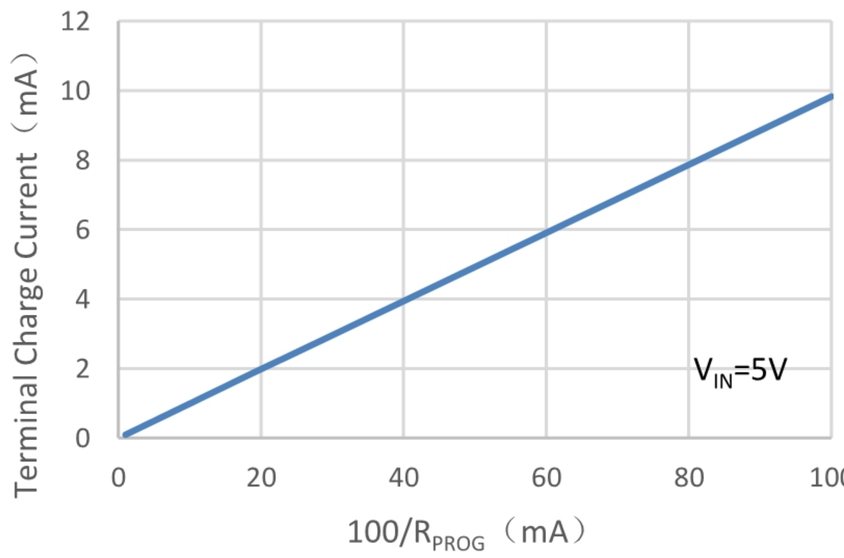
Battery Current vs. Input Voltage



Battery Current vs. R_{PROG}

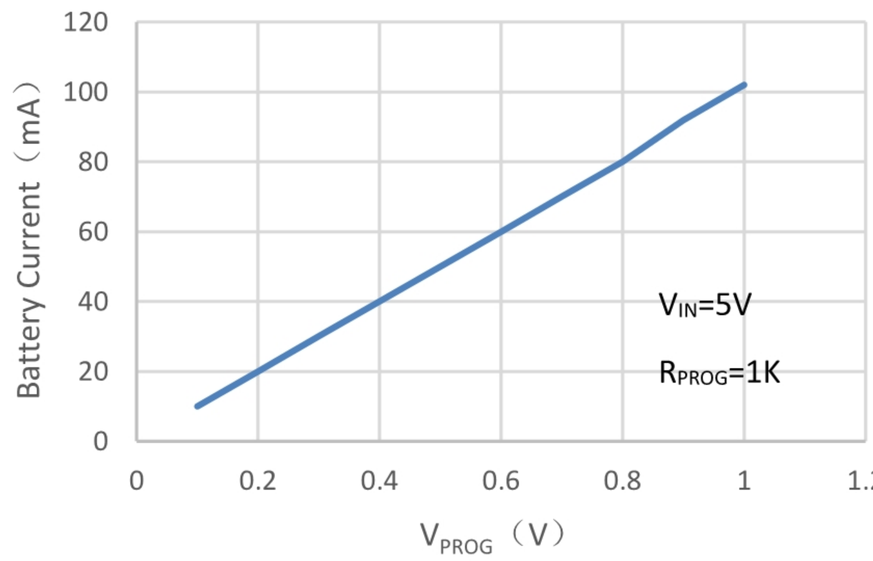


Terminal Charge Current vs. R_{PROG}

