

## Standalone Linear Li-Ion Battery Charger with Thermal Regulation

### GENERAL DESCRIPTION

The PT6112 is a highly integrated Li-ion battery linear charging management device targeted at space limited portable applications. The PT6112 offers an integrated MOSFET and current sensor, reverse blocking protection, high accuracy current and voltage regulation, charge status indication, and charge termination in a SOT23 or ESOP8 package. The PT6112 has low external component count. The PT6112 charges a battery in three phases: trickle charging, constant current, and constant voltage. No external sense resistor is needed, and no blocking diode is required due to the internal MOSFET architecture. The thermal feedback regulates the charging current to limit the chip temperature during high power operation or high ambient temperature to maximize the charge rate without risk of overheating. The charge voltage is fixed at 4.2V, and the charge current can be programmed externally with a single resistor. The PT6112 automatically terminates the charge cycle when the charge current drops to 1/10 the programmed value after the final float voltage is reached. The PT6112 automatically re-starts the charge if the battery voltage falls below an internal threshold.

### FEATURES

- Charges Single Cell Li-Ion Batteries Directly from USB Port
- Programmable Charge Current Up to 800mA
- No MOSFET, Sense Resistor or Blocking Diode Required
- Complete Linear Charger in SOT23-5 or ESOP8 Package for Single Cell Lithium-Ion Batteries
- Constant-Current/Constant-Voltage Operation with Thermal Regulation to Maximize Charge Rate Without Risk of Overheating
- Preset 4.2V Charge Voltage with  $\pm 1\%$  Accuracy

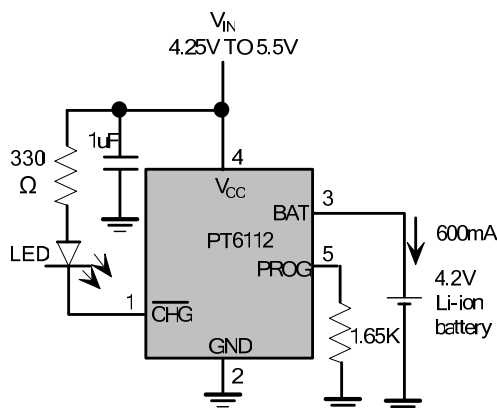
### APPLICATIONS

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

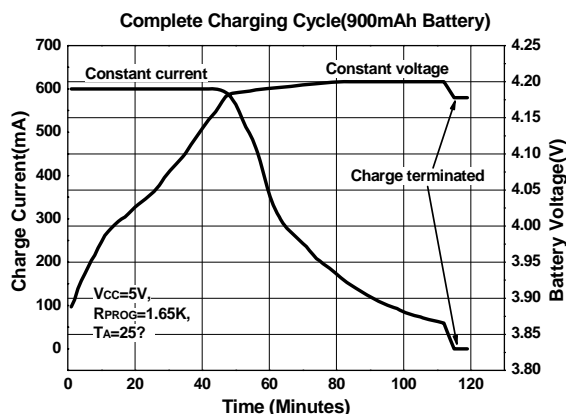
### ORDERING INFORMATION

PACKAGE	TEMPERATURE RANGE	ORDERING PART NUMBER	TRANSFER MEDIA	MARKING
SOT23-5	-40°C to 85°C	PT6112E23E	Tape & Reel	6112
ESOP8	-40°C to 85°C	PT6112EESO	Tape & Reel	PT6112 xxxxxX

