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Dual Level Lithium Ion Battery Charger

PRODUCTION DATA SHEET

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DESCRIPTION

The LX2206 can be used with a wall adapter or USB power source to charge a single cell Lithium Ion or Lithium Polymer battery. There are two logic selectable and program-mable charge current levels which can be set from anywhere between 50mA to 1A. The termination current is 1/10 the charge level set by the High Level Programming Current Pin.

Power status indicators (STAT and DCOK) can be configured to show charge in progress, battery fully charged and external power on. The STAT pin is capable of sourcing or sinking 10mA. The DCOK output is an open drain output.

The LX2206 enters a low quiescent current sleep mode when power is removed or when it is logically shutdown to minimize battery drain.

There are several protection features which include: under voltage lock out, inrush current limiting, reverse current blocking on the IN pin, a thermal loop to reduce charge current to maintain a low die temperature, an unsafe battery temperature charge inhibitor, and conditioning mode is provided for deeply discharged batteries.

IMPORTANT: For the most current data, consult *MICROSEMI*'s website: **http://www.microsemi.com**

KEY FEATURES

- Two Independent Programmable Charge Currents
- 0.5% Float Voltage Tolerance
- Charging up to 1A.
- Charging from USB Port.
- USB Current Compliance
- Full Battery Indicator
- CC/CV w Thermal Feedback
- Battery Temperature Monitor
- Precision Charge Termination
- Power Good Indication

APPLICATIONS

- MP3 Player
- PDA
- PMC
- Digital Camera
- Charge Cradle

PRODUCT HIGHLIGHT
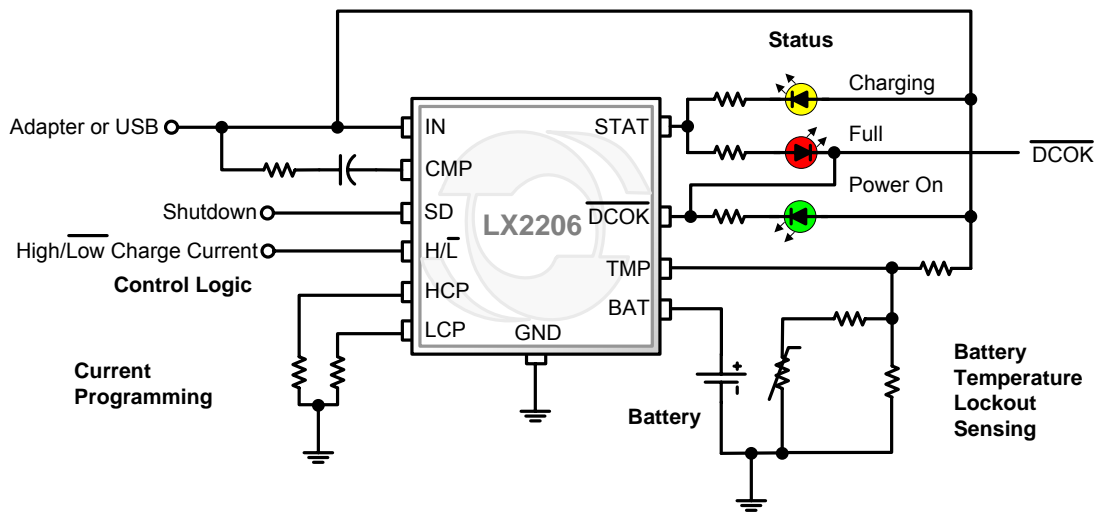
PACKAGE ORDER INFO

T$_A$ (°C)	**LD** Plastic MLPD 10-Pin
	RoHS Compliant / Pb-free
-40 to 85	**LX2206ILD**

Note: Available in Tape & Reel. Append the letters "TR" to the part number. (i.e. 2206ILD-TR)

LX2206

Microsemi® TM

Dual Level Lithium Ion Battery Charger

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ABSOLUTE MAXIMUM RATINGS

Supply Input Voltage (IN, BAT) .... -0.3V to 7V
All other pins ....-0.3V to V_{SUPPLY}
Battery Charging Current 1.1A
Operating Temperature Range ....-40 to 150°C
Maximum Operating Junction Temperature .... 150°C
Storage Temperature Range...-65°C to 150°C
Lead Temperature (Soldering 10 seconds)... 300°C
Package Peak Temp. for Solder Reflow (40 seconds maximum exposure) ... 260°C (+0 -5)

Note: Exceeding these ratings could cause damage to the device. All voltages are with respect to Ground. Currents are positive into, negative out of specified terminal.

