Single and Dual Cell Li+ Battery Charger IC –LP28006

General Description

The LP28006 is a fully integrated low cost single-cell Li-Ion battery charger IC ideal for portable applications. The LP28006 is capable of being powered up from AC adapter. The LP28006 enters sleep mode when AC adapter is removed. The LP28006 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 1A with an external resister. The internal thermal feedback circuitry regulates the die temperature to optimize the charge rate for all ambient temperatures. The LP28006 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

LP28006 - □ □ □ □ □

F: Pb-Free

Package Type
QV: TDFN-10

Output Voltage
42: 4.2V
84: 8.4V

Applications

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

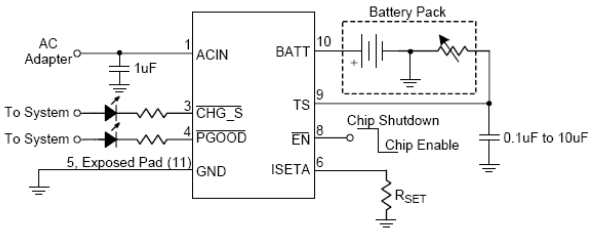
Marking Information

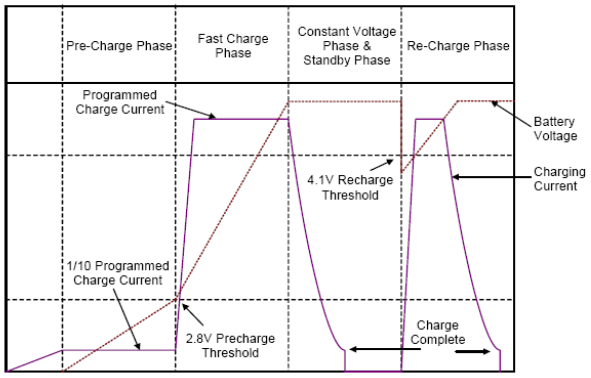
Please see website of LP28006:
www.lowpowersemi.com.

Features

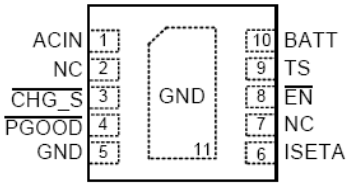
- 18V Maximum Rating for AC Adapter
- Internal Integrate P-MOSFETs
- AC Adapter Power Good Status Indicator
- Charge Status Indicator
- Under Voltage Protection
- Over Voltage Protection
- Automatic Recharge Feature
- Battery Temperature Monitoring
- Small 10-Lead WDFN Package
- Thermal Feedback Optimizing Charge Rate
- RoHS Compliant and 100% Lead (Pb)-Free

