Single and Dual Cell Li+ Battery Charger IC –LP28009

General Description

The LP28009 is a fully integrated low cost single-cell and dual cell Li-Ion battery charger IC ideal for portable applications. The LP28009 is capable of being powered up from AC adapter. The LP28009 enters sleep mode when AC adapter is removed. The LP28009 optimizes the charging task by using a control algorithm including preconditioning mode, fast charge mode and constant voltage mode. The charging task is terminated as the charge current drops below the preset threshold. The AC adapter charge current can be programmed up to 1.2A with an external resister. The internal thermal feedback circuitry regulates the die temperature to optimize the charge rate for all ambient temperatures. The LP28009 features 18V maximum rating voltages for AC adapter. The other features are under voltage protection, over voltage protection for AC adapter supply and battery temperature monitoring.

Order Information

LP28009 □ □ □ □ □

- F: Pb-Free
- Package Type
  - SP: SOP-8(EP)
- Output Voltage
  - 42: 4.2V
  - 84: 8.4V

Applications

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

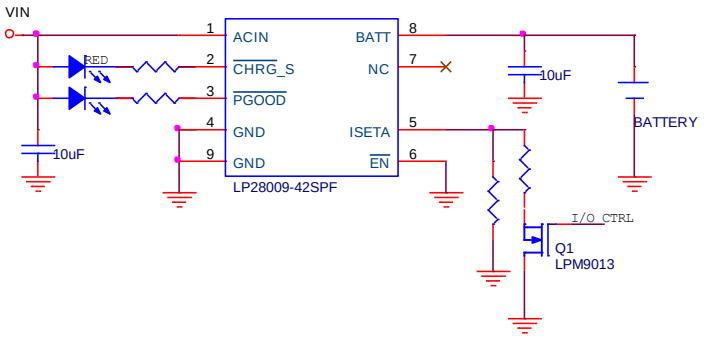
Features

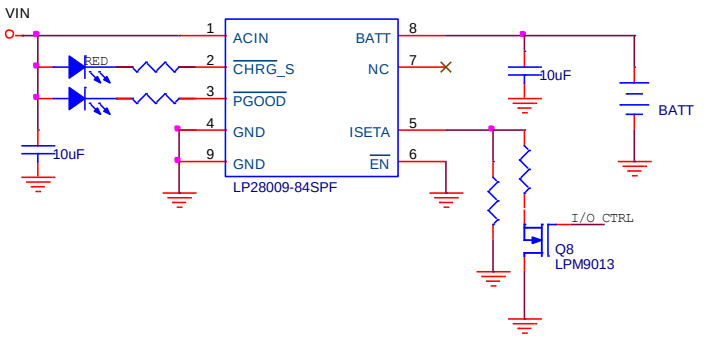
- 18V Maximum Rating for AC Adapter
- Internal Integrate P-MOSFETs
- AC Adapter Power Good Status Indicator
- Charge Status Indicator
- Under Voltage Protection
- Over Voltage Protection
- Automatic Recharge Feature
- Battery Temperature Monitoring
- Small 8-Lead SOP(EP) Package
- Thermal Feedback Optimizing Charge Rate
- ROHS Compliant and 100% Lead (Pb)-Free

Marking Information

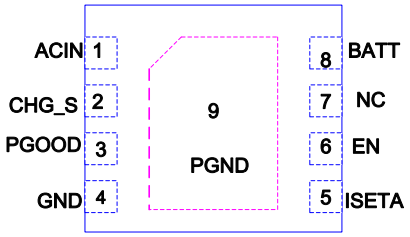
Device	Marking	Package	Shipping
LP28009		SP:SOP-8	3K/REEL