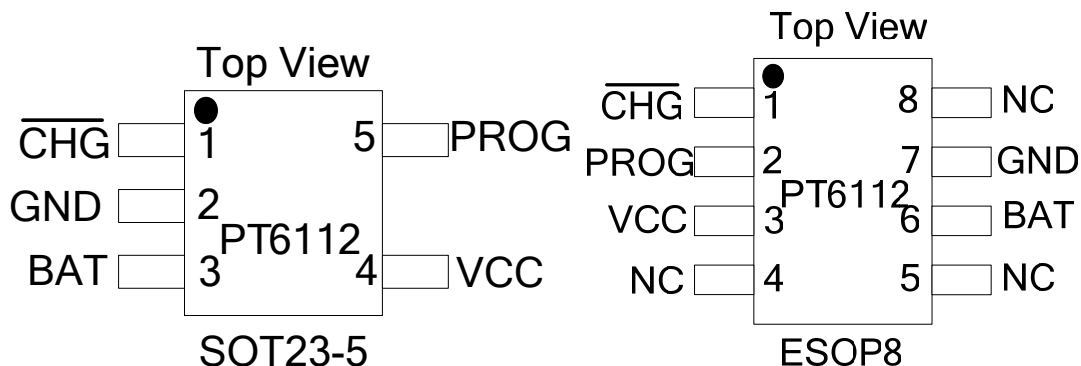
### TYPICAL APPLICATION CIRCUIT



### KEY PERFORMANCE CHART



### PIN ASSIGNMENT



### PIN DESCRIPTIONS

Names		Pin No.	Description
SOT23-5	ESOP8		
1	1	$\overline{\text{CHG}}$	Open-Drain Charges Status Output.
2	7	GND	Ground
3	6	BAT	Charge Current Output. The positive side of battery.
4	3	VCC	Positive Input Supply Voltage.
5	2	PROG	Charge Current Program, Charge Current Monitor and Shutdown Pin.
	4,5,8	NC	Not Connection

### ABSOLUTE MAXIMUM RATINGS (Note1)

SYM	PARAMETER	VALUE
$V_{CC}$	Input supply voltage	-0.3 to 7
PROG		-0.3 to 7
BAT		-0.3 to 7
$\overline{\text{CHG}}$		-0.3 to 7
BAT Short-Circuit Duration		Continuous
BAT Pin Current		1000 mA
Operating Ambient Temperature Range		-40 to 85 °C
Storage Temperature Range		-65 to 125 °C
Lead Temperature	Soldering, 10Sec	260 °C
$P_{TR1}$	Package Thermal Resistance, ESOP-8 $\theta_{JA}$	45 °C /W
$P_{TR2}$	Package Thermal Resistance, SOT-23-5 $\theta_{JA}$	220 °C /W

## Standalone Linear Li-Ion Battery Charger with Thermal Regulation

### RECOMMENDED OPERATING RANGE (Note 2)

SYMBOL	PARAMETER	VALUE
$V_{CC}$	Input supply voltage	4.25 to 5.5

**Note 1:** Absolute Maximum Ratings indicate limits beyond which damage to the device may occur.

**Note 2:** Recommended operating Range indicates conditions for which the device is functional, but does not guarantee specific performance limits.

### ELECTRICAL CHARACTERISTICS (Note 3,4,5)

Specifications are at  $T_A=25^{\circ}\text{C}$ ,  $V_{CC}=5\text{V}$ , unless otherwise noted

SYMBOL	PARAMETERS	CONDITIONS	MIN	TYP	MAX	UNITS
$V_{CC}$	Input Supply Voltage		4.25		5.5	V
$I_{CC}$	Input Supply Current	Charge Mode( <b>Note 6</b> ), $R_{PROG}=10\text{K}$		200	500	$\mu\text{A}$
		Standby Mode(Charge Terminated)		100	200	$\mu\text{A}$
		Shut Down Mode: $R_{PROG}$ Not Connected, $V_{CC} < V_{BAT}$ , or $V_{CC} < V_{UV}$		50	100	$\mu\text{A}$
$V_{FLOAT}$	Regulated Output (Float) Voltage	$0^{\circ}\text{C} \leq T_A \leq 85^{\circ}\text{C}$ , $I_{BAT} = 40\text{mA}$	4.158	4.2	4.242	V
$I_{BAT}$	BAT pin Current	$R_{PROG}=10\text{K}$ , Current Mode		100		mA
		$R_{PROG}=2\text{K}$ , Current Mode	450	500	535	mA
		Standby Mode, $V_{BAT}=4.2\text{V}$	0	-2.5	-6	$\mu\text{A}$
		Shutdown Mode( $R_{PROG}$ Not Connected)		$\pm 1$	$\pm 2$	$\mu\text{A}$
		Sleep Mode, $V_{CC}=0\text{V}$		$\pm 1$	$\pm 2$	$\mu\text{A}$
$I_{TRIKL}$	Trickle Charge Current	$V_{BAT} < V_{TRIKL}$ , $R_{PROG}=2\text{K}$		50		mA
$V_{TRIKL}$	Trickle Charge Threshold Voltage	$R_{PROG}=10\text{K}$ , $V_{BAT}$ Rising	2.65	2.9	3.15	V
$V_{TRHYS}$	Trickle Charge Hysteresis Voltage	$R_{PROG}=10\text{K}$		80		mV
$V_{UV}$	$V_{CC}$ Undervoltage Lockout Threshold	From $V_{CC}$ low to high	3.6	3.8	3.98	V
$V_{UVHYS}$	$V_{CC}$ Undervoltage Lockout Hysteresis			200		mV
$V_{MSD}$	Manual Shutdown Threshold Voltage	PROG Pin Rising		1.21		V
		PROG Pin Falling		1.0		V
$V_{ASD}$	$V_{CC} - V_{BAT}$ Lockout Threshold Voltage	$V_{CC}$ From Low to High		100		mV
		$V_{CC}$ From High to Low		30		mV
$I_{TERM}$	C/10 Termination Current Threshold	$R_{PROG}=10\text{K}$		0.10		mA/mA
		$R_{PROG}=2\text{K}$		0.10		mA/mA
$V_{PROG}$	PROG Pin Voltage	$R_{PROG}=10\text{K}$ , Current Mode		1.0		V