Typical Application Circuit





Functional Pin Description

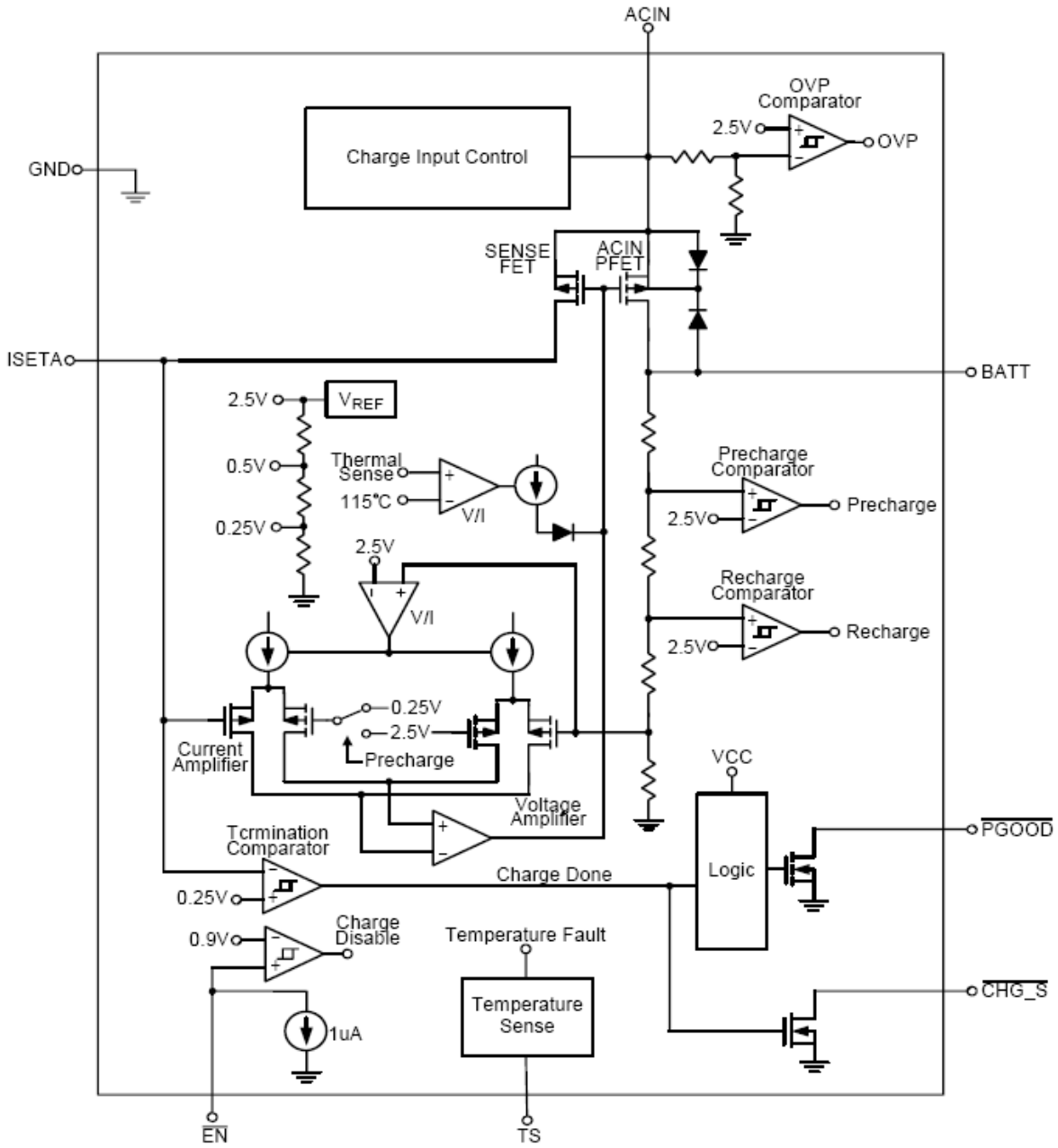
Package Type	Pin Configurations
TDFN- 10	(TOP VIEW) 