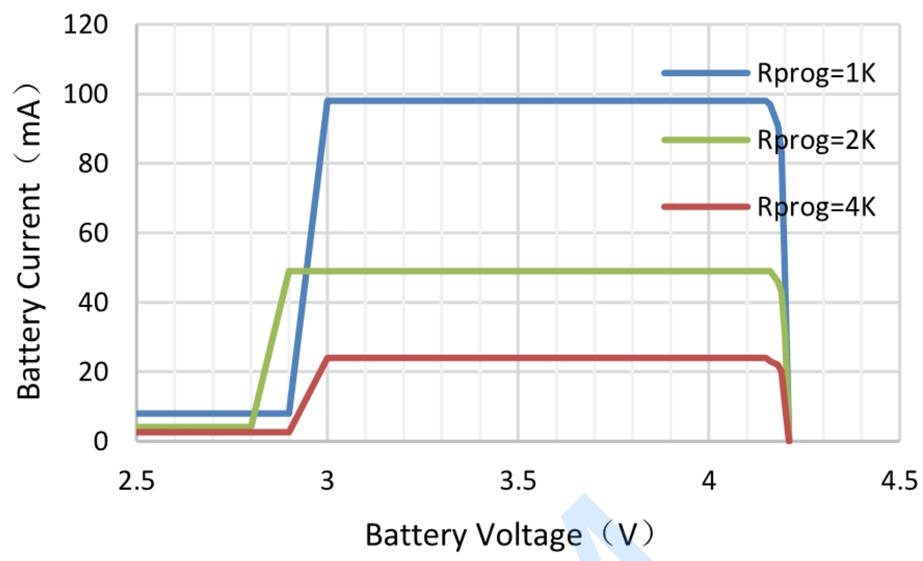


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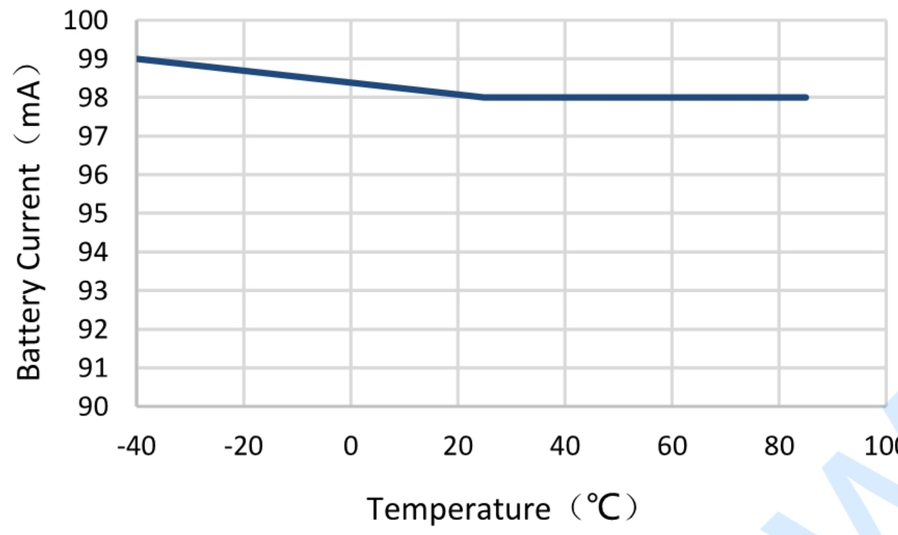
Battery Current vs. V_{PROG}