### ELECTRICAL CHARACTERISTICS (continued) (Note 3,4,5)

SYMBOL	PARAMETERS	CONDITIONS	MIN	TYP	MAX	UNITS
$I_{\overline{CHG}}$	CHG Pin Weak Pull-Down Current	$V_{\overline{CHG}} = 5V$	3	6	15	$\mu A$
$V_{\overline{CHG}}$	CHG Pin Output Low Voltage	$I_{\overline{CHG}} = 5mA$		0.35	0.8	V
$\Delta V_{RECHG}$	Recharge Battery Threshold Voltage	$V_{FLOAT} - V_{CHG}$		150		mV
$T_{LIM}$	Junction Temperature in Constant Temperature Mode			120		$^{\circ}C$
$R_{ON}$	Power FET "ON" Resistance(Between VCC and BAT)			600		m $\Omega$
$t_{SS}$	Soft-Start time	$I_{BAT} = 0$ to $I_{BAT} = 1000V/R_{PROG}$		100		$\mu s$
$T_{RECHG}$	Recharge Comparator Filter Time	$V_{BAT}$ High to Low		2		ms
$T_{TERM}$	Termination Comparator Filter Time	$I_{BAT}$ falling below $I_{CHG} / 10$		1000		$\mu s$
$I_{PROG}$	PROG Pin Pull-Up Current			3		$\mu A$

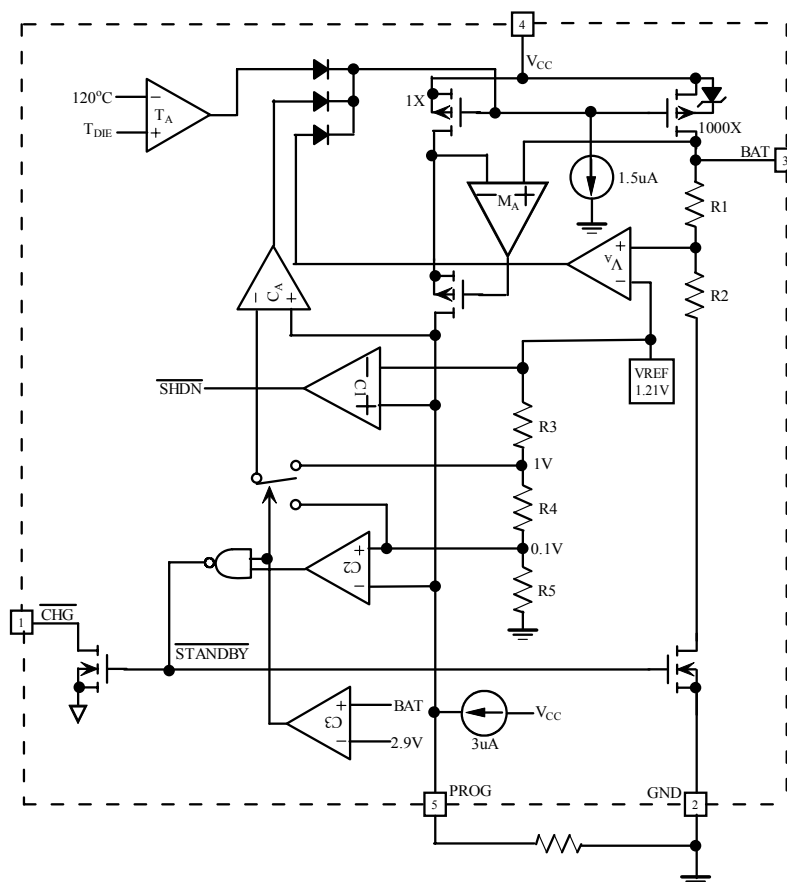
**Note 3:** Electrical Characteristics state DC and AC electrical specifications under particular test conditions which guarantee specific performance limits. This assumes that the device is within the recommended operating Range. Specifications are not guaranteed for parameters where no limit is given, however, the typical value is a good indication of device performance.