Pin Description

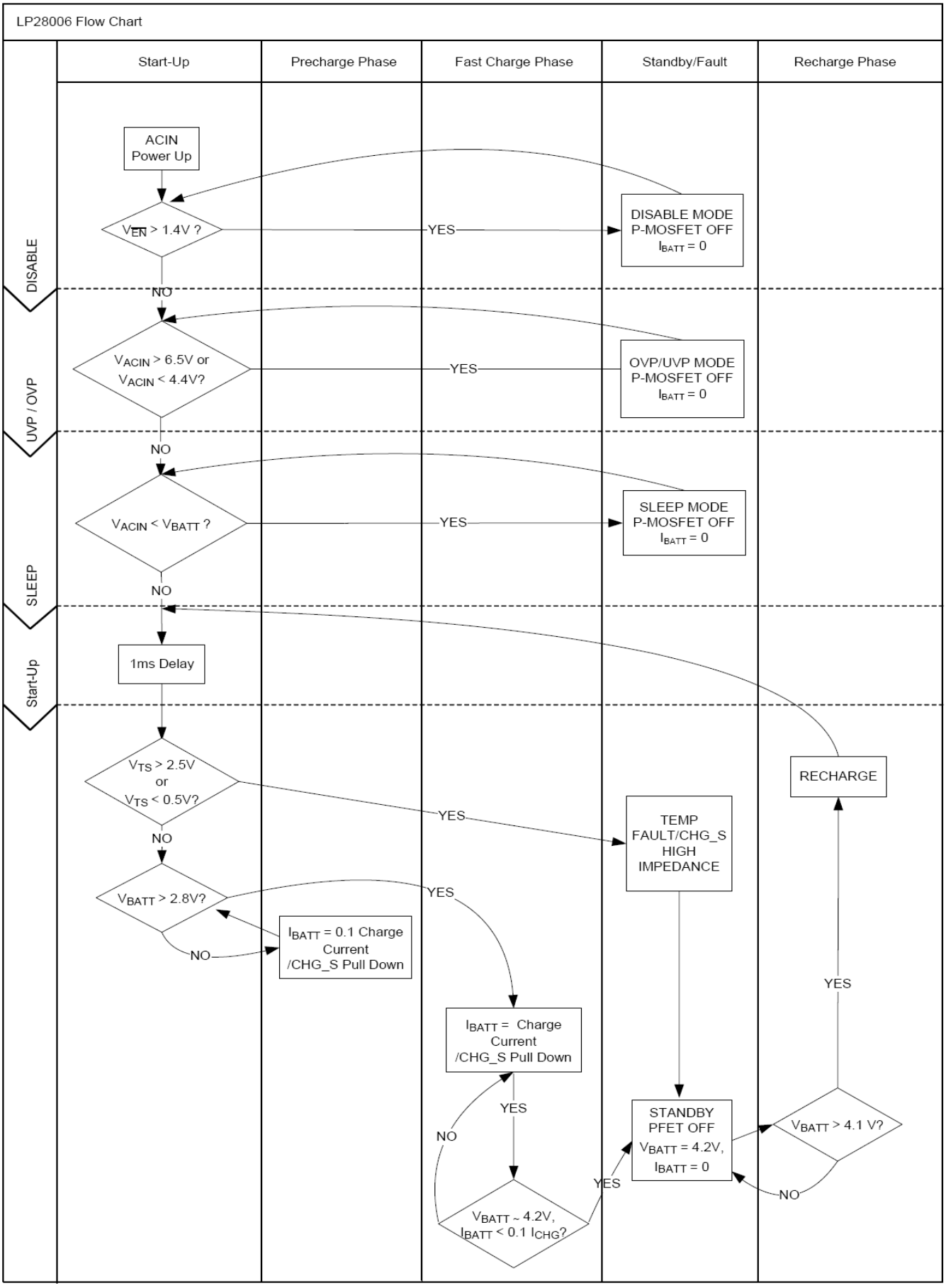
Pin No.	Pin Name	Pin Function
1	ACIN	Wall Adaptor Charge Input Supply.
2, 7	NC	No Internal Connection.
3	$\overline{\text{CHG\_S}}$	Charge Status Indicator Output (open drain).
4	$\overline{\text{PGOOD}}$	Power Good Indicator Output (open drain).
5	GND	Ground.
6	ISETA	Wall Adaptor Supply Charge Current Set Point.
8	$\overline{\text{EN}}$	Charge Enable Input (active low).
9	TS	Temperature Sense Input.
10	BATT	Battery Charge Current Output.
11 (Exposed Pad)	GND	Exposed pad should be soldered to PCB board and connected to GND.

Note: LP28006-42QVF and LP28006-84QVF of Battery (Pin10) is output pin, the pin connector to Battery.

Function Block Diagram



LP28006-42 Flow Chart



Absolute Maximum Ratings (Note 1)

- ACIN Input Voltage ---------- –0.3V to 18V
- $\overline{EN}$ Input Voltage ---------- –0.3V to 6V
- Output Current ---------- 1.2A
- Power Dissipation, P_D @ T_A = 25°C
  WDFN-10L 3x3 ---------- 0.926W
- Package Thermal Resistance (Note 2)
  WDFN-10L 3x3, θ_{JA} ---------- 108°C/W
  WDFN-10L 3x3, θ_{JC} ---------- 8.2°C/W
- Lead Temperature (Soldering, 10 sec.) ---------- 260°C
- Junction Temperature ---------- 150°C
- Storage Temperature Range ---------- –65°C to 150°C
- ESD Susceptibility (Note 3)
  HBM (Human Body Mode) ---------- 2kV
  MM (Machine Mode) ---------- 200V

Recommended Operating Conditions (Note 4)

- ACIN Input Voltage Range ---------- 4.5V to 6V
- Junction Temperature Range ---------- –40°C to 125°C
- Ambient Temperature Range ---------- –40°C to 85°C

