PT6103

Standalone Linear Li-Ion Battery Charger with Thermal Regulation and Battery Thermal Protection

GENERAL DESCRIPTION

The PT6103 is a highly integrated Li-ion battery linear charging management device targeted at space limited portable applications. The PT6103 offers an integrated MOSFET and current sensor, reverse blocking protection, high accuracy current and voltage regulation, charge status indication, and charge termination in SOT23,DFN6,DFN8 or ESOP8 package. The PT6103 charges a battery in three phases: trickle charging, constant current and constant voltage. 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 PT6103 automatically terminates the charge cycle when the charge current drops to 1/10 the programmed value after the final float voltage is reached.

Once the temperature outside the normal range thresholds is detected the PT6103 immediately stops the charging and CHG pin output 10Hz square wave. And charging is stopped until restart the chip again. And when the TS pin is floating or connected to ground, the battery temperature protection is disabled.

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 SOT23-6, DFN6, DFN8 or ESOP8 Package for Single Cell Lithium-Ion Batteries
- Battery Thermal Protection
- Constant-Current/Constant-Voltage Operation with Thermal Regulation to Maximize Charge Rate Without Risk of Overheating
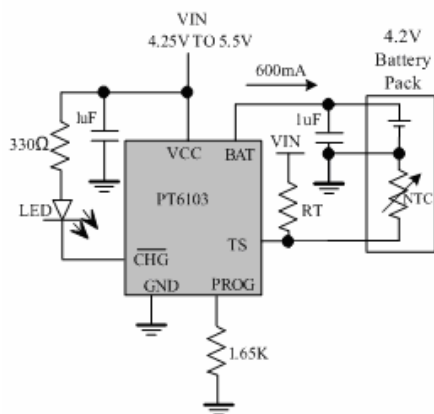- Preset 4.2V Charge Voltage with ±1% Accuracy

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
SOT23-6	-40℃ to 85℃	PT6103E23F	Tape & Reel	6103
ESOP8	-40℃ to 85℃	PT6103ESOH	Tape & Reel	PT6103 xxxxxX
DFN6	-40℃ to 85℃	PT6103EDFF	Tape & Reel	6103
DFN8	-40℃ to 85℃	PT6103EDFH	Tape & Reel	PT6103 xxxxxX

TYPICAL APPLICATION CIRCUIT

KEY PERFORMANCE CHART

Complete Charging Cycle(1600mAh Battery)

PIN ASSIGNMENT
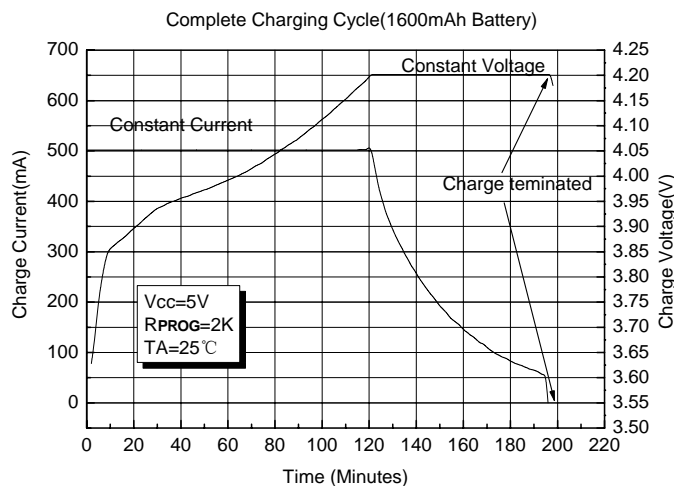
Top View

SOT23-6
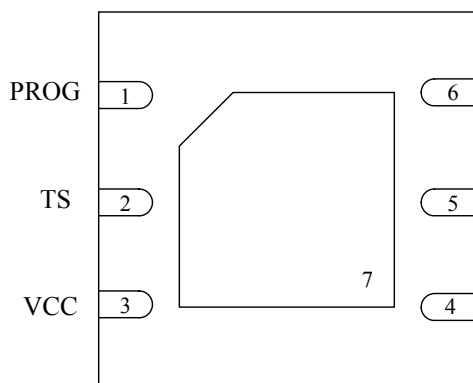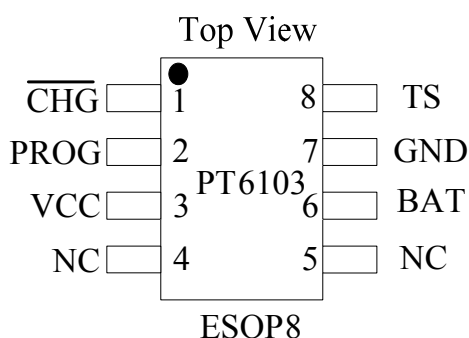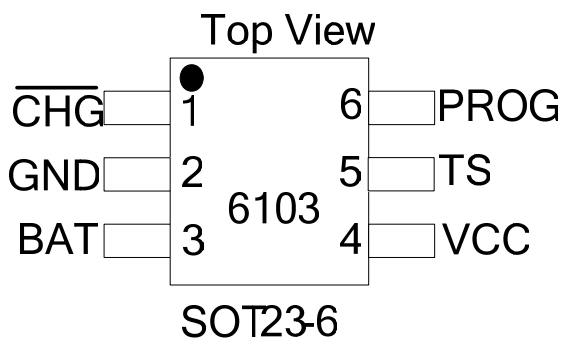
Top View