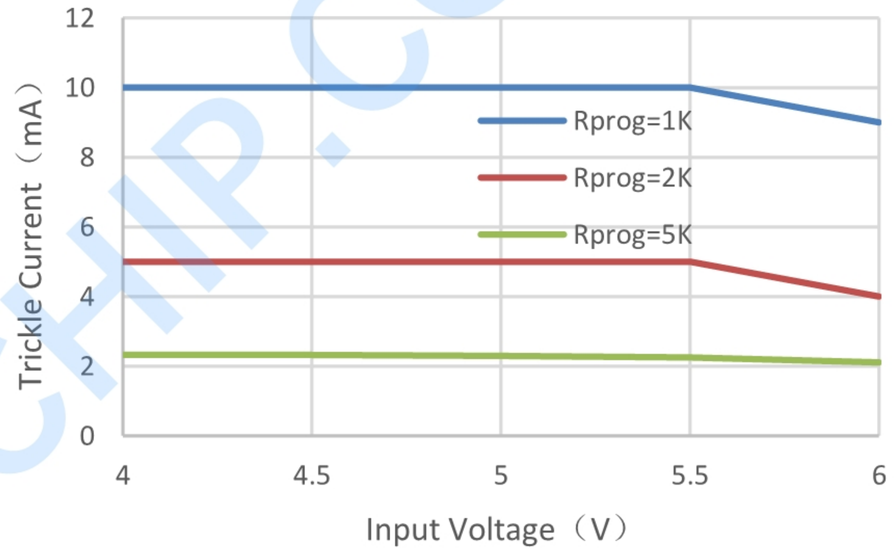
Battery Current vs. Battery Voltage



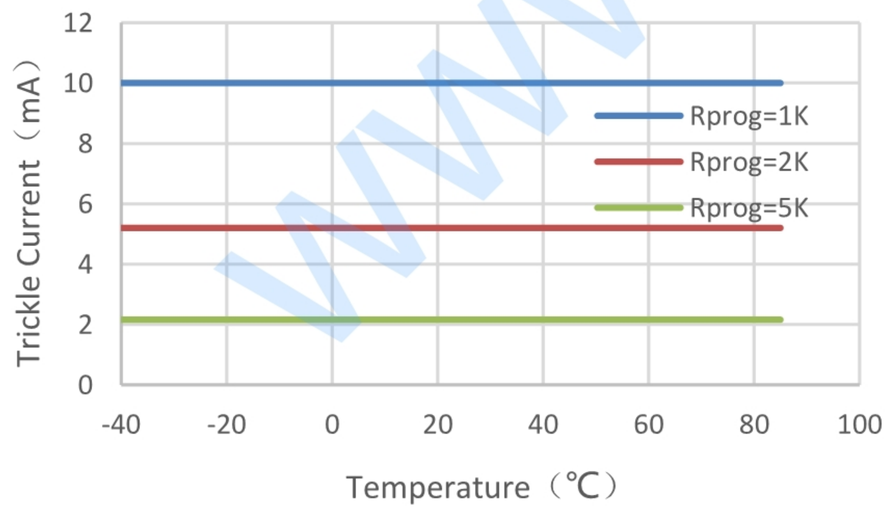
Battery Current vs. Temperature



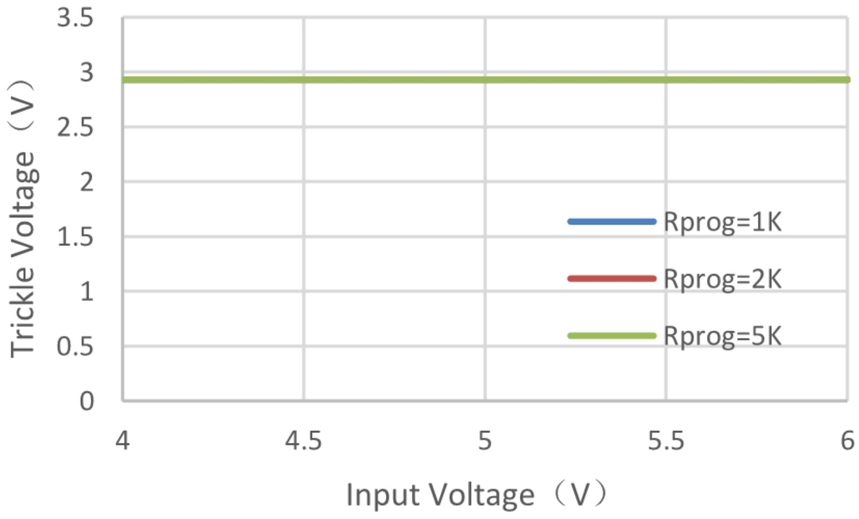
Trickle Current vs. Input Voltage



Trickle Current vs. Temperature

