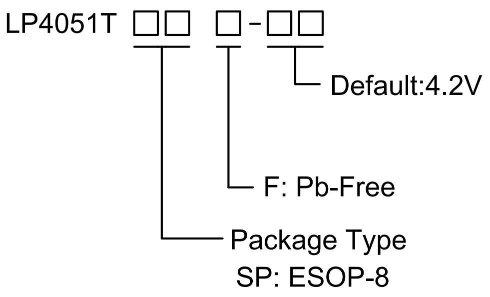
1A Standalone Linear Li-Ion Battery Charger

General Description

The LP4051T is a complete constant-current/ constant- voltage linear charger for single cell lithium-ion batteries. Its ESOP8 package and low external component count make the LP4051T ideally suited for portable applications. Furthermore, the LP4051T is specifically designed to work within USB power specifications. Thermal feedback regulates the charge current to limit the die temperature during high power operation or high ambient temperature. The charge voltage is fixed at V_{FLOAT} and the charge current can be programmed externally with a single resistor.

The LP4051T 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 LP4051T automatically enters a low current state, dropping the battery drain current to less than 1μA. Other features include charge current monitor, automatic recharge and a status pin to indicate charge termination and the presence of an input voltage.

Order Information



Features

- Protection of Reverse Connection of Battery
- Programmable Charge Current Up to 1A
- No MOSFET, Sense Resistor or Blocking Diode Required
- Constant-Current/Constant-Voltage Operation with Thermal Regulation to Maximize Charge Rate Without Risk of Overheating
- 1μA Supply Current in Shutdown
- Drainage Charge Current Thermal Regulation Status Outputs for LED or System Interface Indicates Charge and Full
- Optional Battery Temperature Monitoring Before and During Charge Automatic Sleep Mode for Low-Power
- Consumption Available in ESOP-8 Package
- RoHS Compliant and 100% Lead (Pb)-Free

Applications

- ✧ Portable Media Players/MP3 players
- ✧ Cellular and Smart mobile phone
- ✧ PDA/DSC
- ✧ Bluetooth Applications

Marking Information

Device	Marking	Package	Shipping
LP4051TSPF	LPS LP4051T YWX	ESOP-8	4K/REEL
Marking indication: Y:Production year W:Production week X: Series Number			

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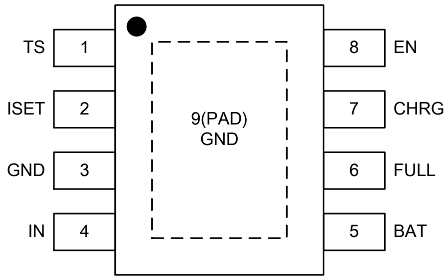
Functional Pin Description

Package Type	Pin Configurations
ESOP-8	 ESOP-8 (Top View)

Pin Description

No.	NAME	DESCRIPTION
1	TS	Temperature Detection Pin. Connect this pin to GND or set the voltage at this pin under 0.2V to disable TS function
2	ISET	Charge Current Program and Charge Current Monitor Pin. The charge current is programmed by connecting a 1% resistor, R_{ISET}, to ground. When charging in constant-current mode, this pin servos to 1V. In all modes, the voltage on this pin can be used to measure the charge current using the following formula: $IBAT=1200/R_{ISET}$
3	GND	GND is the connection to system ground.
4	IN	IN is the input power source. Connect to a wall adapter.
5	BAT	BAT is the connection to the battery.
6	FULL	Open-Drain Charge Status Output. When the battery is charging, the FULL pin could be pulled High by an external pull high resistor. When the charge cycle is completed, the pin is pulled Low by an internal N-channel MOSFET.
7	CHRG	Open-Drain Charge Status Output. When the battery is charging, the STAT pin is pulled low by an internal N-channel MOSFET. When the charge cycle is completed, the pin could be pulled High by an external pull high resistor.
8	EN	Chip enable pin. Charging when the pin is floating or connected to a high voltage. Discharge when the pin pull low.