ESOP8

DFN-6 (2*2) top view
PT6103

DFN-8 (3*3) top view
PT6103

PIN DESCRIPTIONS

Names		Pin No.	Description
SOT23-6	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	8	TS	Temperature Sense
6	2	PROG	Charge Current Program, Charge Current Monitor and Shutdown Pin.
	4,5	NC	Not Connection

Names		Pin No.	Description
DFN6	DFN8		
1	1	PROG	Charge Current Program, Charge Current Monitor and Shutdown Pin.
2	2	TS	Temperature Sense
3	4	VCC	Positive Input Supply Voltage.
4	5	BAT	Charge Current Output. The positive side of battery.
5	7	GND	Ground
6	8	$\overline{\text{CHG}}$	Open-Drain Charges Status Output.
	3,6		Not Connection

ABSOLUTE MAXIMUM RATINGS (Note1)

SYM	PARAMETER	VALUE
VCC	Input supply voltage	-0.3 to 6
$\overline{\text{CHG}}$,PROG,BAT,TS		-0.3 to VCC
BAT Short-Circuit Duration		Continuous
BAT Pin Current		1000 mA
Operating Ambient Temperature Range		-40 to 85 ℃
Storage Temperature Range		-65 to 125 ℃
Lead Temperature	Soldering, 10Sec	260 ℃
P_{TR1}/P_{TR2}	Package Thermal Resistance, ESOP-8 θ_{JA1} /SOT23-6 θ_{JA2}	45 ℃ /W / 220 ℃ /W
P_{TR3}/P_{TR4}	Package Thermal Resistance, DFN6 θ_{JA3} /DFN8 θ_{JA4}	45 ℃ /W / 45 ℃ /W

RECOMMENDED OPERATING RANGE (Note 2)

SYMBOL	PARAMETER	VALUE
VCC	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℃, VCC=5V, unless otherwise noted

SYMBOL	PARAMETERS	CONDITIONS	MIN	TYP	MAX	UNITS
VCC	Input Supply Voltage		4.25		5.5	V
I_{CC}	Input Supply Current	Charge Mode(**Note 6**), R_{PROG} =10K		220	500	μA
		Standby Mode(Charge Terminated)		100	200	μA
		Shut Down Mode: R_{PROG} Not Connected , VCC < $V_{BAT,}$ or VCC < V_{UV}		60	100	μA
V_{FLOAT}	Regulated Output (Float) Voltage	0℃≤T_A≤85℃, I_{BAT} = 40mA	4.158	4.2	4.242	V
I_{BAT}	BAT pin Current	R_{PROG} =10K, Current Mode		100		mA
		R_{PROG} =2K, Current Mode	465	500	535	mA
		Standby Mode, V_{BAT} =4.2V	0	-2.5	-6	μA
		Shutdown Mode(R_{PROG} Not Connected)		±1	±2	μA
		Sleep Mode, V_{CC} =0V		±1	±2	μA
I_{TRIKL}	Trickle Charge Current	V_{BAT} < V_{TRIKL}, R_{PROG} =2K		50		mA
V_{TRIKL}	Trickle Charge Threshold Voltage	R_{PROG} =10K, V_{BAT} Rising	2.65	2.9	3.15	V
V_{TRHYS}	Trickle Charge Hysteresis Voltage	R_{PROG} =10K		120		mV
V_{UV}	VCC Undervoltage Lockout Threshold	From VCC high to low	3.6	3.8	3.98	V
V_{UVHYS}	VCC Undervoltage Lockout Hysteresis			240		mV
V_{MSD}	Manual Shutdown Threshold Voltage	PROG Pin Rising		1.24		V
		PROG Pin Falling		1.0		V
V_{ASD}	VCC – V_{BAT} Lockout Threshold Voltage	VCC From Low to High		100		mV
		VCC From High to Low		50		mV
I_{TERM}	C/10 Termination Current Threshold	R_{PROG} =10K		0.10		mA/mA
		R_{PROG} =2K		0.10		mA/mA
V_{PROG}	PROG Pin Voltage	R_{PROG} =10K, Current Mode		1.0		V
$I_{\overline{CHG}}$	CHG Pin Weak Pull-Down Current	$V_{\overline{CHG}}$ =5V	3	6	15	μA
$V_{\overline{CHG}}$	CHG Pin Output Low Voltage	$I_{\overline{CHG}}$=5mA		0.35	0.8	V
ΔV_{RECHG}	Recharge Battery Threshold Voltage	V_{FLOAT} - V_{CHG}		150		mV