Typical Application Circuit





Functional Pin Description

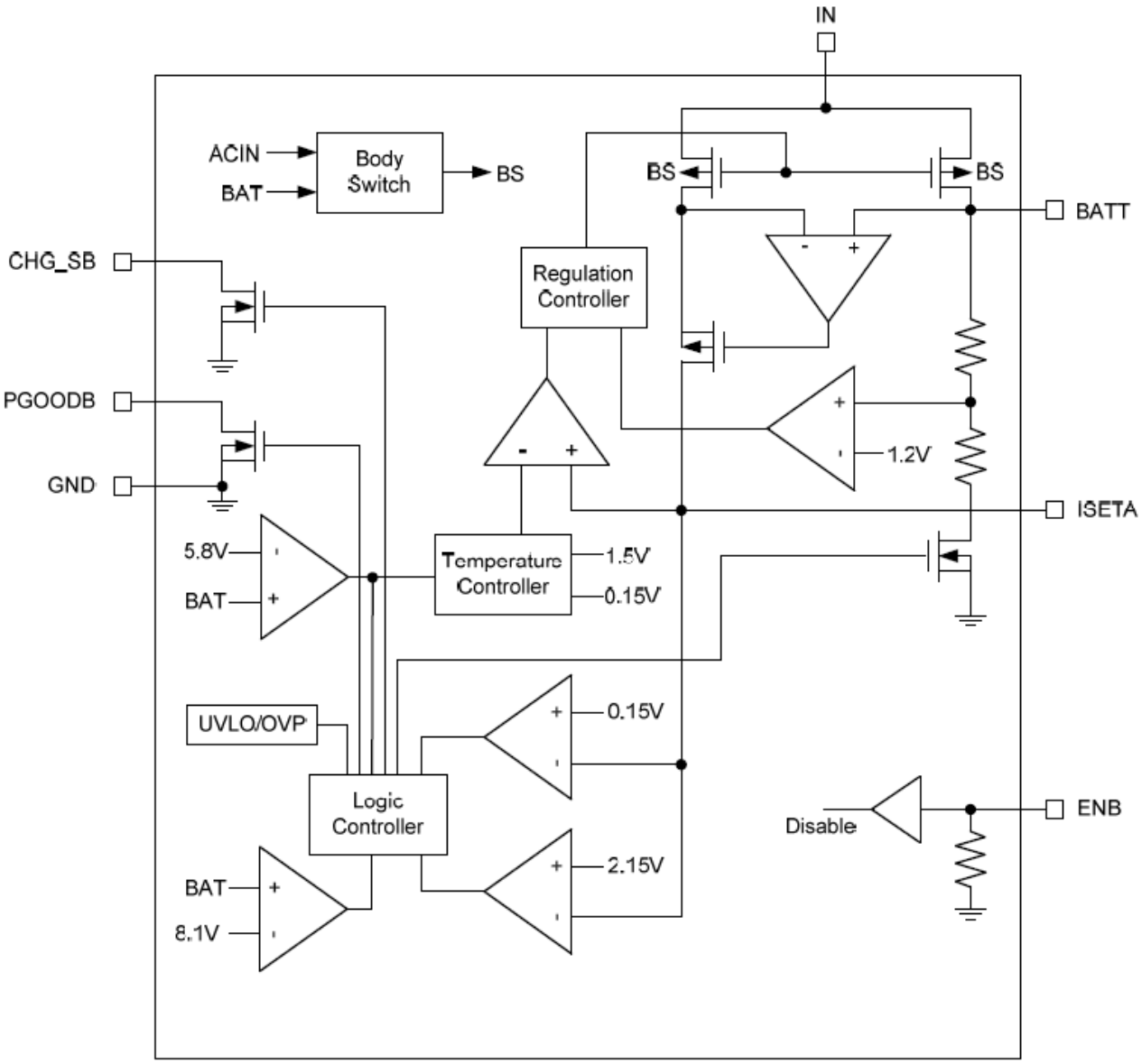
Package Type	Pin Configurations
ESOP- 8	

Pin Description

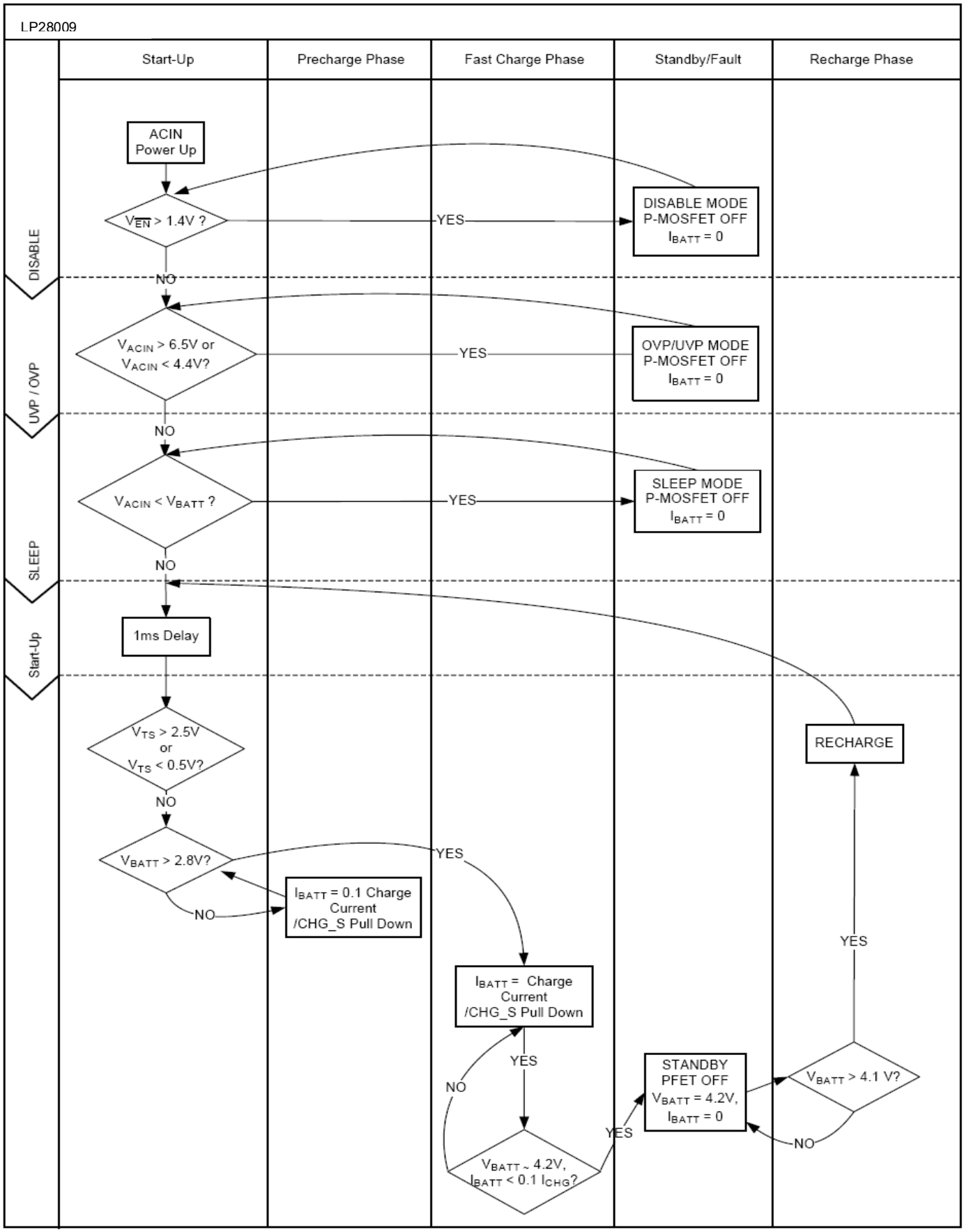
Pin No	Pin Name	Pin Function
1	ACIN	Wall Adaptor Charge Input Supply.
2	$\overline{CHG\_S}$	Charge Status Indicator Output(Open Drain).
3	$\overline{PGOOD}$	Power Good Indicator Output(Open drain).
4	GND	Ground.
5	ISETA	Wall Adaptor supply charge current Set point.
6	$\overline{EN}$	Charge Enable Input(active low).
7	NC	No Internal Connection.
8	BATT	Battery Charge Current Output. This pin provides charge current to the battery and regulates the final float voltage to 4.2 or 8.4V. An internal precision resistor divider from this pin sets the float voltage which is disconnected in shutdown mode.
9 (Exposed Pad)	PGND	Exposed Pad Should be soldered to PCB Board and Connected to GND.