Electrical Characteristics

(ACIN = 5V, T_A = 27°C, Unless Otherwise specification)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
Supply Input						
ACIN UVP Rising Threshold Voltage	V_{UV_HIGH}		--	4.4	4.5	V
ACIN UVP Hysteresis	V_{UV_LOW}		50	80	120	mV
ACIN Standby Current	I_{STBY}	V_{BATT} = 4.5V	--	300	500	uA
ACIN Shutdown Current	I_{SHDN}	$V_{\overline{EN}}$ = HIGH	--	50	100	uA
ACIN UVP Current	I_{UVP}	V_{ACIN} = 4V, V_{USB} = 4V, V_{BATT} = 3V	--	150	250	uA
BATT Sleep Leakage Current	I_{SLEEP}	V_{ACIN} = 4V, V_{USB} = 4V, V_{BATT} = 4.5V	--	2	5	uA
Voltage Regulation						
BATT Regulation Voltage	V_{REG}	I_{BATT} = 60mA	4.158	4.2	4.242	V
Regulation Voltage Accuracy			–1	--	+1	%
ACIN MOSFET	$R_{DS(ON)\_ACIN}$	I_{BATT} = 500mA	--	600	--	mΩ
Current Regulation						
ISETA Set Voltage (Fast Charge Phase)	V_{ISETA}	V_{BATT} = 3.5V	2.45	2.5	2.55	V
Full Charge Setting Range	I_{CHG_AC}		100	--	1200	mA
ACIN Charge Current accuracy	I_{CHG_AC}	V_{BATT} = 3.8V, R_{ISET} = 1.5kΩ	--	500	--	mA

Parameter		Symbol	Test Conditions	Min	Typ	Max	Units
Precharge							
BATT Pre-Charge Rising Threshold		V_{PRECH}		2.6	2.8	3	V
BATT Pre-Charge Threshold Hysteresis		ΔV_{PRECH}		50	100	200	mV
Pre-Charge Current		I_{PCHG}	V_{BATT} = 2V	8	10	12	%
Recharge Threshold							
BATT Re-Charge Falling Threshold Hysteresis		ΔV_{RECH_L}	$V_{REG} - V_{BATT}$	60	100	150	mV
Charge Termination Detection							
ISETA Charge Termination Set Voltage		V_{TERM}	V_{BATT} = 4.2V	225	250	275	mV
Termination Current Ratio (default)		I_{TERM}	V_{BATT} = 4.2V	--	10	--	%
Logic Input/Output							
$\overline{CHG\_S}$ Pull Down Voltage		$V_{\overline{CHG\_S}}$	TBD, $I_{\overline{CHG\_S}}$ = 5mA	--	65	--	mV
$\overline{PGOOD}$ Pull Down Voltage		$V_{\overline{PGOOD}}$	TBD, $I_{\overline{PGOOD}}$ = 5mA	--	220	--	mV
$\overline{EN}$ Threshold	Logic-High Voltage	V_{IH}		1.5	--	--	V
	Logic-Low Voltage	V_{IL}		--	--	0.4	V
$\overline{EN}$ Pin Input Current		$I_{\overline{EN}}$	$V_{\overline{EN}}$ = 2V	--	--	2	uA
Battery Temperature Sense							
TS Pin Source Current		I_{TS}	V_{TS} = 1.5V	96	102	108	uA
TS Pin Threshold	Low Voltage	V_{TS_LOW}	Falling	0.485	0.5	0.515	V
	High Voltage	V_{TS_HIGH}	Rising	2.45	2.5	2.55	V
Protection							
Thermal Regulation				--	125	--	°C
OVP SET			Internal Default	--	6.5	--	V

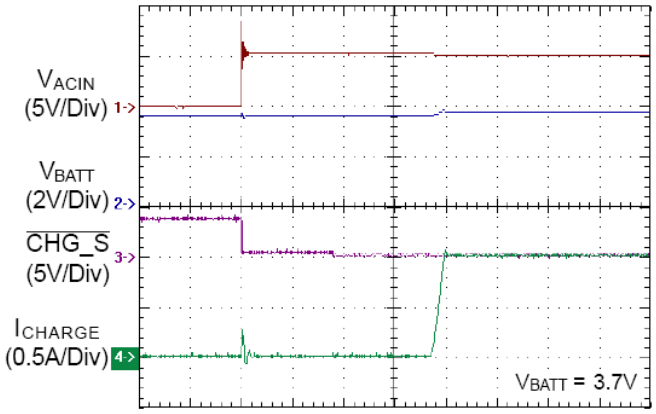
Note 1. Stresses listed as the above "Absolute Maximum Ratings" may cause permanent damage to the device. These are for stress ratings. Functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure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

Note 2. θ_{JA} is measured in the natural convection at T_A = 25°C on a high effective thermal conductivity test board (4 layers, 1S) of JEDEC 51-7 thermal measurement standard. The case point of θ_{JC} is on the expose pad for the package.