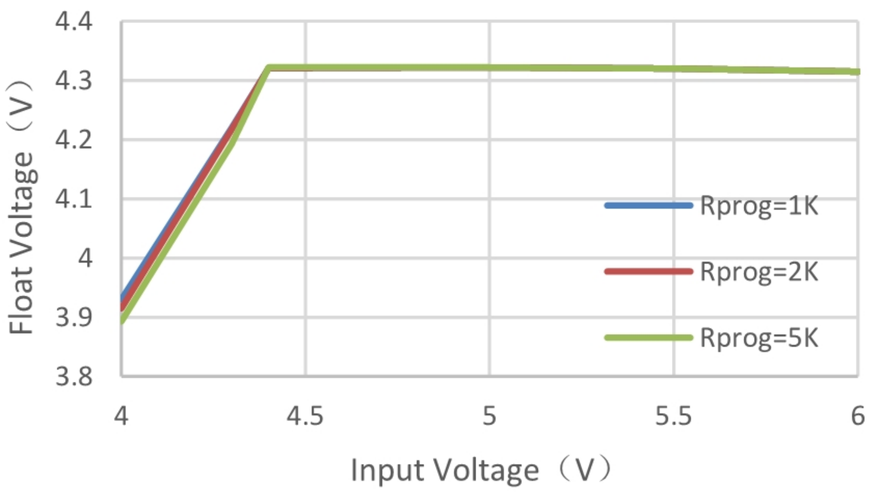


Trickle Voltage vs. Input Voltage

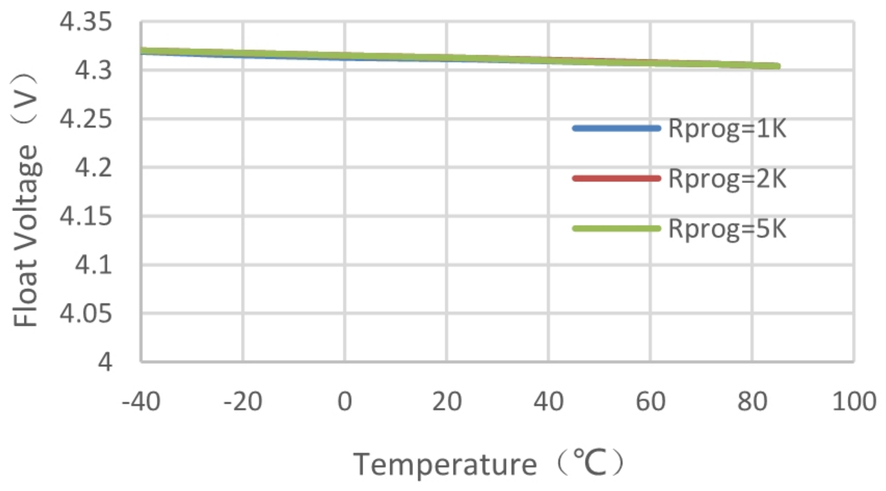


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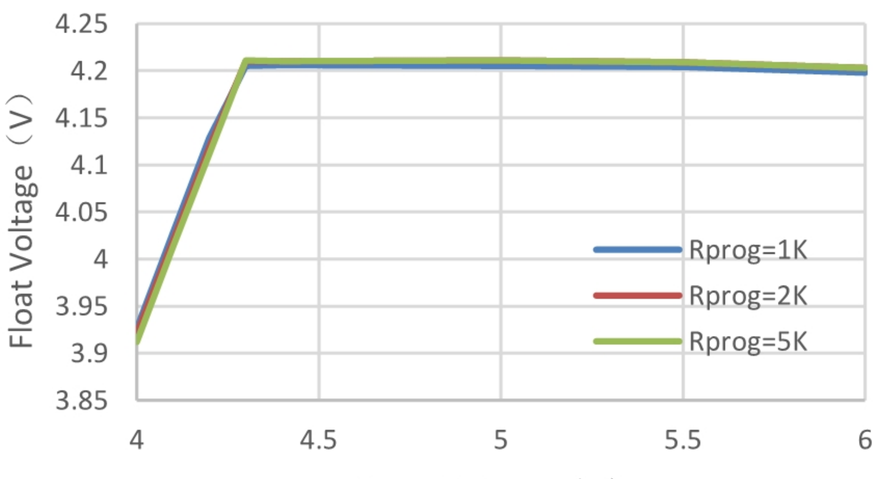
Float Voltage vs. Input Voltage (4.35V)