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

| SYMBOL	PARAMETERS	CONDITIONS	MIN	TYP	MAX	UNITS
V_{TempL}	Cold Battery temperature threshold		80	83	86	%VCC
V_{TempH}	Hot Battery temperature threshold		38	41	44	%VCC
T_{LIM}	Junction Temperature in Constant Temperature Mode			120		℃
R_{ON}	Power FET "ON" Resistance(Between VCC and BAT)			600		mΩ
t_{SS}	Soft-Start time	$I_{BAT}=0$ to $I_{BAT}=1000V/$ RPROG		100		μs
T_{RECHG}	Recharge Comparator Filter Time	V_{BAT} High to Low		2		ms
T_{TERM}	Termination Comparator Filter Time	I_{BAT} falling below $I_{CHG}/10$		1		ms
T_{TEMP}	Temperature Comparator Filter time			50		ms
I_{PROG}	PROG Pin Pull-Up Current			3		μA

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˚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 100uA) but does not include any current delivered to the battery through the BAT pin (approximately 100mA).

SIMPLIFIED BLOCK DIAGRAM
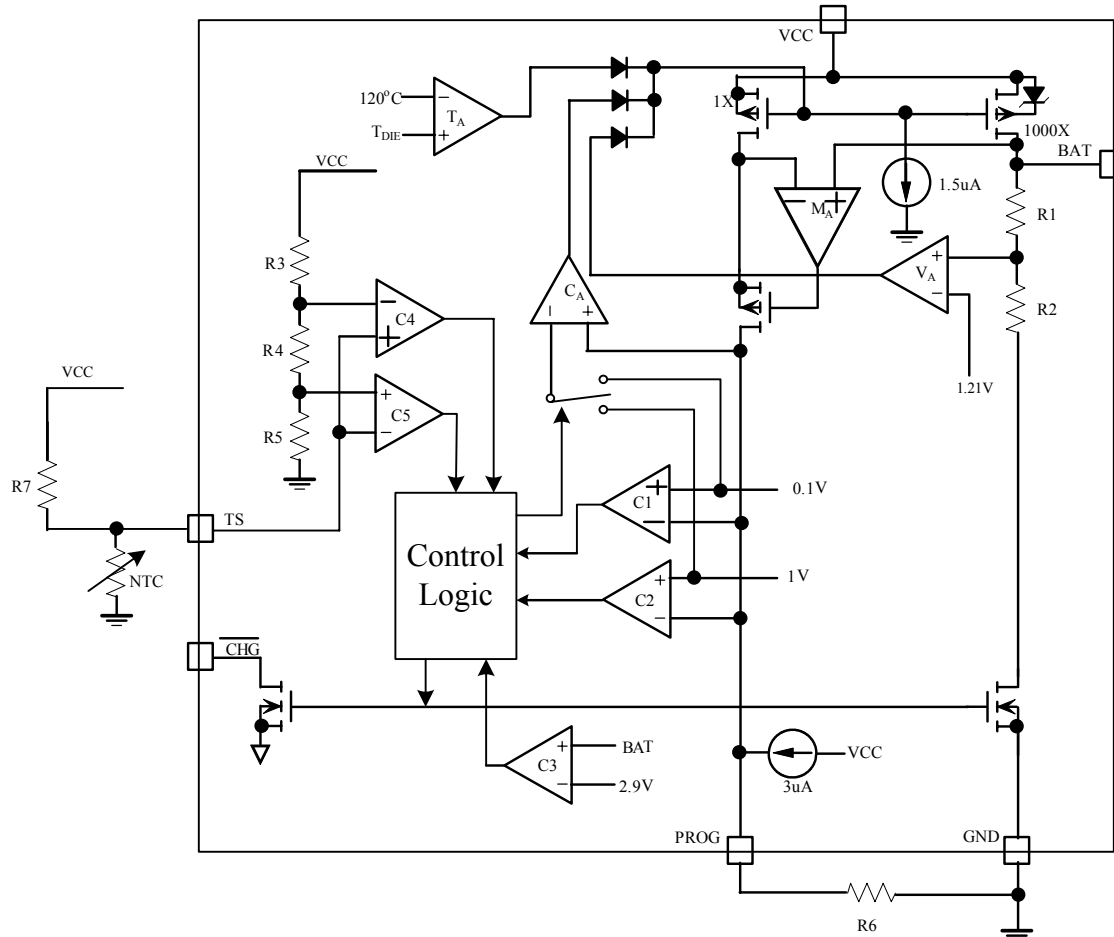
OPERATION DESCRIPTION

The PT6103 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 $1/10^{th}$ 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 $1/10^{th}$ the programmed value, the charging cycle ends.