Note: LP28009-42SPF and LP28009-84SPF of Battery (Pin8) is output pin, the pin connector to Battery.

Function Block Diagram



LP28009-42 Flow Chart



Absolute Maximum Ratings

VIN, VBATT, VCHGSB, VPGOOD, VEN ---------- -0.3V to 15V

Storage Temperature Range---------- -65℃ to 150℃

VISETA ---------- -0.3V to 3.6V

Junction Temperature (TJ) ---------- 150℃

Lead Temperature (soldering,10 sec.) ---------- 260℃

Operating Ratings

Supply Voltage ---------- 9V to 13.5V

Thermal Resistance(θJA) ---------- 46℃/W

Operating Temperature Range ---------- -40℃ to 85℃

Electrical Characteristics

(TA=25℃, VIN=10V; unless otherwise specified.)

Symbol	Parameter	Conditions	Min	Typ	Max	Units
VIN	Input Operating Voltage Range		9	10	13.5	V
Icc	Input Supply Current	Charge Mode.RSET=30K		300		uA
		Standby Mode (Charge Terminated)		250		UA
		Shutdown Mode (RSET Not Connected VIN < VBATT or VIN < Vuv)		190		uA
VFLOAT	Regulated Output(Float) Voltage	0℃ ≤ TA ≤ 85℃	8.316	8.4	8.484	V
IBATT	BATT Pin Current	RSET=1.5k,Current Mode		500		mA
		RSET=0.75k,Current Mode		1000		mA
		Standby Mode, VBATT=8.4V	-1	0	1	uA
		Shutdown Mode	-1	0	1	uA
		Sleep Mode, VIN=0V	-1	0	1	uA
ITRICKLE	Trickle Charge Current	VBATT <VTRICKLE, RSET=1.5K		60		mA
		VBATT <VTRICKLE, RSET=0.75K		120		mA
VTRICKLE	Trickle Charge Threshold Voltage	RSET=1.5K, VBATT Rising		5.8		V
VTRHYS	Trickle Charge Hysteresls Voltage	RSET=1.5K		250		mV
VMSD	Manual Shutdown Threshold Voltage	ISETA Pin Rising		2.15		V
		ISETA Pin Falling		2.05		V
VASD	VIN – VBATT Lockout	Vin from High to Low		30		mV