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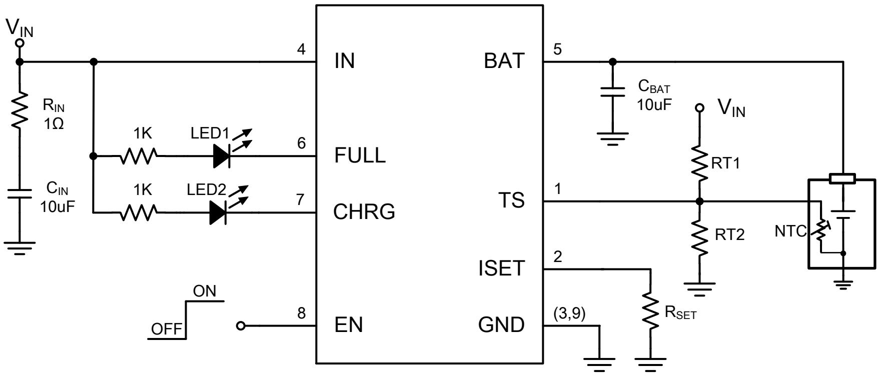
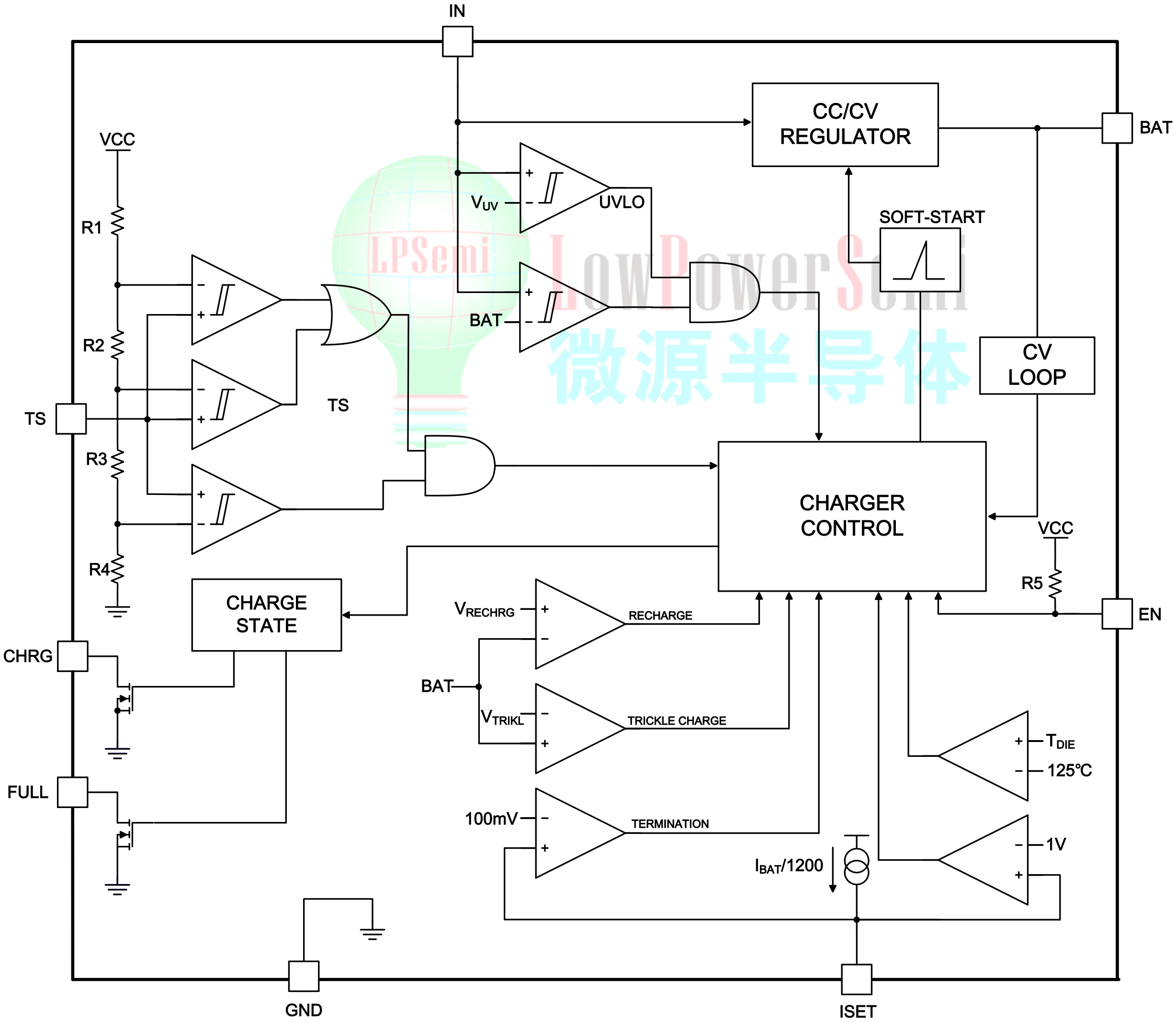
Typical Application Circuit