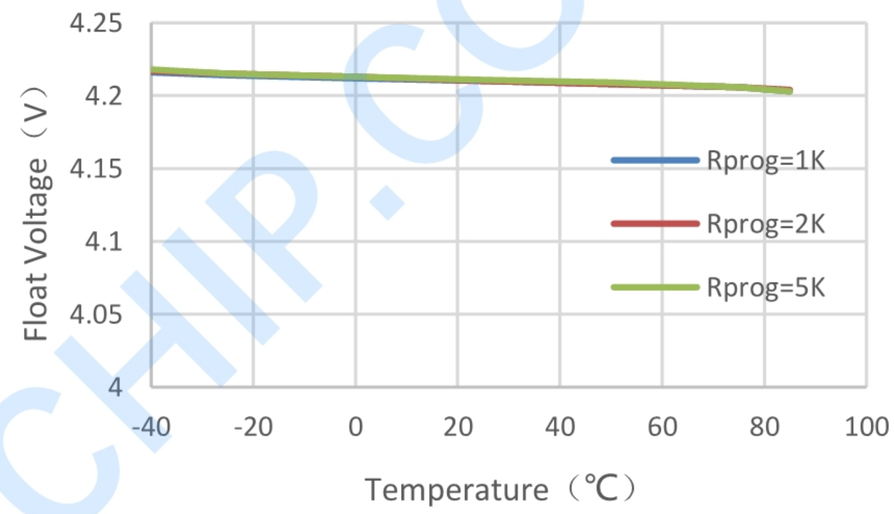
Float Voltage vs. Temperature (4.35V)



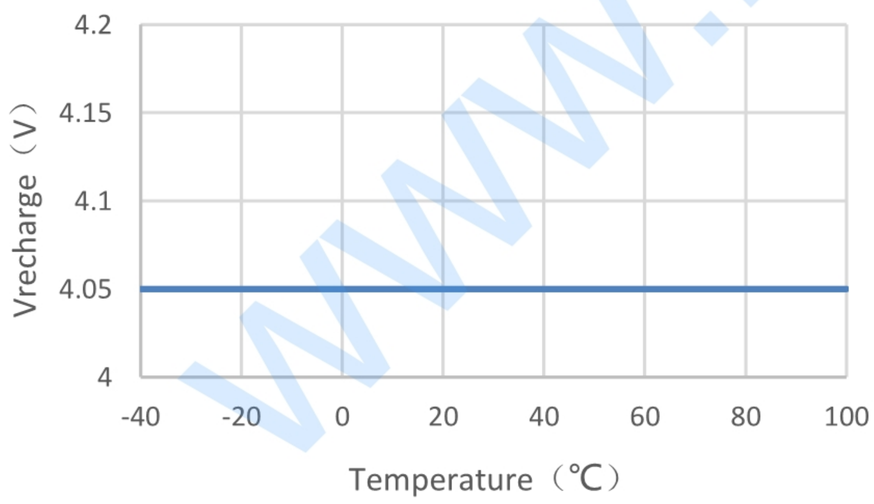
Float Voltage vs. Input Voltage (4.2V)



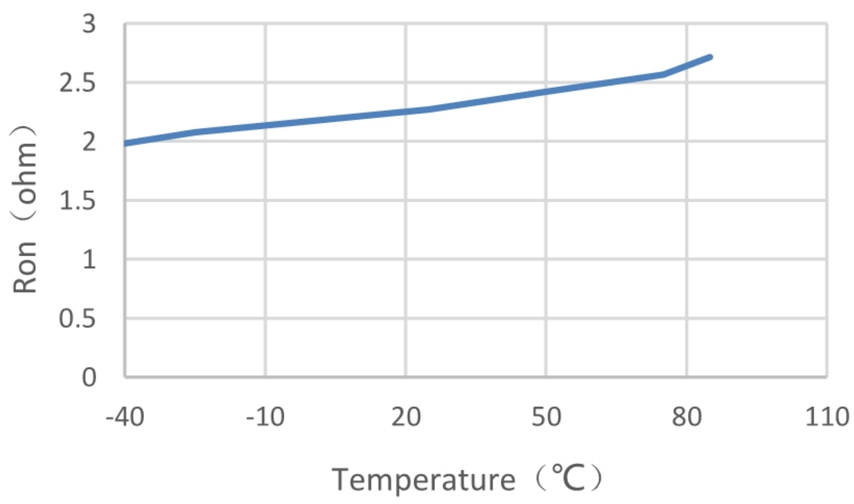
Float Voltage vs. Temperature (4.2V)



Vrecharge vs. Temperature (4.2V)