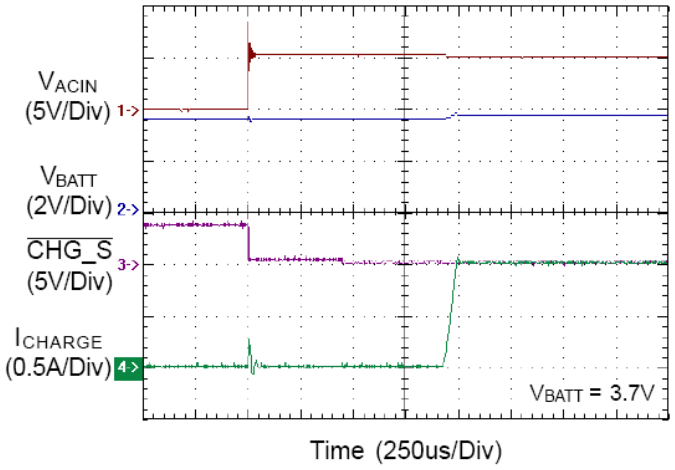
	Threshold Voltage	Vin from Low to High		60		mV
ITERM	C/10Termination Current Threshold	RSET=1.5K		0.1		mA/ mA
		RSET=0.75K		0.1		mA/ mA
VSET	ISETA pin Voltage	RSET=1.5K,Current Mode		1.5		V
ICHG_SB	CHG_SB Pin Weak Pull-Down Current	VCHG_SB=5.0V		25		uA
VCHG_SB	CHG_SB Pin Output Low Voltage	ICHG_SB=5mA		0.35		V
VPGOOD	PGOOD Pin Output Low Voltage	IPGOOD_SB=5mA		0.35		V

Parameter		Symbol	Test Conditions	Min	Typ	Max	Units
Precharge							
BATT Pre-Charge Rising Threshold		VPRECH		2.6	2.8	3	V
BATT Pre-Charge Threshold Hysteresis		ΔVPRECH		50	100	200	mV
Pre-Charge Current		IPCHG	VBATT=2V	8	10	12	%
Recharge Threshold							
BATT Pre-Charge Falling Threshold Hysteresis		ΔVPRECH_L	VREG – VBATT	60	100	150	mV
Charge Termination Detection							
Termination Current Ratio(default)		ITERM	VBATT=4.2V	--	10	--	%
Logic Input/Output							
$\overline{CHG\_S}$ Pull Down Voltage		VCHG_S	TBD, $\overline{ICHG}$_S=5mA	--	65	--	mV
PGOOD Pull Down Voltage		VPGOOD	TBD, IPGOOD=5mA	--	220	--	mV
$\overline{EN}$ Threshold	Logic-High Voltage	VIH		1.5	--	--	V
	Logic-Low Voltage	VIL		--	--	0.4	V
$\overline{EN}$ Pin Input Current		I$\overline{EN}$	I$\overline{EN}$=2V	--	--	2	μA
Protection							
Thermal Regulation				--	125	--	℃
OVP SET			Internal Default	--	6.5	--	V

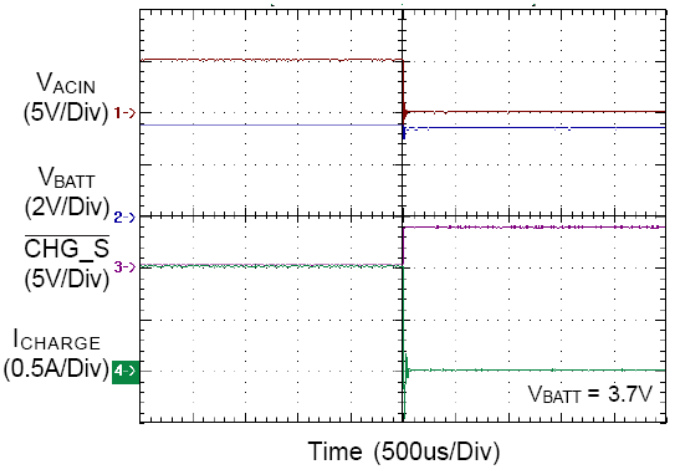
Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
Supply Input						
ACIN UVP Rising Threshold Voltage	VUV_HIGH			4.4	4.5	V
ACIN UVP Hysteresis	VUV_LOW		50	80	120	mV
ACIN Standby Current	ISTBY	VBATT=4.5V		300	500	μA
ACIN Shutdown Current	ISHDN	$\overline{VEN}$=HIGH		50	100	μA
ACIN UVP Current	IUVP	VACIN=4V, VUSB=4V, VBATT=3V		150	250	μA
BATT Sleep Leakage Current	ISLEEP	VACIN=4V, VUSB=4V, VBATT=4.5V		2	5	μA
Voltage Regulation						
BATT Regulation Voltage	VREG	IBATT=60mA	4.158	4.2	4.242	V
Regulation Voltage Accuracy			-1		+1	%
ACIN MOSFET	RDS(ON)_ACIN	IBATT=500mA		600		mΩ
Current Regulation						
ISETA Set Voltage (Fast Charge Phase)	VISETA	VBATT=3.5V	2.45	2.5	2.55	V
Full Charge Setting Range	ICHG_AC		100	--	1200	mA
ACIN Charge Current Accuracy	ICHG_AC	VBATT=3.8V RISET=1.5KΩ	--	125	--	℃