Functional Block Diagram



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Absolute Maximum Ratings Note 1

✧ Input to GND(IN)	-0.3V to 10V
✧ BAT to GND	-5V to 8V
✧ IN to BAT	10V
✧ Other Pin to GND	-0.3V to 8V
✧ BAT Short-circuit Duration	Continuous
✧ Storage Temperature	-45℃ to 125℃
✧ Operating Junction Temperature Range	-20°C to 85°C
✧ Maximum Soldering Temperature (at leads, 10 sec)	260°C

Note 1. Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Thermal Information

✧ Maximum Power Dissipation (PD,T_A=25°C)	2W
✧ Thermal Resistance (J_A)	50°C/W

ESD Susceptibility

✧ HBM(Human Body Model)	2KV
✧ MM(Machine Model)	200V

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Electrical Characteristics

(The specifications which apply over the full operating temperature range, otherwise specifications are at T_A = 25°C. V_{IN} = 5V, unless otherwise noted.)

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP.	MAX	UNITS
V_{IN}	Adapter/USB Voltage Range		4.5	5	6	V
I_{CC}	Input Supply Current	Standby Mode (Charge Terminated)		90		uA
V_{FLOAT}	Regulated Output (Float) Voltage	I_{BAT} = 40mA	4.18	4.21	4.24	V
I_{BAT}	BAT Pin Current	R_{ISET} = 12K	90	100	110	mA
		R_{ISET} = 2.4K	450	500	550	
		V_{IN}=NC, V_{BAT} = 4.2V		0	1	uA
I_{TRIKL}	Trickle Charge Current	V_{BAT} < V_{TRIKL}		10		%IBAT
V_{TRIKL}	Trickle Charge Threshold Voltage	R_{ISET} = 10K, V_{BAT} Rising	2.6	2.9	3.2	V
V_{TR-HYS}	Trickle Charge Hysteresis Voltage	R_{ISET} = 10K		100		mV
V_{UV}	Under voltage Lockout Threshold	V_{IN} Rising		3.7		V
V_{UV-HYS}	Under voltage Lockout Hysteresis			200		mV
V_{ASD}	V_{IN} –V_{BAT} Lockout Threshold Voltage	V_{IN} Rising		150		mV
I_{TERM}	Termination Current Threshold	R_{ISET} = 12K		10		%IBAT
		R_{ISET} = 2.4K				
V_{ISET}	ISET Pin Voltage	R_{ISET} = 10K, Current Mode	0.9	1.0	1.1	V
V_{STAT}	FULL/CHRG Pin Output Low Voltage	I_{STAT} = 5mA			0.5	V
I_{STAT}	FULL/CHRG Pin Weak Pull-Down Current	I_{STAT} = 5V			5	uA
ΔV_{RESTAT}	Recharge Battery Threshold Voltage	V_{FLOAT} - V_{RESTAT}		200		mV
V_{TS_H}	TS high temperature threshold			45		%V_{IN}
V_{TS_L}	TS low temperature threshold			78		%V_{IN}
V_{TS_DIS}	TS function disable threshold				0.2	V
V_{EN-ON}	EN Logic-High Voltage Threshold		1.4			V
V_{EN-OFF}	EN Logic-Low Voltage Threshold				0.4	V
T_{LIM}	Junction Temperature in Constant Temperature Mode			125		°C
R_{ON}	Power FET “ON” Resistance (Between IN and BAT)			450		mΩ