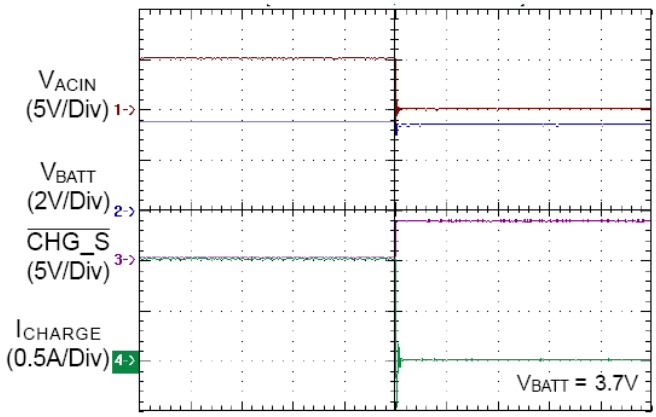
Note 3. Devices are ESD sensitive. Handling precaution is recommended.

Note 4. The device is not guaranteed to function outside its operating conditions.

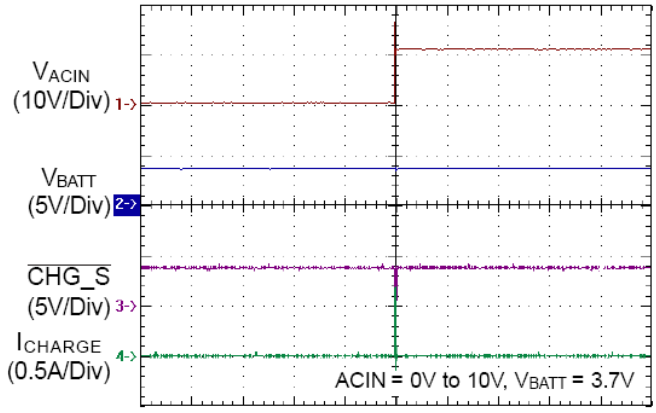
ACIN Power On



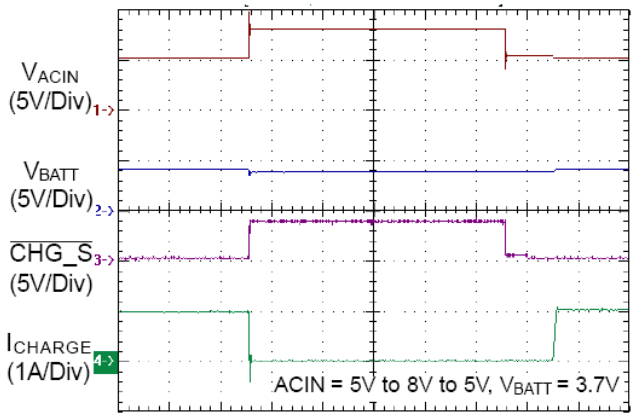
ACIN Power Off



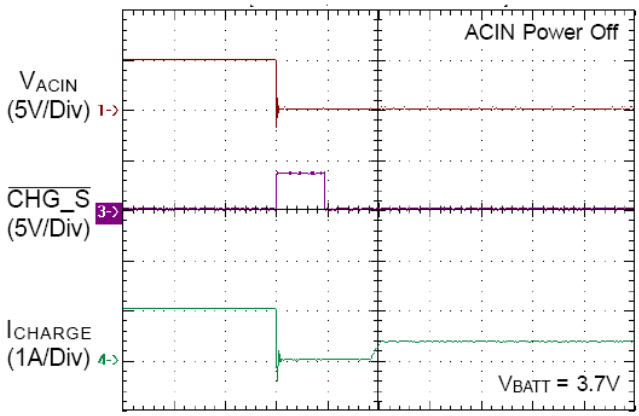
ACIN OVP



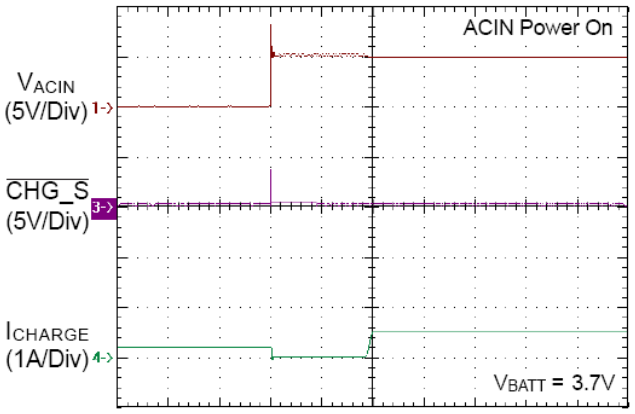
ACIN OVP



Input Voltage Transition



Input Voltage Transition



Application Information

Automatically Power Source Selection

The LP28006 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 LP28006 will turn on ACINP-MOSFET. Sleep Mode : The LP28006 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.

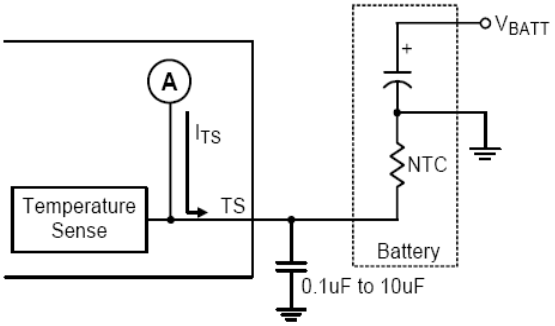
ACIN Over Voltage Protection

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.

Battery Temperature Monitoring

The LP28006 continuously monitors battery temperature by measuring the voltage between the TS and GND pins. The LP28006 has an internal current source to provide the bias for the most common 10kΩ negative-temperature coefficient thermal resistor (NTC) (see Figure 1). The LP28006 compares the voltage on the TS pin against the internal VTS_HIGH and VTS_LOW thresholds to determine if charging is allowed.