After a charge cycle is complete and the charging operation is terminated, the PT6103 keeps monitoring the BAT voltage. It will recharge the battery as soon as the BAT voltage drops below 4.05V. The PT6103 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.
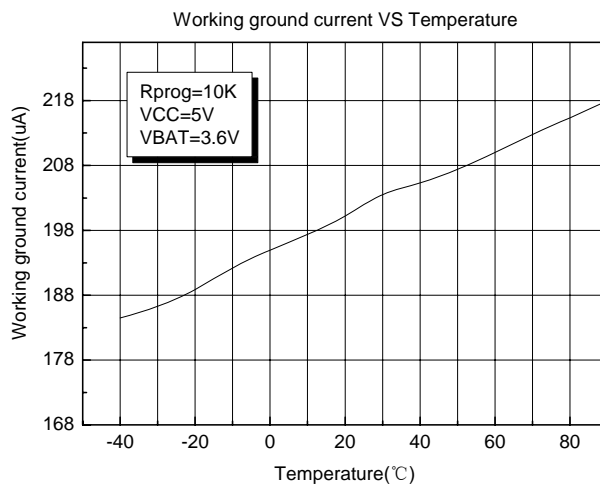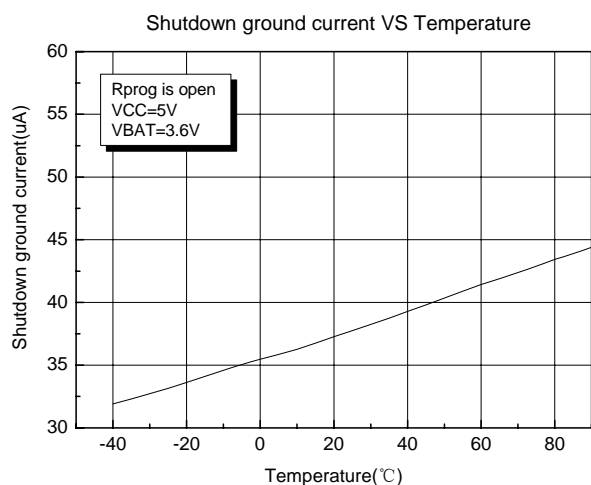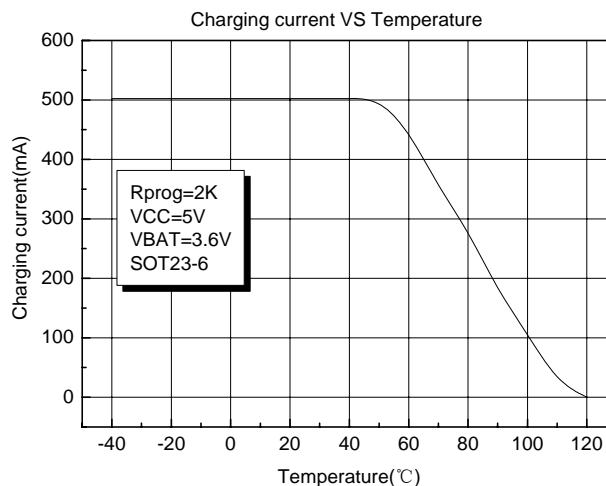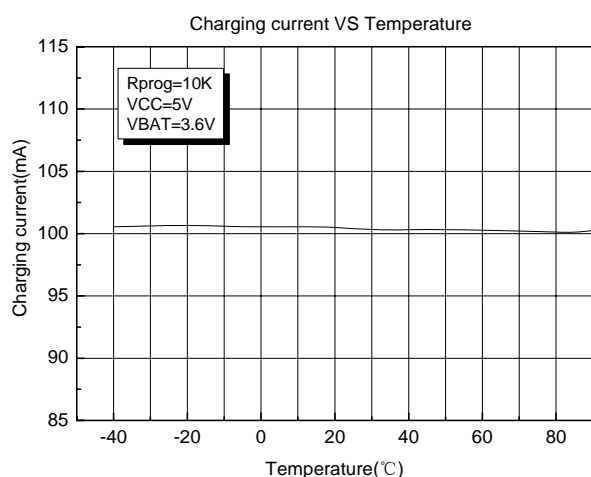
TYPICAL PERFORMANCE CHARACTERISTICS

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

Rprog:	10K	Cin:	1μF, Ceramic Type
V_{CC}=5V, VBAT=3.6V, T_A=25℃		Cout:	1μF , Ceramic Type
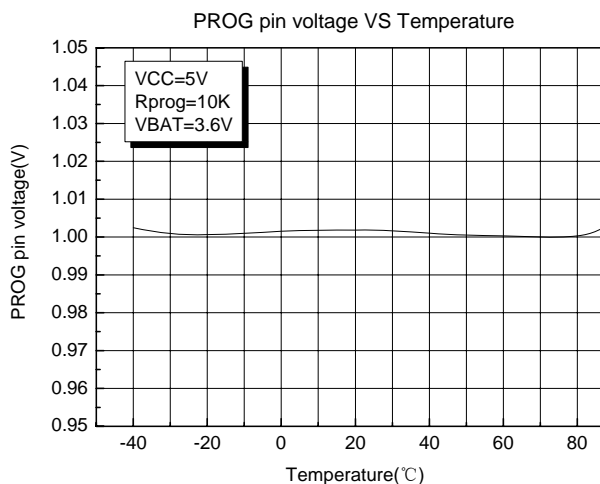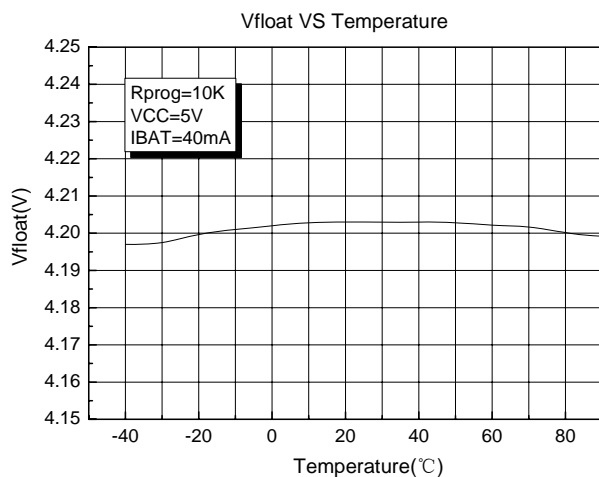
Charging current VS Temperature