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Application Information

The LP4051T is a single cell lithium-ion battery charger using a constant-current/constant-voltage algorithm. It can deliver up to 1000mA of charge current (using a good thermal PCB layout) with a final float voltage accuracy of ±1%(4.2V). The LP4051T 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 LP4051T is capable of operating from a USB power source.

Normal Charge Cycle

A charge cycle begins when the voltage at the IN pin rises above the UVLO threshold level and a 1% ISET resistor is connected from the ISET pin to ground or when a battery is connected to the charger output. If the BAT pin is less than 3V, the charger enters trickle charge mode. In this mode, the LP4051T supplies approximately 1/10 of the ISET programmed value current to bring the battery voltage up to a safe level for full current charging.

When the BAT pin voltage rises above 2.9V (Typ.) , the charger enters constant-current mode, where the ISET rammed charge current is supplied to the battery. When the BAT pin approaches the final float voltage, the LP4051T enters constant-voltage mode and the charge current begins to decrease. When the charge current drops to 1/10 of the ISET rammed value, the charge cycle ends.

Charge Current Program

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

R_{ISET}=1200V/I_{BAT} , I_{BAT}= 1200V/R_{ISET}

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

I_{BAT}= V_{ISET} x 1200/R_{ISET}

Automatic Recharge

Once the charge cycle is terminated, the LP4051T continuously monitors the voltage on the BAT pin using a comparator with a 2ms filter time. A charge cycle restarts when the battery voltage falls below 4.0V (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. CHRG output enters a strong pull-down state during recharge cycles.

Battery Temperature Detection

An internal resistor divider sets the low temperature threshold (V_{TS_L}) and high temperature threshold (V_{TS_H}) at 78% of V_{IN} and 45% of V_{IN}, respectively. For a given TS thermistor, select an appropriate R_{T1} and R_{T2} to set the TS window with following equation:

$$\frac{V_{TS\_L}}{V_{IN}} = \frac{R_{T2} \parallel R_{TS\_COLD}}{R_{T1} + R_{T2} \parallel R_{TS\_COLD}} = T_L = 78\%$$

$$\frac{V_{TS\_H}}{V_{IN}} = \frac{R_{T2} \parallel R_{TS\_HOT}}{R_{T1} + R_{T2} \parallel R_{TS\_HOT}} = T_H = 45\%$$

Where R_{TS_HOT} is the value of the TS resistor at the upper bound of its operating temperature range, and R_{TS_COLD} is its lower bound. The two resistors R_{T1} and R_{T2} determine the upper and lower temperature limits independently. This flexibility allows the IC to operate with most TS resistors for different temperature range requirements. Calculate R_{T1} and R_{T2} with following equation:

$$R_{T1} = \frac{R_{TS\_HOT} \times R_{TS\_COLD} \times (T_L - T_H)}{T_H \times T_L \times \left(R_{TS\_COLD} - R_{TS\_HOT}\right)}$$

$$R_{T2} = \frac{R_{TS\_HOT} \times R_{TS\_COLD} \times (T_L - T_H)}{(1 - T_L) \times T_H \times R_{TS\_COLD} - (1 - T_H) \times T_L \times R_{TS\_HOT}}$$

Connect this pin to GND or set the voltage at this pin under 0.2V if you want to diable TS function.

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Charge Status Indicator (FULL/CHRG)

The charge status output has two different states: strong pull-down (~5mA) and high impedance. The strong pull-down state indicates that the LP4051T is in a charge cycle. High impedance indicates that the charge cycle complete or the LP4051T is in under voltage lockout mode: either V_{IN} is less than 150mV above the BAT pin voltage or insufficient voltage is applied to the IN pin. A microprocessor can be used to distinguish between these two states.