Typical Operating Characteristics

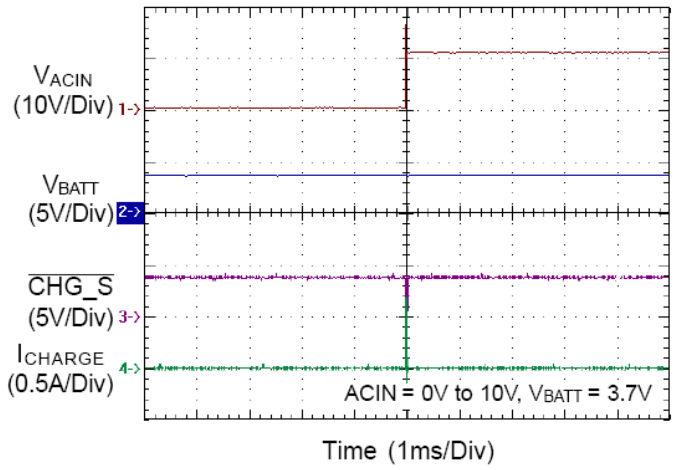
ACIN Power On



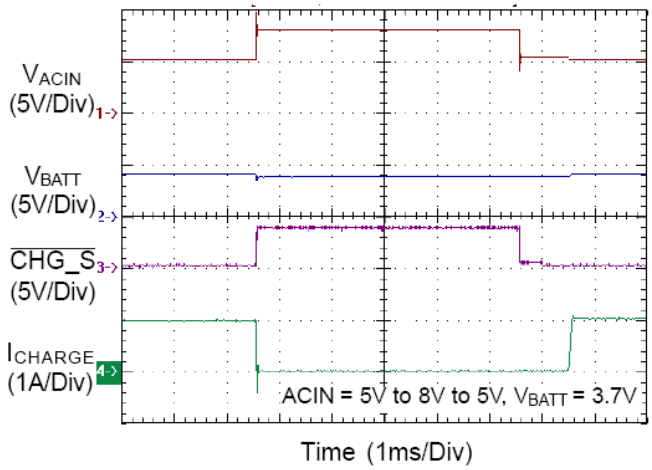
ACIN Power Off



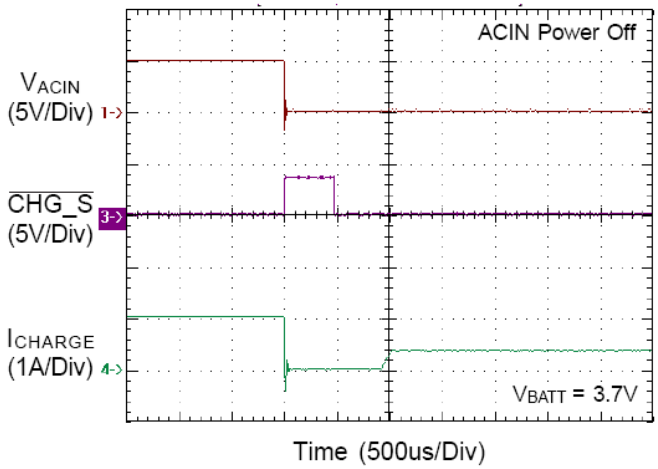
ACIN OVP



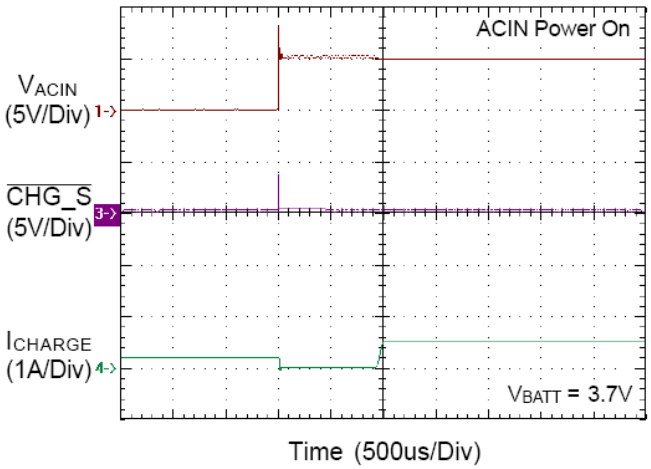
ACIN OVP



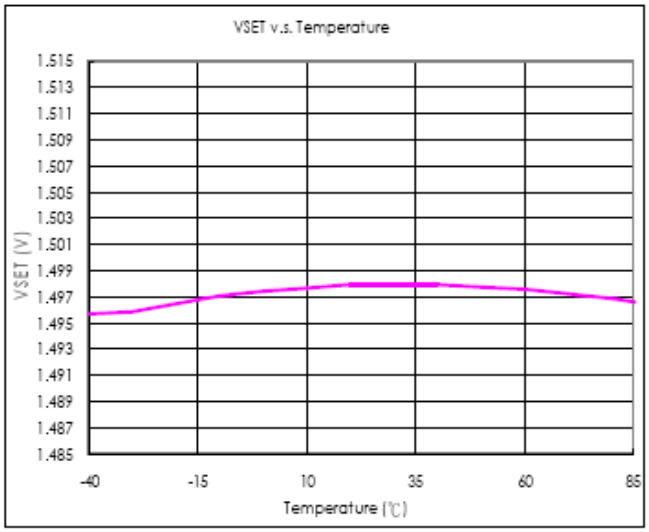
Input Voltage Transition