Rprog=10K
VCC=5V
VBAT=3.6V

Charging current VS Temperature

Rprog=2K
VCC=5V
VBAT=3.6V
SOT23-6

Shutdown ground current VS Temperature

Rprog is open
VCC=5V
VBAT=3.6V

Working ground current VS Temperature

Rprog=10K
VCC=5V
VBAT=3.6V

Vfloat VS Temperature

Rprog=10K
VCC=5V
IBAT=40mA

PROG pin voltage VS Temperature

VCC=5V
Rprog=10K
VBAT=3.6V

TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

PROG pin voltage VS Supply voltage

Rprog=10K
VBAT=3.6
TA=25℃

Vfloat VS Supply voltage

Rprog=10K
VBAT=3.6V
TA=25℃

Trickle charge current VS Supply voltage

Rprog=2K
VBAT=3.6
TA=25℃

Charge current VS Supply voltage

Rprog=2K
VBAT=3.6V
TA=25℃
SOT23-6

Charge current VS battery voltage

VCC=5V
Rprog=2K
TA=25℃
SOT23-6

Charge Current VS Temperature

PROG=1.25K
VCC=5V
VBAT=3.6V
DFN8
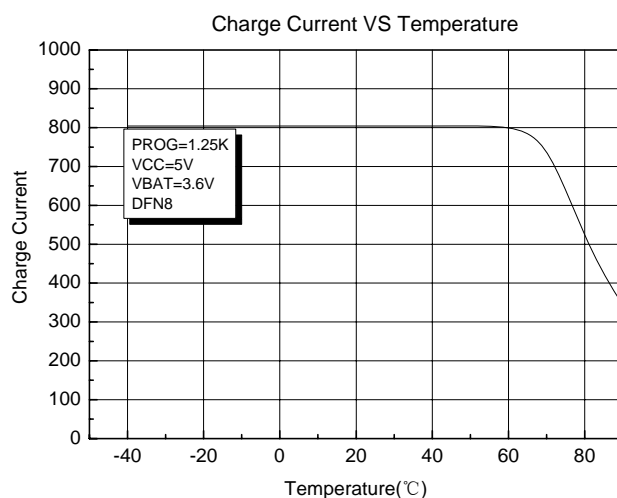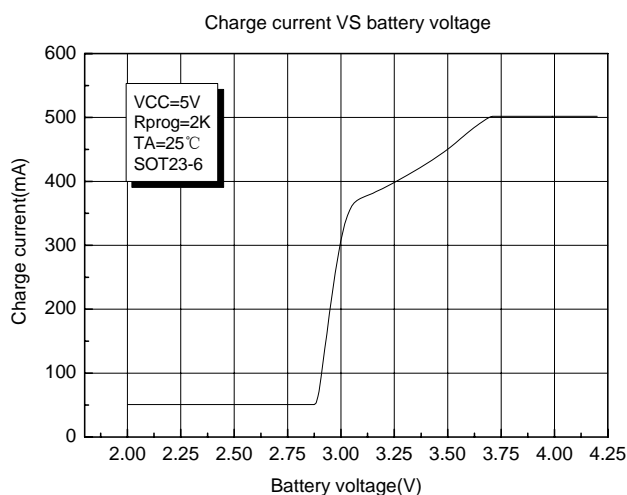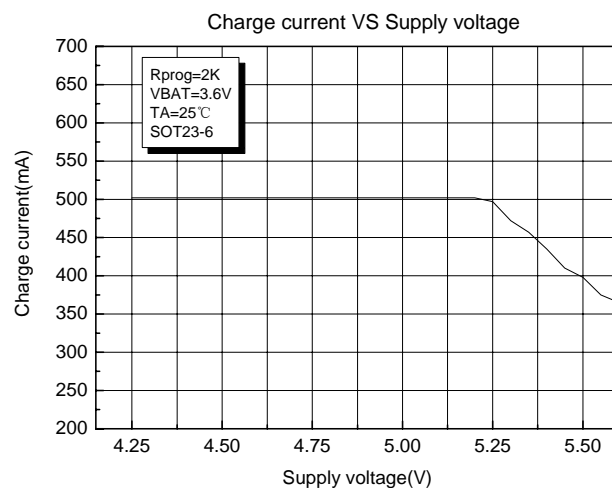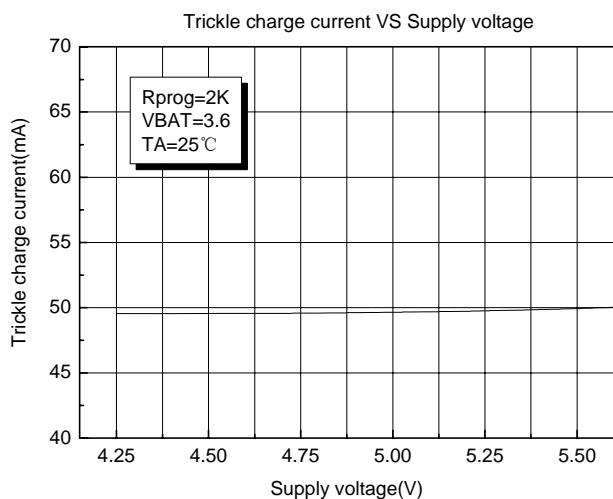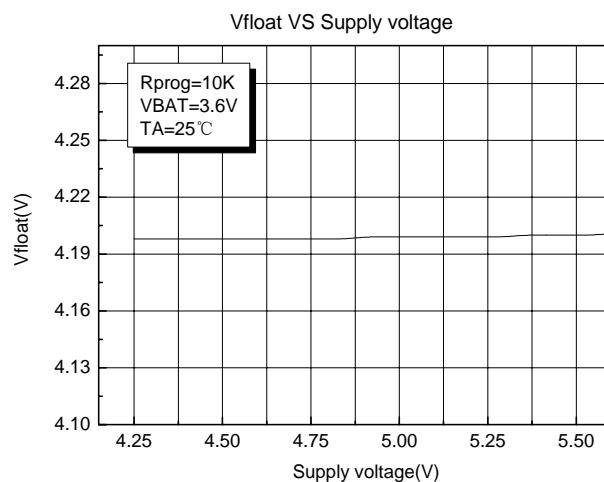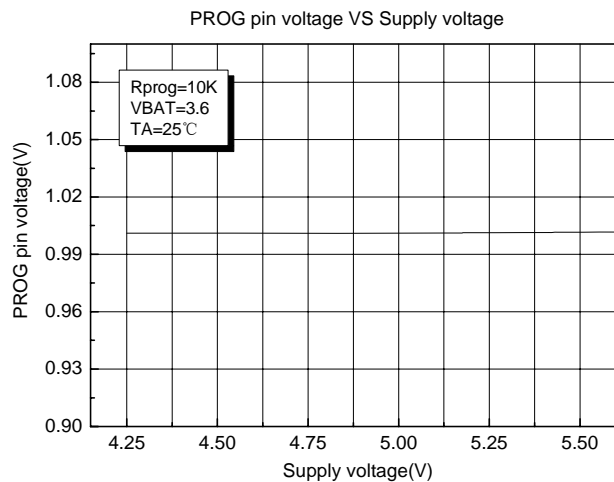
APPLICATION INFORMATION