Ron vs. Temperature



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OPERATION

The PW4054T is a single cell Li-Ion and Li-Pol battery linear charger using a constant-current / constant-voltage algorithm. It is designed specially for small capacity battery that is used in handheld devices, such as GPS tracker, Smart wrist and U-Key. It can deliver up to 300mA of charge current (using a good thermal PCB layout) with a final float voltage accuracy of ±1%. The PW4054T includes an internal P-channel power MOSFET and current regulation circuitry. No blocking diode or external current sense resistor is required, thus the basic charger circuit requires only two external components. Furthermore, the PW4054T 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 charge mode. In this mode, the PW4054T 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, the PW4054T enters constant-voltage mode and the charge current begins to decrease. The charge cycle ends when the PROG voltage is less than 100mV.

Programming charge current

The charge current is programmed using a single resistor from the PROG pin to ground. The battery charge current of constant current mode is 100 times the current out of the PROG pin. The program resistor and the charge current of constant current are calculated using the following equations:

$$I_{BAT} = 100 / R_{PROG} \text{ (A)}$$

For example, I_{BAT}=0.1A, R_{PROG}=1KΩ, I_{BAT}=0.02A,

R_{PROG}=5KΩ. Please choose 1% precision resistor for R_{PROG}, this will effect the accuracy of CC charge current and termination current.

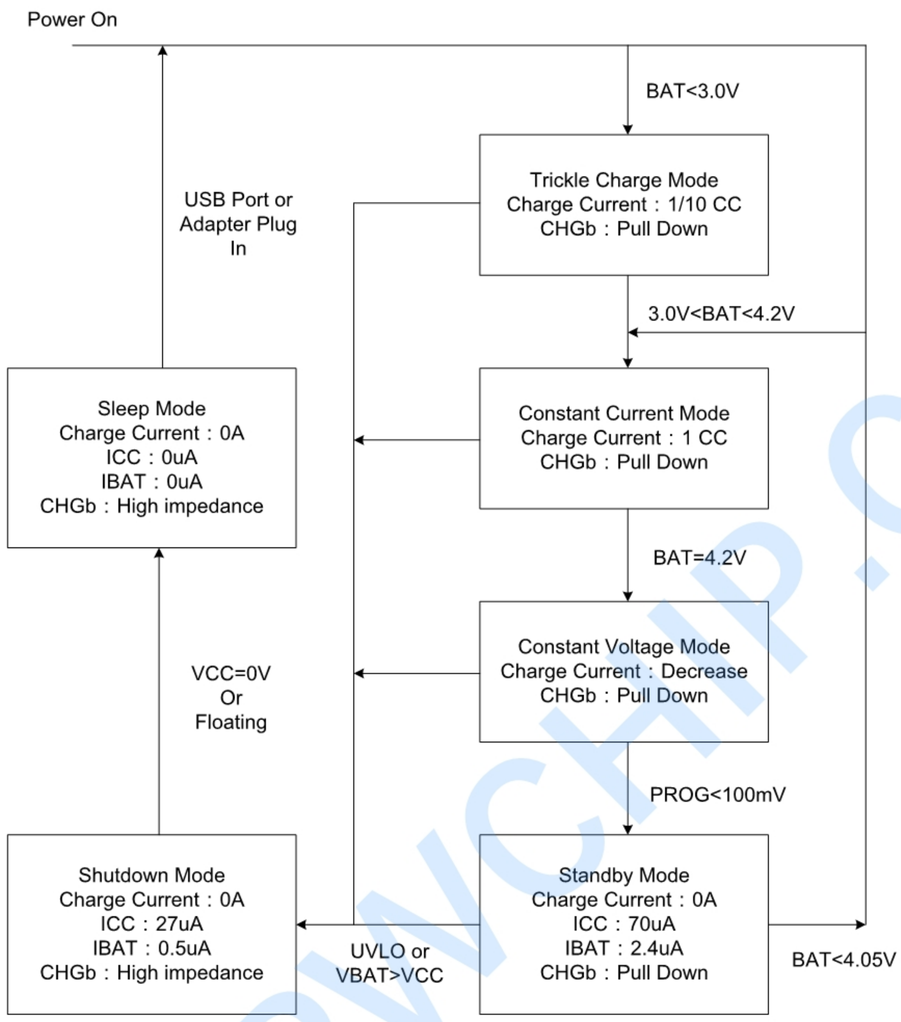
Charge termination

charge cycle is terminated when the charge current falls to 1/10 of 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 T_{TERM} (typically 1ms), charging is terminated. The charge current is latched off and the PW4054T enters standby mode, where the input supply current drops to 70uA. (Note: 1/10 CC termination is disabled in trickle charging mode).