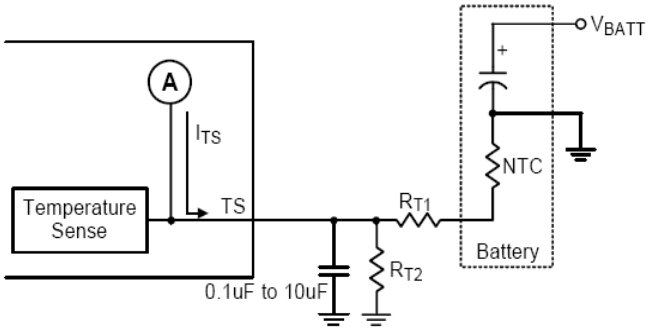
When the temperature outside the VTS_HIGH and VTS_LOW thresholds is detected, the device will immediately stop the charge. The LP28006 stops charge and keep monitoring the battery temperature when the temperature sense input voltage is back to the threshold between VTS_HIGH and VTS_LOW, the charger will be resumed. Charge is resumed when the temperature returns to the normal range. However the user may modify thresholds by the negative-temperature coefficient thermal resistor or adding two external resistors. (see Figure 2.)The capacitor should be placed close to TS(Pin 9) and connected to the ground plane. The capacitance value(0.1uF to 10uF) should be selected according to the quality of PCB layout. It is recommended to use 10uF if the layout is poor if prevent noise.



$V_{TS} = I_{TS} \times R_{NTC}$

Turn off when $V_{TS} \geq 2.5V$ or $V_{TS} \leq 0.5V$

Figure 1. Temperature Sensing Configuration



$$V_{TS} = I_{TS} \frac{R_{T2} \times (R_{T1} + R_{NTC})}{R_{T1} + R_{T2} + R_{NTC}}$$