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:

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

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 PT6103 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 PT6103 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℃. This feature protects the PT6103 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 PT6103.

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

The conditions that cause the PT6103 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_{CC} is the input supply voltage

   V_{BAT} is the battery voltage

   I_{BAT} is the charge current.

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

   $T_A = 120℃ - PD \cdot \theta_{JA}$

   $T_A = 120℃ - (V_{CC} - V_{BAT}) \cdot I_{BAT} \cdot \theta_{JA}$

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.

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 V_{CC} 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 ±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 V_{CC} and GND in this kind of applications.
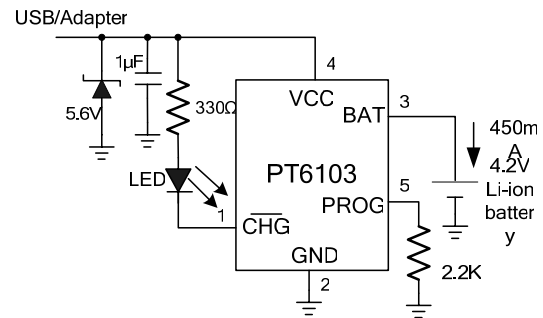
EXTERNAL COMPONENT SELECTION GUIDE

● **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.
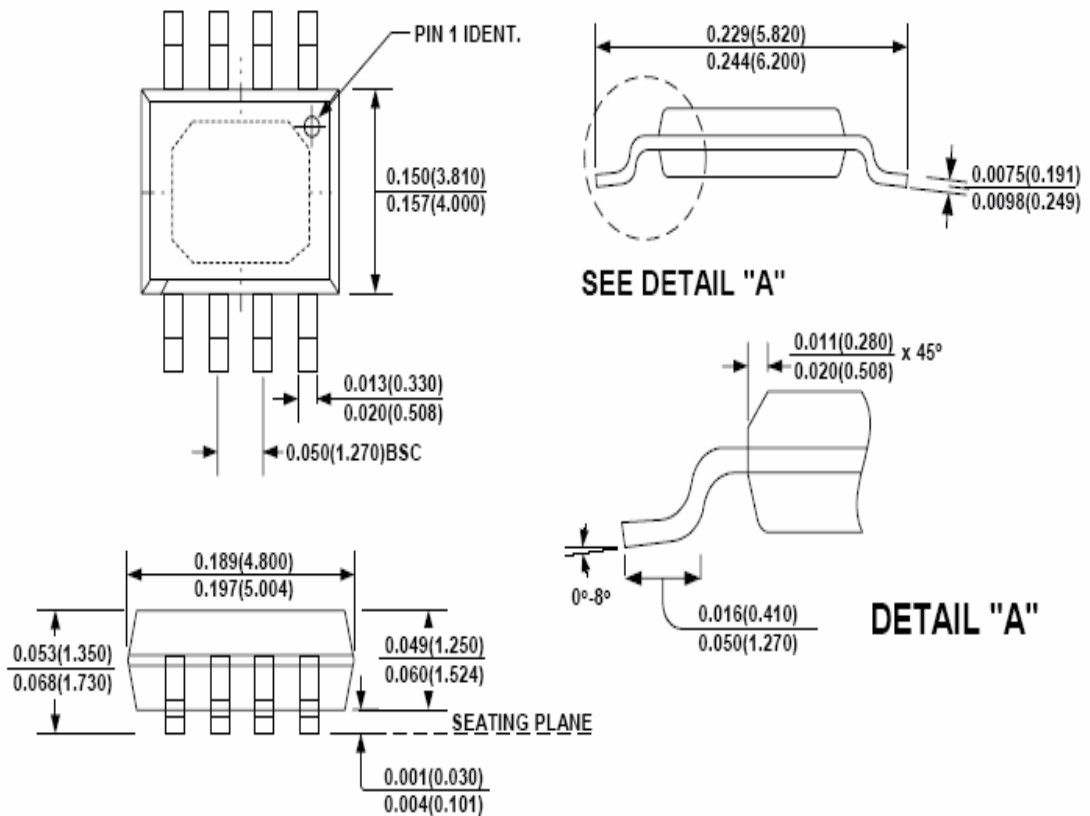
● **Programmed resistor**

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

SOT23-6
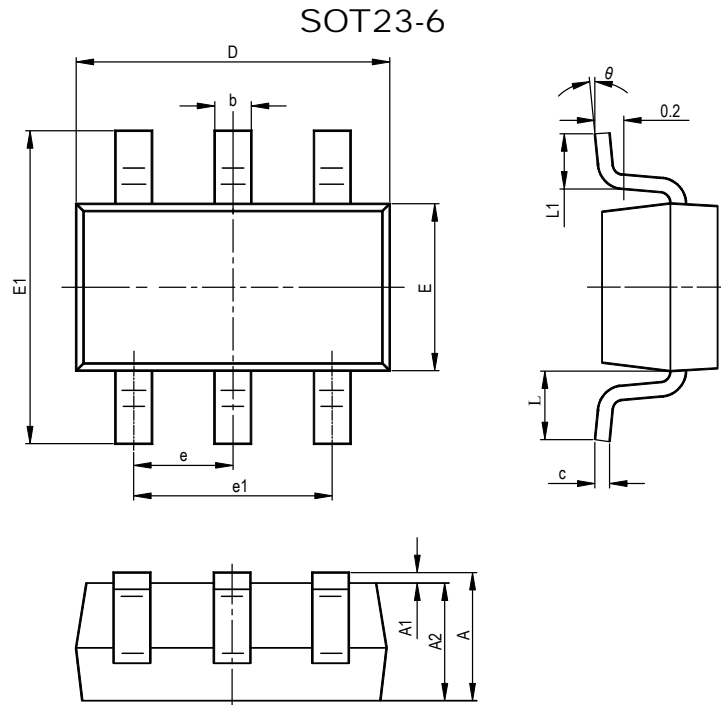
SYMBOL	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.400	0.012	0.016
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950TYP		0.037TYP	
e1	1.800	2.000	0.071	0.079
L	0.700REF		0.028REF	
L1	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°