Function	CHRG	FULL
Charging	Low	Hi-Z
Charge END	Hi-Z	Low

Thermal Limit

An internal thermal feedback loop reduces the charge current if the die temperature attempts to rise above a preset value of approximately 125°C. This feature protects the LP4051T 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 LP4051T.

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.

Power Dissipation

The conditions that cause the LP4051T 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:

$$P_D=(V_{IN}-V_{BAT}) \cdot I_{BAT}$$

where PD is the power dissipated, VIN is the input supply voltage, VBAT is the battery voltage and IBAT is the charge current. The approximate ambient temperature at which the thermal feedback begins to protect the IC is:

$$T_A=125℃-P_D\theta_{JA}$$

$$T_A=125℃-(V_{IN}-V_{BAT}) \cdot I_{BAT} \cdot \theta_{JA}$$

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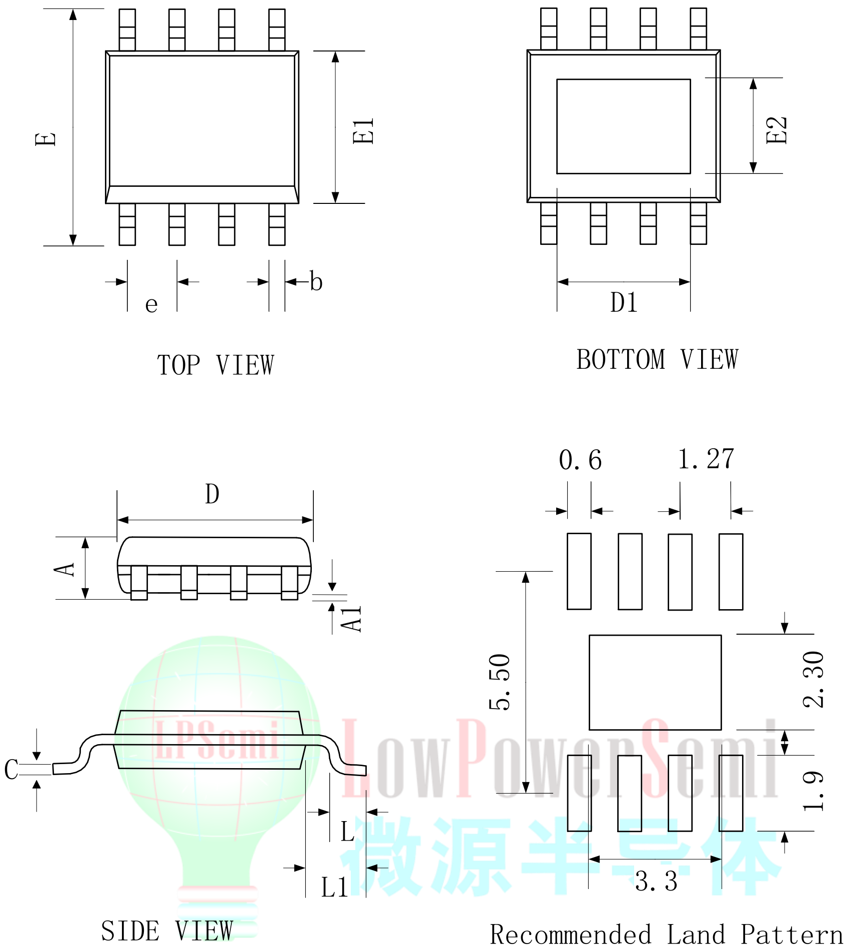
Packaging Information

ESOP-8



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SYMBOL	Dimensions In Millimeters		
	MIN	NOM	MAX
A	1.35	-	1.75
A1	0.00	-	0.15
b	0.30	0.40	0.50
c	0.20 REF		
D	4.70	4.90	5.10
D1	3.2 REF		
E	5.70	6.00	6.30
E1	3.70	3.90	4.10
E2	2.30 REF		
e	1.27 BSC		
L	0.40	0.60	0.80
L1	1.05 REF		