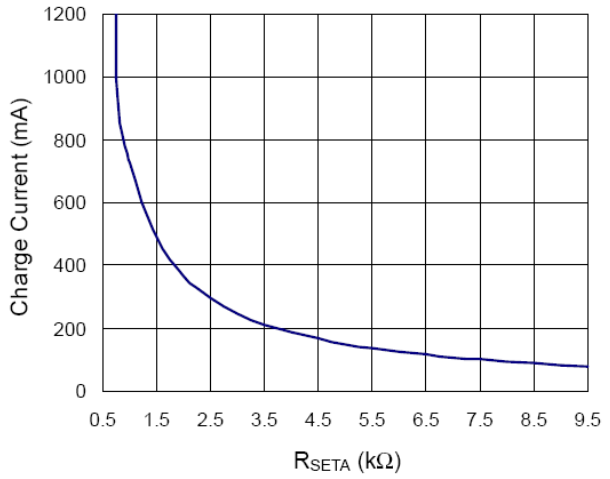
Turn off when $V_{TS} \geq 2.5V$ or $V_{TS} \leq 0.5V$

Figure 2. Temperature Sensing Circuit

Fast-Charge Current Setting The LP28006 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 LP28006 applies a pre-charge mode to the battery. This feature revives deeply discharged cell sand protects battery life. The LP28006 internal determines the pre-charge rate as 10% of the fast-charge current. Battery Voltage Regulation. The LP28006 monitors the battery voltage through the BATT pin. Once the battery voltage level closes to the VREG threshold, the LP28006 voltage enters constant phase and the charging current begins to taper down. When battery voltage is over the VREG threshold, the LP28006 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.

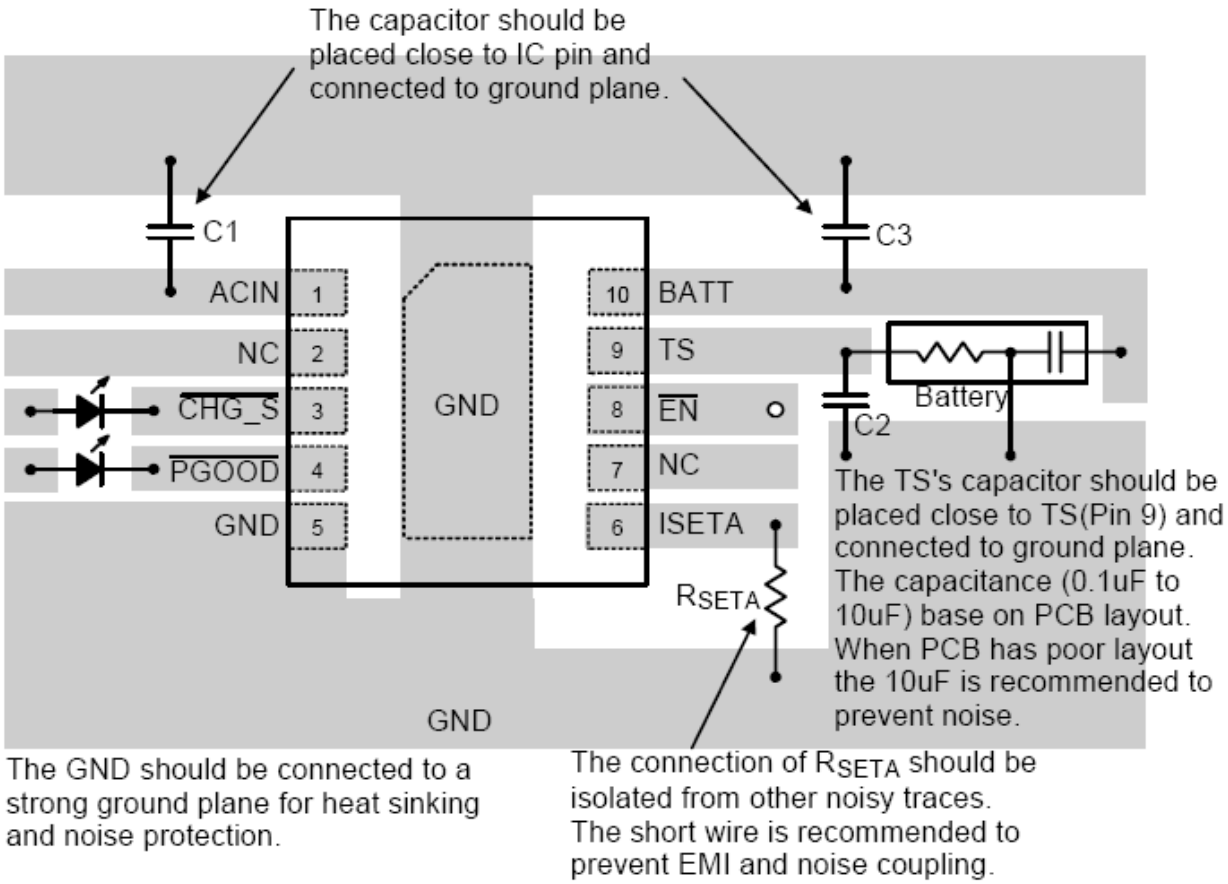
Charge State		$\overline{CHG\_S}$	$\overline{PGOOD}$
ACIN	Charge	ON	ON
	Charge done	OFF	ON