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 1/10 of the programmed value. The 1ms filter time (T_{TERM}) 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 1/10 of the programmed value, the PW4054T terminates thecharge cycle and ceases to provide any current through the BAT pin, the chip will be put into standby mode. In this state, all loads on the BAT pin must be supplied by the battery.

The PW4054T constantly monitors the BAT pin voltage in standby mode. If this voltage drops below the Vfloat-0.15V (typically) recharge threshold (VRECHRG), another charge cycle begins and current is once again supplied to the battery. The state diagram of a typical charge cycle is as below:



Charge status indicator (CHGB)

The charge status output indicator is an open drain circuit. The indicator has two different states: pulldown (~16mA), and high impedance. The pull-down state indicates that the PW4054T is in a charge cycle. High impedance indicates that the charge cycle is complete. The CHGB also can be used to detect the charge states by a microprocessor with a pull-upresistor

Shutdown mode

The PW4054T will be put into shutdown mode when the battery voltage is higher than the VCC voltage or VCC-VBAT is less than VASD. This reduces the battery drain current to less than 0.5uA and the supply current to less than 27uA. A new charge cycle can be initiated when the VCC-VBAT is high than VASD.

The PW4054T also be put into shutdown mode when VCC voltage down to UVLO threshold. In this state, the CHGB pin is high impedance state. The CHGB pin is also in a high impedance state if the charge cycle is completed.

Automatic recharge

Once the charge cycle is terminated, the PW4054T continuously monitors the voltage on the BAT pin using a comparator with a 2ms filter time (T_{RECHRG}). A charge cycle restarts when the battery voltage falls below delta V_{RECHRG} (which corresponds to approximately 80% to 90% battery capacity). This ensures that the battery is kept at or near a fully charged condition and eliminates the need for periodic charge cycle initiations. CHGB output enters a pull-down state during recharge cycles.

APPLICATION INFORMATIONS

Stability considerations

The constant-voltage mode feedback loop is stable without an output capacitor provided a battery is connected to the charge output. With no battery present, an output capacitor is recommended to reduce ripple voltage.

In constant-current mode, the PROG pin is in the feedback loop, not the battery. The constant-current mode stability is affected by the impedance at the PROG pin. With no additional capacitance on the PROG pin, the charger is stable with program resistor values as high as 100KΩ. However, additional capacitance on this node reduces the maximum allowed program resistor thus it should be avoided.

Power dissipation

PW4054T has low temperature coefficient, at higher temperatures, the charging current will decrease slightly. To -40 ℃ ~125 ℃ temperature range the change of the charging current is very small. Nearly all of this power dissipation is generated by the internal MOSFET. This is calculated to be approximately:

$$P_D = (V_{CC} - V_{BAT}) * I_{BAT}$$

Maximum allowable power dissipation limited by the packaging format and cooling conditions in actual applications. For SOT23-5L package, PD is not allowed to exceed 0.3W. For example, the worse case application of PW4054T is V_{CC}=5.5V, V_{BAT}=3V, I_{BAT}=0.1A, so P_D=0.25W, it is safe. At charge cycle, the battery voltage is rising gradually, so the power dissipation is reduce accordingly. The power dissipation turn into heat, please taken into consideration when design system.

VCC bypass capacitor

Many types of capacitors can be used for input bypass, however, caution must be exercised when using multilayer ceramic capacitors. Because of the self-resonant and high Q characteristics of some types of ceramic capacitors, a 10uF/16V ceramic capacitor is recommended for this bypass capacitor. Due to a high voltage transient will be generated under some startup conditions, such as connecting the charger input to a live power source.