**Note 4:** Typicals are measured at 25 $^{\circ}C$  and represent the parametric norm.

**Note 5:** Datasheet min/max specification limits are guaranteed by design, test, or statistical analysis.

**Note 6:** Supply current includes PROG pin current (approximately 100 $\mu A$ ) but does not include any current delivered to the battery through the BAT pin (approximately 100mA).

### SIMPLIFIED BLOCK DIAGRAM



### OPERATION DESCRIPTION

The PT6112 is a standalone linear Li-ion battery charger with thermal regulation. With the internal 0.6 ohms MOSFET, the minimum operating voltage can be less than 4.25V. One external 1% precision resistor is required to set the charging current value. When the voltage at the VCC pin rises above the UVLO threshold, the normal charging cycle begins. If the battery voltage is less than 2.9V, the device will operate in a trickle charging mode. The charging current in the trickle charging mode is 1/10<sup>th</sup> of the programmed value, which effectively protects the battery from damage and prolongs its lifetime. When the voltage at the BAT pin rises above 2.9V, the charger enters the constant-current mode in which case the charging

current equals to the programmed value. Once the voltage at the BAT pin reaches 4.2V, the charger goes into the constant voltage mode where the charging current decreases. Once the charging current drops to 1/10<sup>th</sup> the programmed value, the charging cycle ends.

After a charge cycle is complete and the charging operation is terminated, the PT6112 keeps monitoring the BAT voltage. It will recharge the battery as soon as the BAT voltage drops below 4.05V. The PT6112 includes a soft-start circuit to minimize the inrush current at the start of a charge cycle. When the PROG pin is floating, the charger goes into the shutdown mode. It acts as chip enable pin.

### TYPICAL PERFORMANCE CHARACTERISTICS

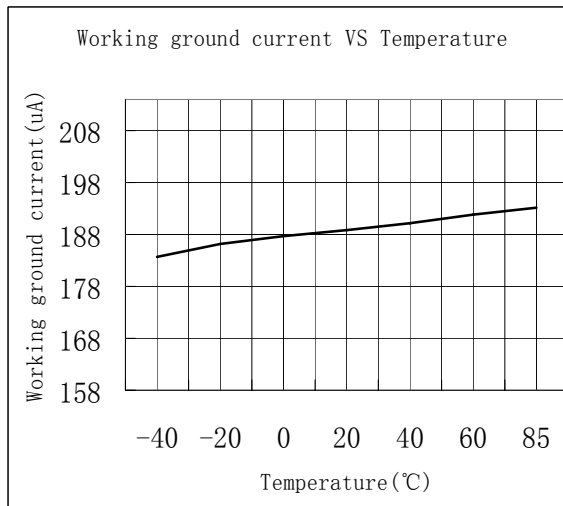
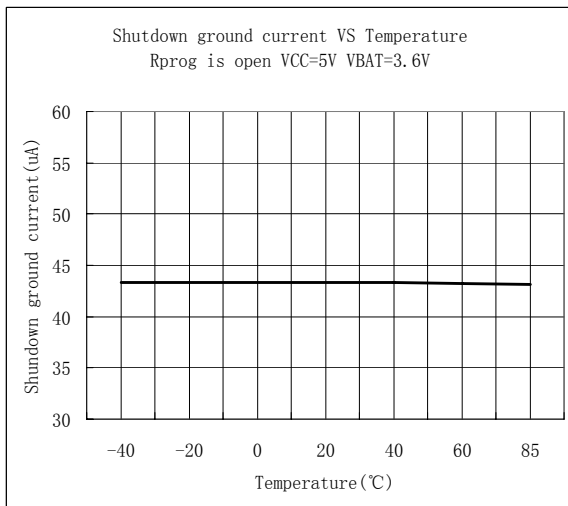
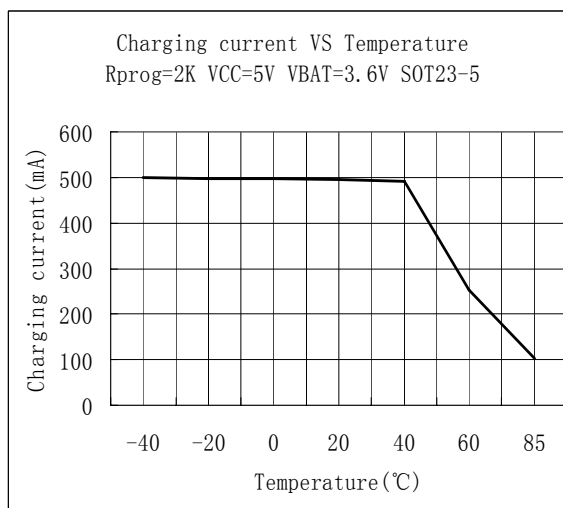
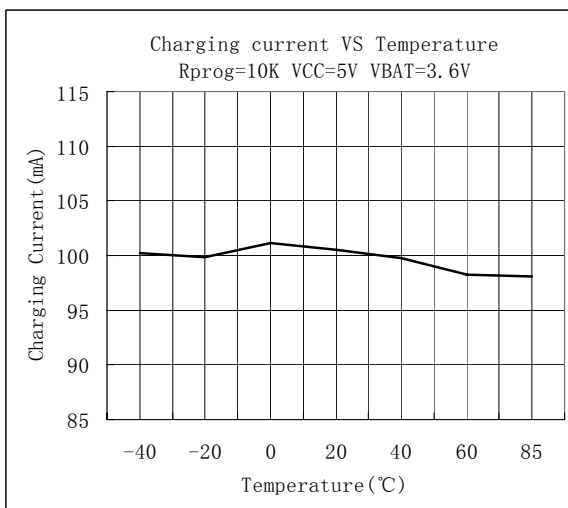
Note: Typical characteristics are obtained under the following conditions unless otherwise noted:

Rprog: 10K

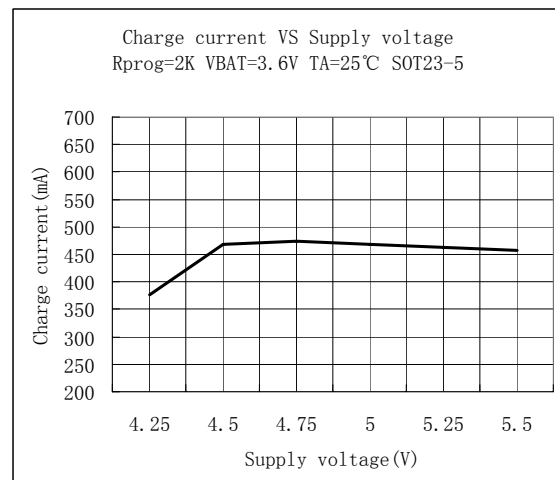
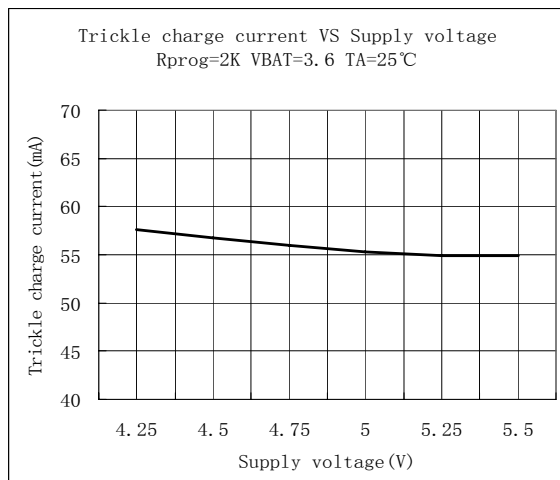
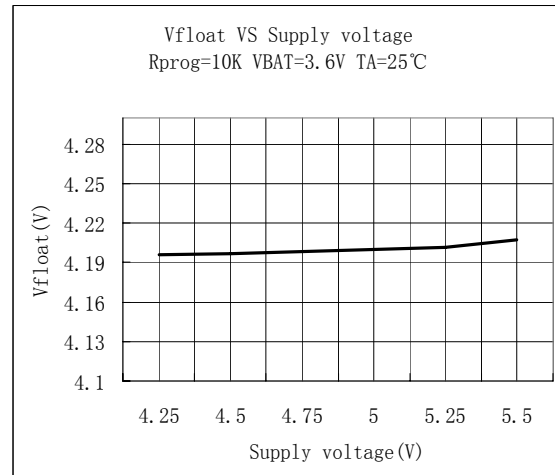
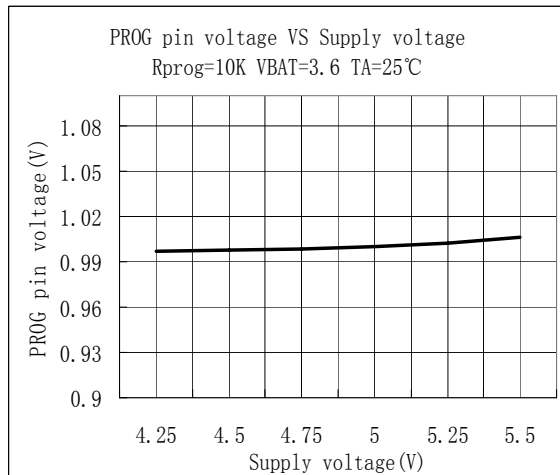
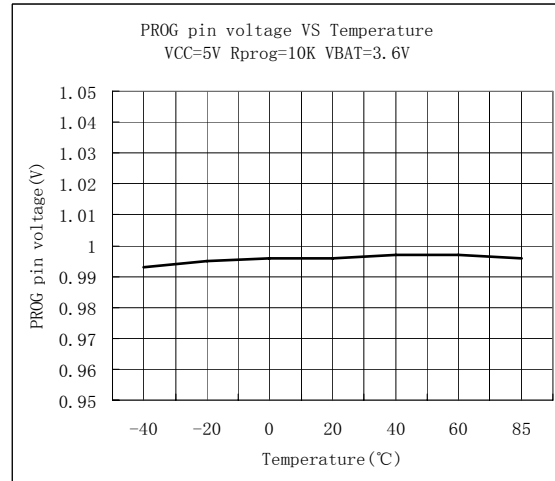
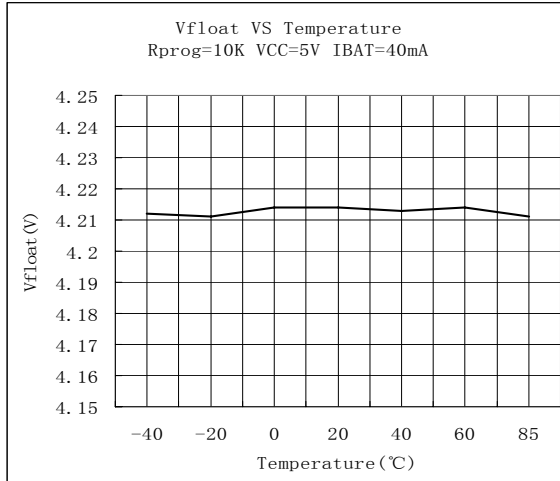
Cin: 1 $\mu$ F, Ceramic Type

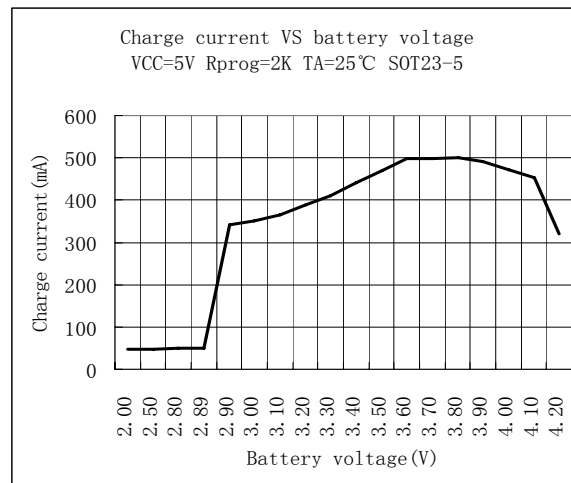
VCC=5V, VBAT=3.6V, TA=25°C

Cout: 1 $\mu$ F, Ceramic Type



### TYPICAL PERFORMANCE CHARACTERISTICS (Continued)





### APPLICATION INFORMATION

#### Adjusting Charging Current

The charging current is programmed using 1% precision resistor from PROG pin to ground. The charging current and the programming resistor are calculated using the following equations:

$$R_{PROG} = 1000V / I_{CHG}, \quad I_{CHG} = 1000V / R_{PROG}$$

#### Charge status indicator

The charging status indicator pin has three different states: strong pull down (about 10mA current sink), weak pull down (about 6μA current sink), and high impedance. The strong pull down mode indicates the PT6112 is in a charging cycle. A weak pull down mode indicates the Vcc reaches the UVLO and the charger is ready to charge. The high impedance indicates the PT6112 is in Under Voltage Lock Out (UVLO) mode: either VCC is less than 100mV above the BAT pin voltage or insufficient voltage is applied to the VCC pin. A microprocessor can distinguish the three states.