Temperature Regulation and Thermal Protection In order to maximize the charge rate, the LP28006 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), theLP28006 throttles back on the charge current in order to maintain a junction temperature around the thermal regulation threshold (125°C). The LP28006 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.

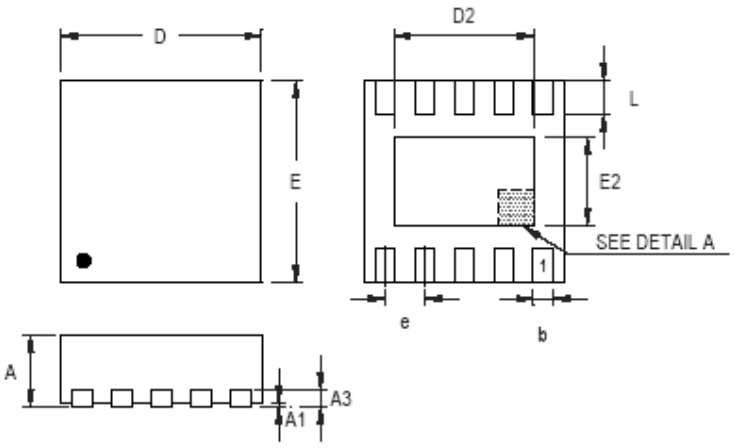
Selecting the Input and Output Capacitors
In most applications, the most important is the high-frequency decoupling capacitor on the input of the LP28006.A 1uF ceramic capacitor, placed in close proximity to input pin and GND pin is recommended. In some applications depending on the power supply characteristics and cable length, it may be necessary to add an additional 10uFceramic capacitor to the input. The LP28006 requires a small output capacitor for loop stability. A 1uF ceramic capacitor placed between the BATT pin and GND is typically sufficient.

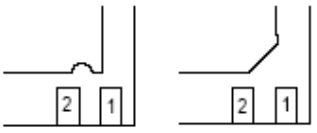
Layout Consideration
The LP28006 is a fully integrated low cost single-cell Li-Ion battery charger ideal for portable applications. Careful PCB layout is necessary. For best performance, place all peripheral components as close to the IC as possible. A short connection is highly recommended. The following guide lines should be strictly followed when designing a PCB layout for the LP28006.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. The TS's capacitor should be placed close to TS (Pin 9) and connected to ground plane. The capacitance (0.1uF to10uF) base on PCB layout. When PCB has poor layout, the 10uF is recommended to prevent noise.


The capacitor should be placed close to IC pin and connected to ground plane.
C1
C3
ACIN
1
NC
2
CHG_S
3
PGOOD
4
GND
5
GND
10
BATT
9
TS
8
EN
7
NC
6
ISETA
RSETA
C2
Battery
The TS's capacitor should be placed close to TS(Pin 9) and connected to ground plane. The capacitance (0.1uF to 10uF) base on PCB layout. When PCB has poor layout the 10uF is recommended to prevent noise.
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.

Packaging Information





DETAIL A

Pin #1 ID and Tie Bar Mark Options

Note : The configuration of the Pin #1 identifier is optional, but must be located within the zone indicated.

Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.700	0.800	0.028	0.031
A1	0.000	0.050	0.000	0.002
A3	0.175	0.250	0.007	0.010
b	0.180	0.300	0.007	0.012
D	2.950	3.050	0.116	0.120
D2	2.300	2.650	0.091	0.104
E	2.950	3.050	0.116	0.120
E2	1.500	1.750	0.059	0.069
e	0.500		0.020	
L	0.350	0.450	0.014	0.018

W-Type 10L DFN 3x3 Package