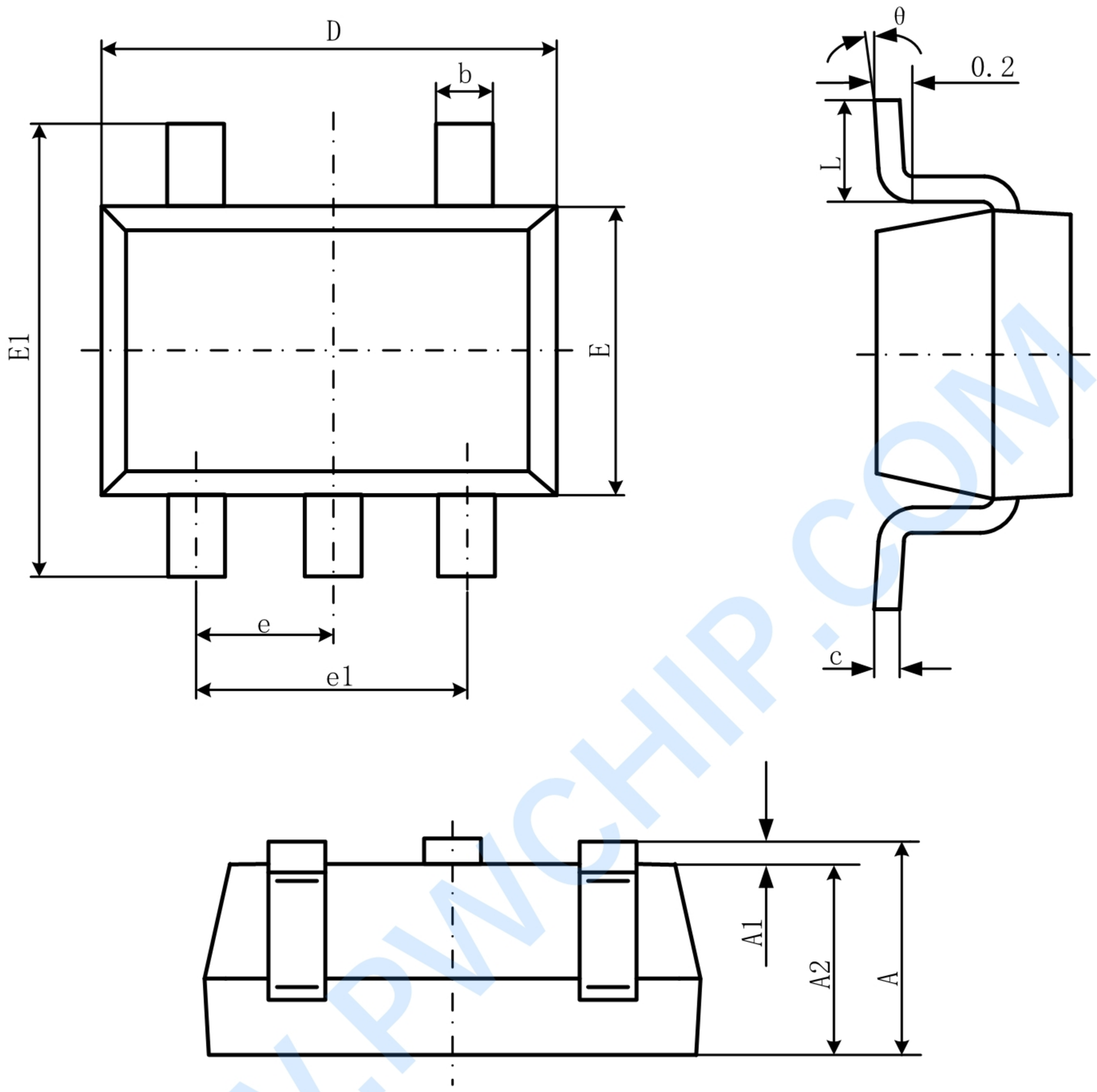
Charge current soft-start

The PW4054T includes a soft-start circuit to minimize the inrush current at the start of a charge cycle. When a charge cycle is initiated, the charge current ramps from zero to the full-scale current over a period of approximately 190us. This has the effect of minimizing the transient current load on the power supply during start-up.

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PACKAGE DESCRIPTION

SOT23-5L



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°

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