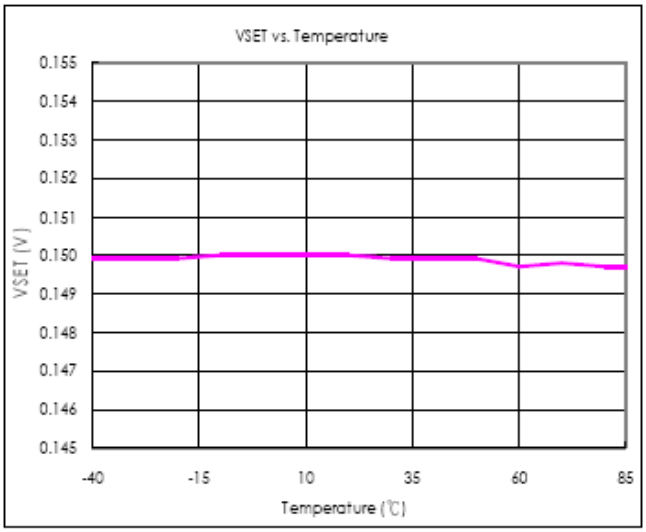
Input Voltage Transition



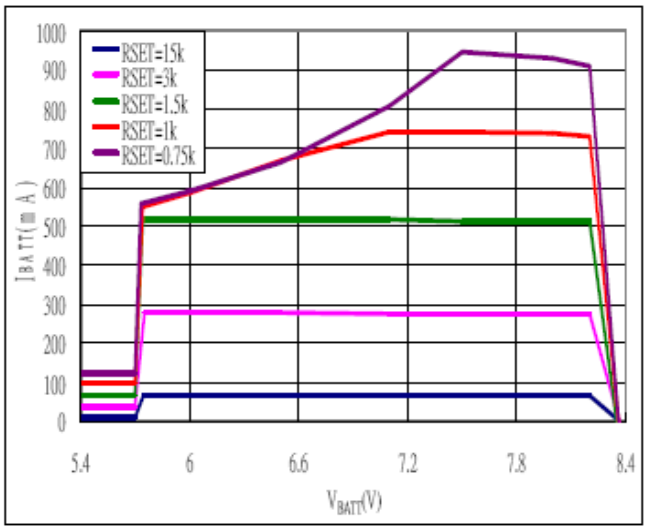
V_{SET} vs. Temperature (V_{BATT} > 5.8V)



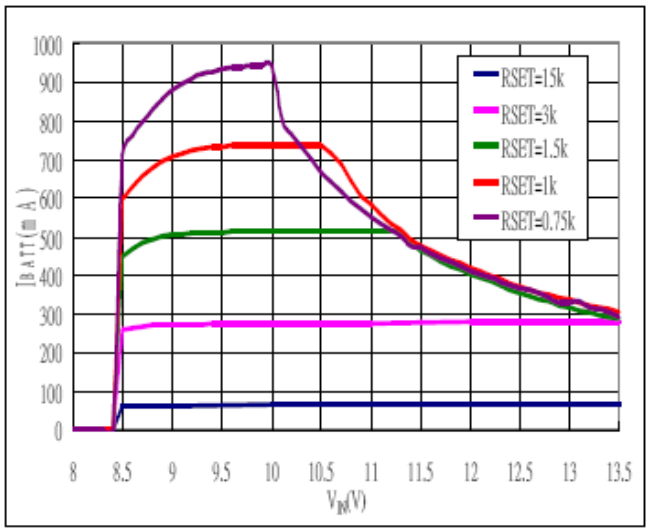
V_{SET} vs. Temperature (V_{BATT} < 5.8V)



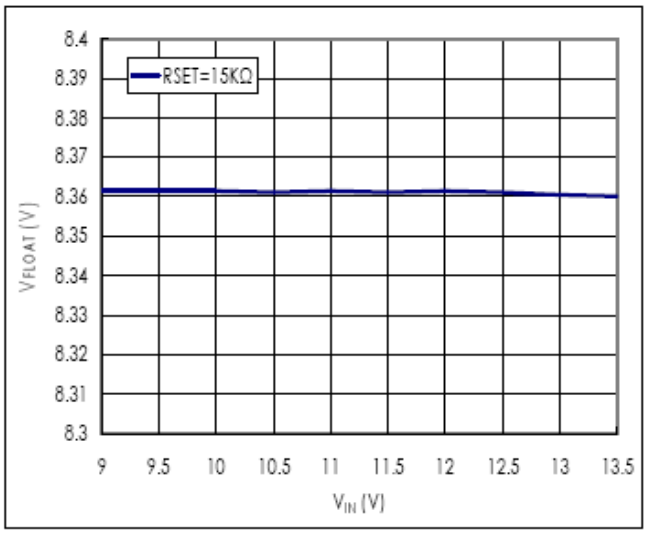
Charge Current vs. Battery Voltage (V_{IN}=10V)