#### 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 PT6112 from excessive temperature and allows the user to push the limits of the power handling capability of a given circuit board

without risk of damaging the PT6112.

The conditions that cause the PT6112 to reduce charge current through thermal feedback can be approximated by considering the power dissipated in the IC. Nearly all of this power dissipation is generated by the internal MOSFET—this is calculated to be approximately:

$$PD = (V_{CC} - V_{BAT}) \cdot I_{BAT}$$

Where PD is the power dissipated

V<sub>CC</sub> is the input supply voltage

V<sub>BAT</sub> is the battery voltage

I<sub>BAT</sub> is the charge current.

The approximate ambient temperature at which the thermal feedback begins to protect the IC is:

$$T_A = 120^{\circ}\text{C} - PD \cdot \theta_{JA}$$

$$T_A = 120^{\circ}\text{C} - (V_{CC} - V_{BAT}) \cdot I_{BAT} \cdot \theta_{JA}$$

Reducing the voltage drop across the internal MOSFET can significantly decrease the power dissipation in the IC. This has the effect of increasing the current delivered to the battery during thermal regulation. One method is by dissipating some of the power through an external component, such as a resistor or diode. By dropping voltage across a resistor in series with a 5V wall adapter, the on-chip power dissipation can be decreased, thus increasing the thermally regulated charge current.



### Undervoltage Lockout (UVLO)

An internal undervoltage lockout circuit monitors the input voltage and keeps the charger in shutdown mode until VCC rises above the undervoltage lockout threshold. The UVLO circuit has a built-in hysteresis of 200mV. Furthermore, to protect against reverse current

in the power MOSFET, the UVLO circuit keeps the charger in shutdown mode if VCC falls to within 30mV of the battery voltage. If the UVLO comparator is tripped, the charger will not come out of shutdown mode until VCC rises 100mV above the battery voltage.

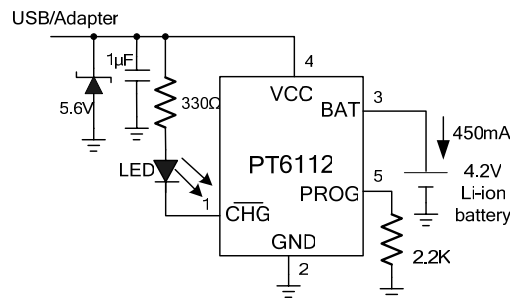
### STABILITY CONSIDERATIONS

The constant-voltage mode feedback loop is stable without an output capacitor provided a battery is connected to the charger 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 the programming resistor value as high as 20k. However, additional capacitance on this node reduces the maximum allowed program resistor. The pole frequency at the PROG pin should be kept above 100kHz.

### Adapter/USB Applications

For USB or adapter application, there is  $\pm 10\%$  voltage variation in the power supply; this device should be damaged if input voltage is higher than 5.5V. To protect the device, a 5.6V break down diode is suggested connects between VCC and GND in this kind of applications.



### EXTERNAL COMPONENT SELECTION GUIDE

#### ● Output Capacitors

With no battery present, an output capacitor is recommended to reduce ripple voltage. When using high value, low ESR ceramic capacitors, it is recommended to add a 1Ω resistor in series with the