PACKAGE INFORMATION

DFN-6
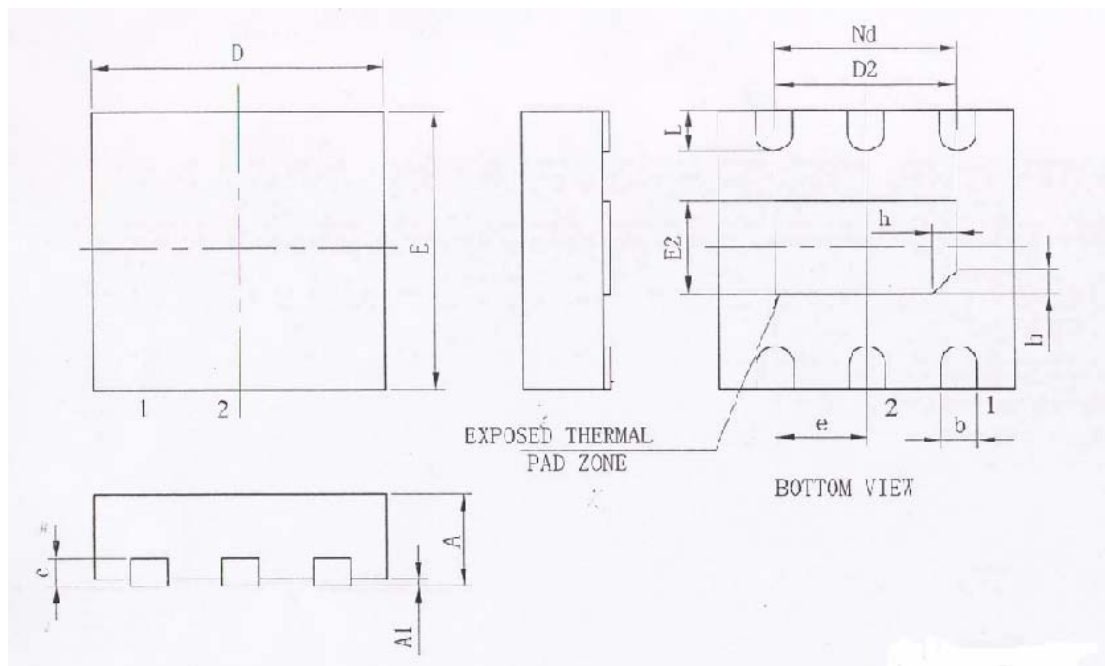
SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	0.70	0.75	0.80
A1	-	0.02	0.05
b	0.25	0.30	0.35
c	0.18	0.20	0.25
D	1.95	2.00	2.05
D2	1.00	-	1.45
e	0.65BSC		
Nd	1.30BSC		
E	1.95	2.00	2.05
E2	0.50	-	0.85
L	0.25	0.30	0.40
h	0.10	0.15	0.20
L/F 表面电镀	NiPdAu(镍钯金)		
载体尺寸（mil）	63*43		

PACKAGE INFORMATION

DFN-8
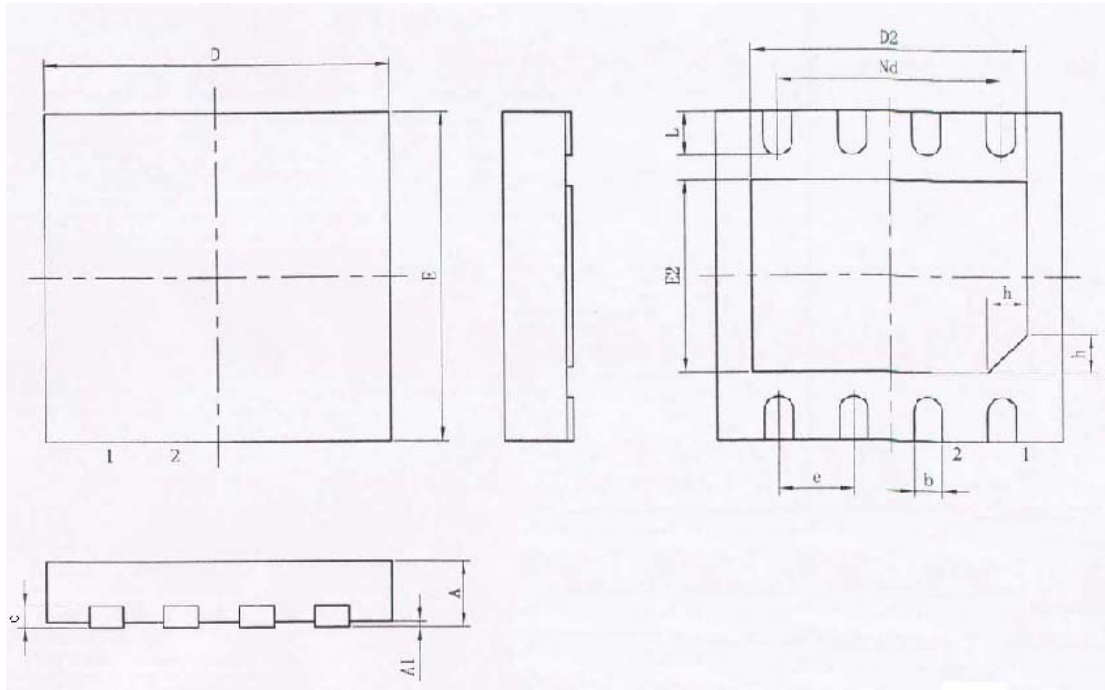
SYMBOL	MILLIMETER		
	MIN	**NOM**	**MAX**
A	0.70	0.75	0.80
A1	-	0.02	0.05
b	0.25	0.30	0.35
c	0.18	0.20	0.25
D	2.90	3.00	3.10
D2	2.50REF		
e	0.65BSC		
Nd	1.95BSC		
E	2.90	3.00	3.10
E2	1.55REF		
L	0.30	0.40	0.50
h	0.20	0.25	0.30