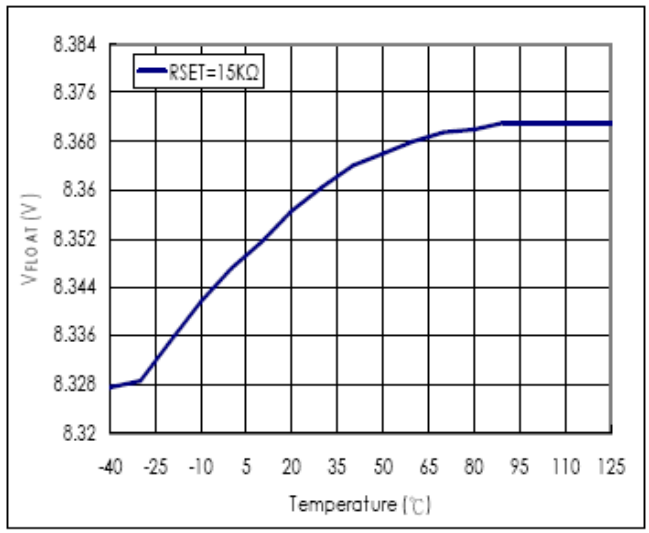
Charge Current vs. V_{IN} (V_{BATT}=8.0V)



Regulated Output Voltage vs. Supply Voltage



Regulated Output Voltage vs. Temperature



Application Information

Automatically Power Source Selection

The LP28009 is a battery charger IC which is designed for Li-ion Battery with 4.2V rated voltage.

ACIN Mode : When the ACIN input voltage is higher than the UVP voltage level (4.4V), the LP28009 will turn on ACINP-MOSFET. Sleep Mode : The LP28009 will enter Sleep Mode when ACIN input voltage are removed. This feature provides low leakage current from the battery during the absence of input supply.

ACIN Over Voltage Protection

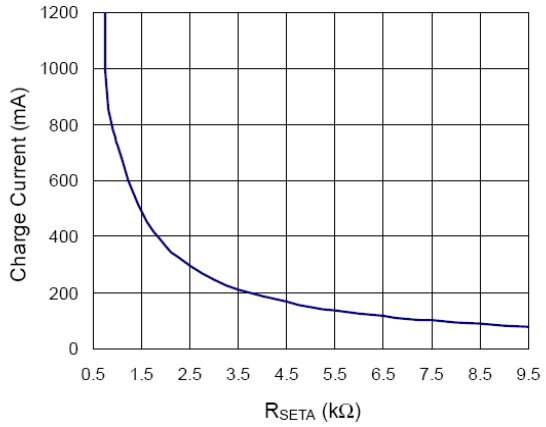
The ACIN input voltage is monitored by an internal OVP comparator. The comparator has an accurate reference of 2.5V from the band-gap reference. The OVP threshold is set by the internal resistive. The protection threshold is set to 6.5V. When the input voltage exceeds the threshold, the comparator outputs a logic signal to turn off the power P-MOSFET to prevent the high input voltage from damaging the electronics in the handheld system. When the input over voltage condition is removed (ACIN < 6V), the comparator re-enables the output by running through the soft-start.

Fast-Charge Current Setting

The LP28009 offers ISETA pin to determine the ACIN charge rate from 100mA to 1.2A. The charge current can be calculated as following equation.

$$I_{charge\_ac} = K_{SET} \frac{V_{SET}}{R_{SETA}}$$

The parameter K_{SET} = 300 ; V_{SET} = 2.5V. R_{SETA} is the resistor connected between the ISETA and GND.



Pre- Charge Current Setting

During a charge cycle if the battery voltage is below the VPRECH threshold, the LP28009 applies a pre-charge mode to the battery. This feature revives deeply discharged cell sand protects battery life. The LP28009 internal determines the pre-charge rate as 10% of the fast-charge current.

Battery Voltage Regulation

The LP28009 monitors the battery voltage through the BATT pin. Once the battery voltage level closes to the VREG threshold, the LP28009 voltage enters constant phase and the charging current begins to taper down. When battery voltage is over the VREG threshold, the LP28009 will stop charge and keep to monitor the battery voltage. However, when the battery voltage decreases 100mV below the VREG, it will be recharged to keep the battery voltage. Charge Status Outputs. The open-drain CHG_S and PGOOD outputs indicate various charger operations as shown in the following table. These status pins can be used to drive LEDs or communicate to the host processor. Note that ON indicates the open-drain transistor is turned on and LED is bright.

Charge State		$\overline{CHG\_S}$	$\overline{PGOOD}$
ACIN	Charge	ON	ON
	Charge done	OFF	ON

Temperature Regulation and Thermal Protection

In order to maximize the charge rate, the LP28009 features a junction temperature regulation loop. If the power dissipation of the IC results in a junction temperature greater than the thermal regulation threshold (125°C), theLP28009 throttles back on the charge current in order to maintain a junction temperature around the thermal regulation threshold (125°C). The LP28009 monitors the junction temperature, TJ, of the die and disconnects the battery from the input if TJ exceeds 125°C. This operation continues until junction temperature falls below thermal regulation threshold (125°C) by the hysteresis level. This feature prevents the chip from damage.