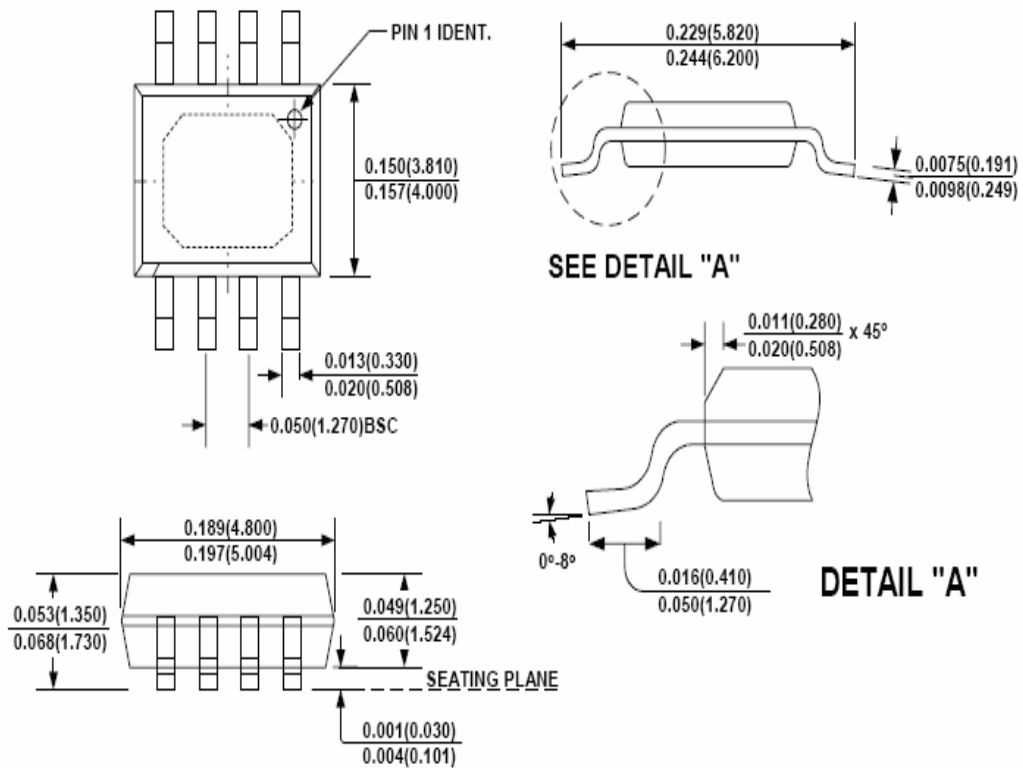
capacitor. No series resistor is needed if tantalum capacitors are used.

#### ● Programmed resistor

Use a resistor with 1% precision to increase the charging current accuracy.

### PACKAGE INFORMATION

#### ESOP8 package

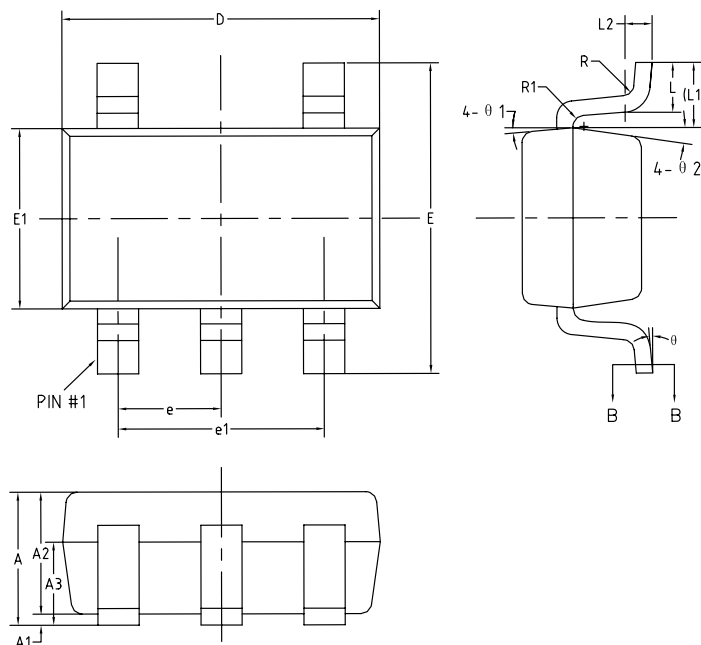


#### NOTE:

1) Control dimension is in inches. Dimension in bracket is millimeters.

### PACKAGE INFORMATION

SOT23-5



SYMBOL	MILLIMETERS		
	MIN	TYP	MAX
A	-	-	1.25
A1	0	-	0.15
A2	1.00	1.10	1.20
A3	0.60	0.65	0.70
b	0.36	-	0.50
b1	0.36	0.38	0.45
c	0.14	-	0.20
c1	0.14	0.15	0.16
D	2.826	2.926	3.026
E	2.60	2.80	3.00
E1	1.526	1.626	1.726
e	0.95BSC		
e1	1.90BSC		
L	0.35	0.45	0.60
L1	0.59REF		
L2	0.25BSC		
R	0.10	-	-
R1	0.10	-	0.25
θ	0°	-	8°
θ1	3°	5°	7°
θ2	6°	8°	10°