Selecting the Input and Output Capacitors

In most applications, the most important is the high-frequency decoupling capacitor on the input of the LP28009.A 1uF ceramic capacitor, placed in close proximity to input pin and GND pin is recommended. In some applications depending on the power supply characteristics and cable length, it may be necessary to add an additional 10uFceramic capacitor to the input.

The LP28009 requires a small output capacitor for loop stability. A 1uF ceramic capacitor placed between the BATT pin and GND is typically sufficient.

Layout Consideration

The LP28009 is a fully integrated low cost single-cell Li-Ion battery charger ideal for portable applications. Careful PCB layout is necessary. For best performance, place all peripheral components as close to the IC as possible. A short connection is highly recommended. The following guide lines should be strictly followed when designing a PCB layout for the LP28009.Input capacitor should be placed close to IC and connected to ground plane.

The trace of input in the PCB should be placed far away the sensitive devices or shielded by the ground.

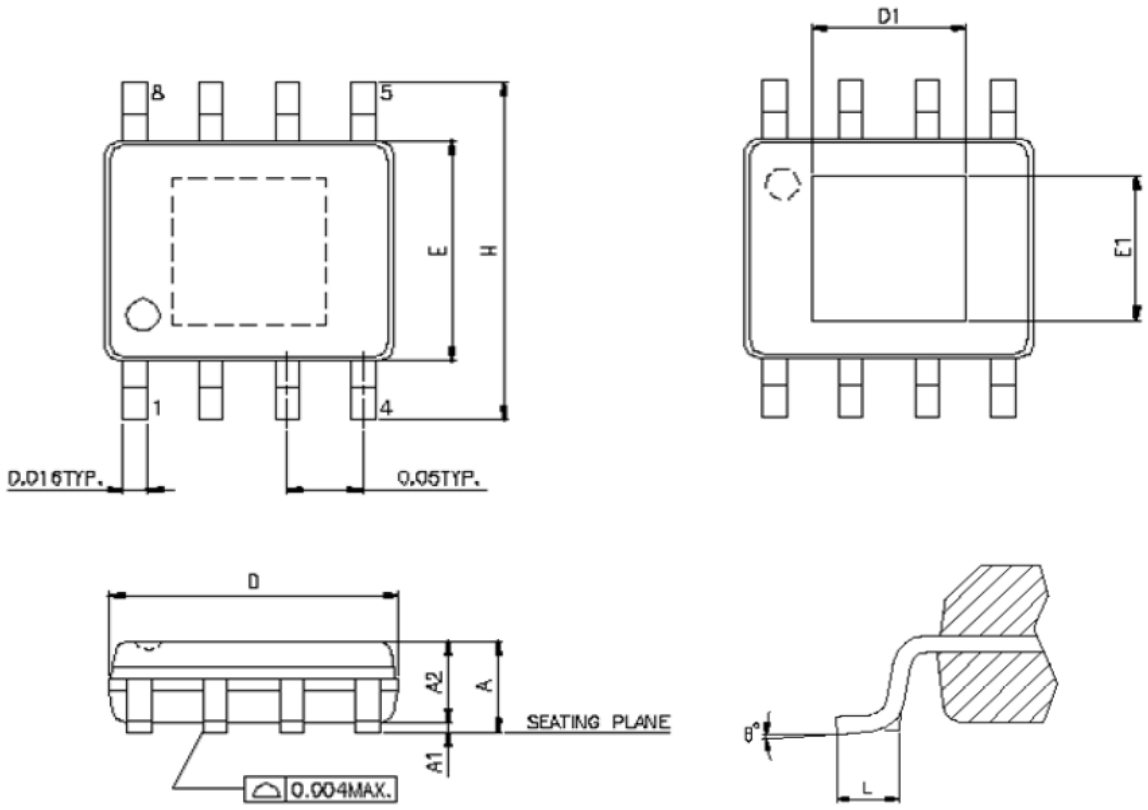
The GND should be connected to a strong ground plane for heat sinking and noise protection. The connection of RSETA should be isolated from other noisy traces.

The short wire is recommended to prevent EMI and noise coupling.

Output capacitor should be placed close to IC and connected to ground plane to reduce noise coupling. When PCB has poor layout, the 10uF is recommended to prevent noise.

Packaging Information

E-SOP-8L



SYMBOL	COMMON					
	DIMENSIONS MILLIMETER			DIMENSIONS INCH		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	1.35	-	1.75	0.053	-	0.069
A1	0.05		0.15	0.002	-	0.006
A2	-	-	1.50	-	-	0.059
b	0.4 BSC			0.016 BSC		
D	4.8	-	5.0	0.189	-	0.196
D1	2.97 REF			0.117 REF		
E	3.8	-	4.0	0.150	-	0.157
E1	2.18 REF			0.086 REF		
e	1.27 BSC			0.05 BSC		
H	5.8	-	6.2	0.228	-	0.244
L	0.4	-	1.27	0.016	-	0.050
θ	0	-	8	0	-	8

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