PACKAGE PIN OUT

IN	1		10	BAT
CMP	2		9	TMP
STAT	3	Connect Bottom PAD to GND	8	HCP
$\overline{DCOK}$	4		7	LCP
SD	5		6	H/$\overline{L}$

LD PACKAGE PINOUT
(Top View)
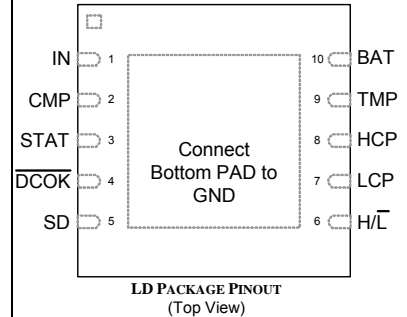
RoHS / Pb-free 100% matte Tin Lead Finish

THERMAL DATA

LD **Plastic Micro Leadframe Package 10-Pin**

THERMAL RESISTANCE-JUNCTION TO AMBIENT, θ_{JA}	49°C/W

Junction Temperature Calculation: $T_J = T_A + (P_D \times \theta_{JA})$.
The θ_{JA} numbers are guidelines for the thermal performance of the device/pc-board system. All of the above assume no ambient airflow.
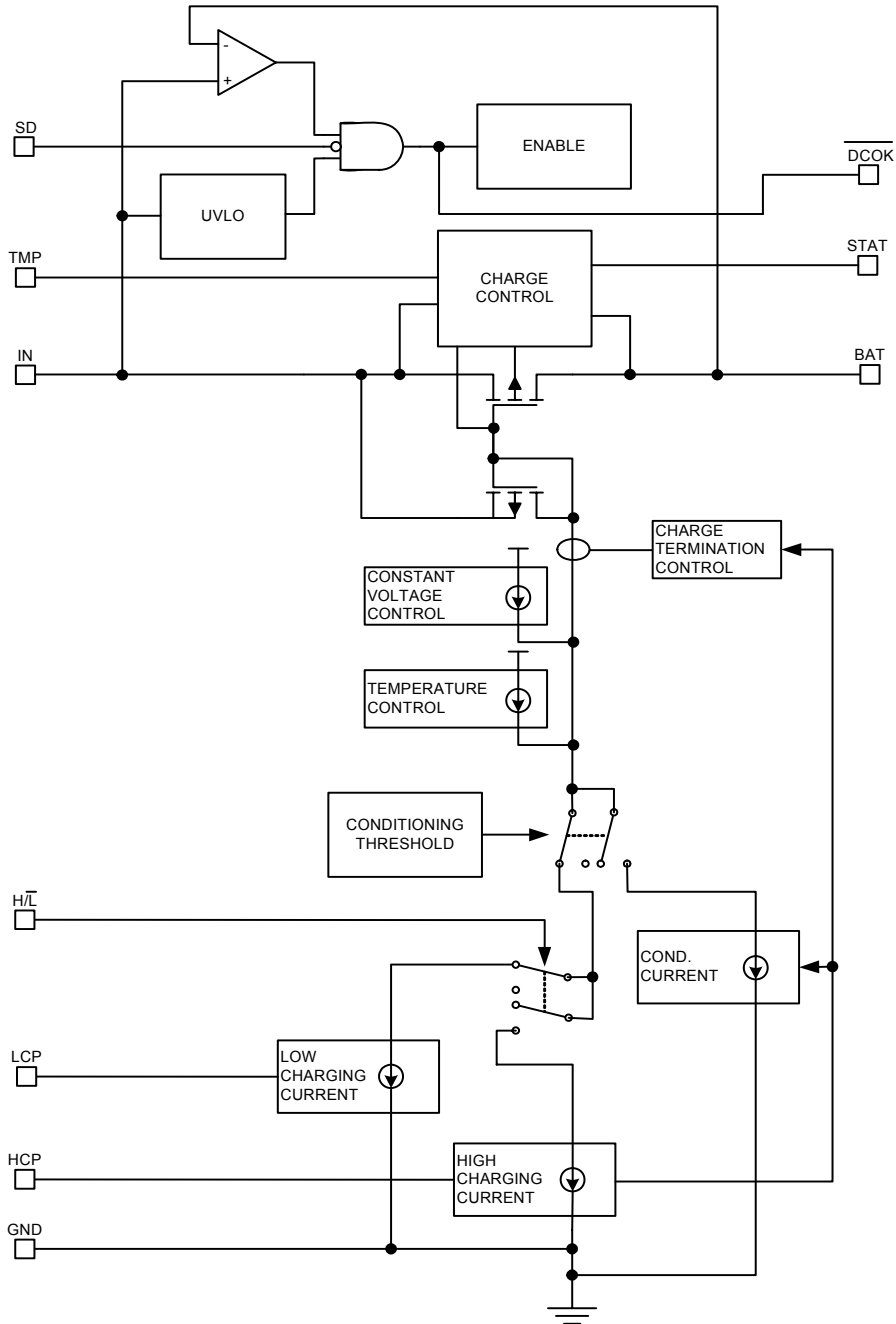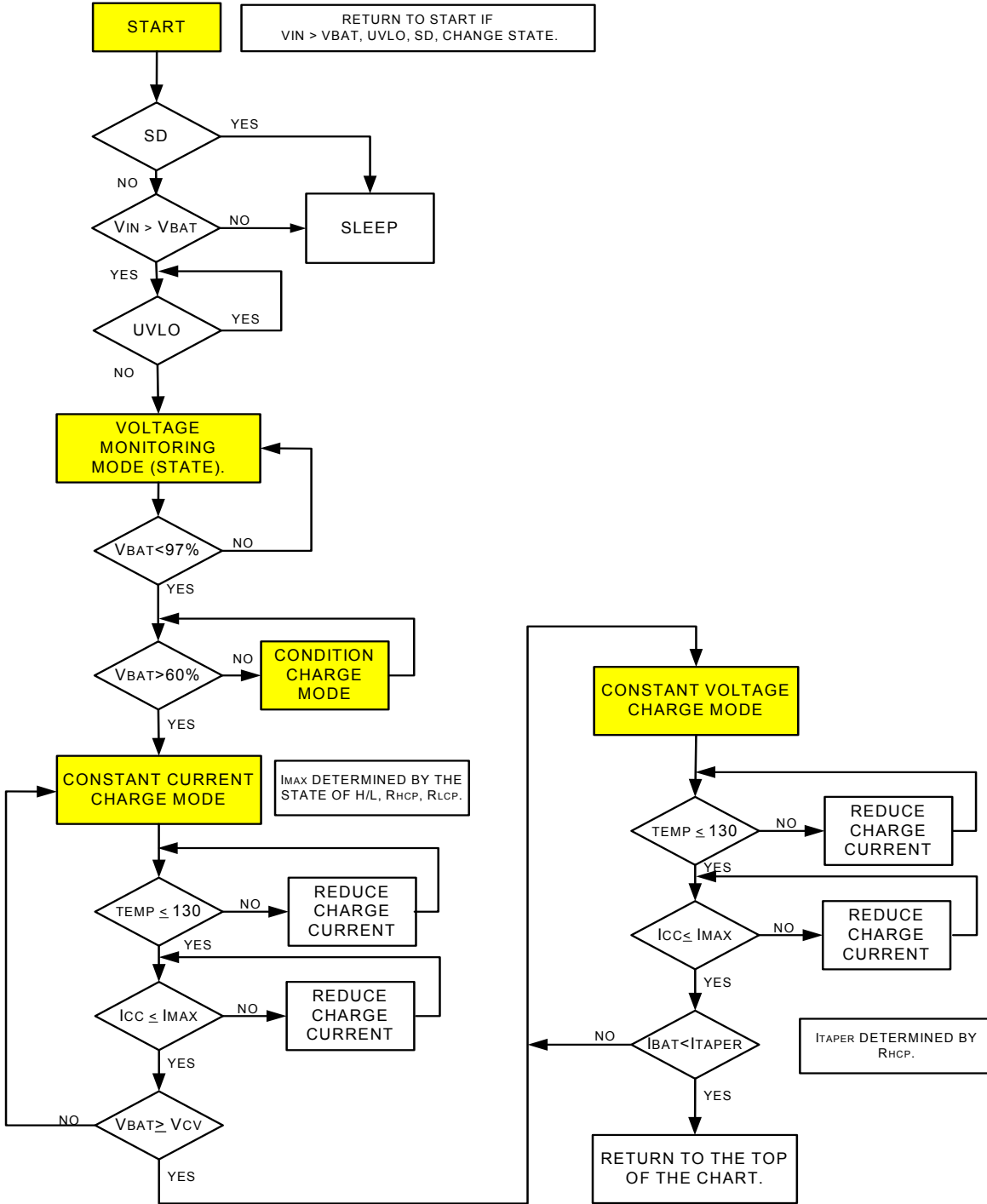
FUNCTIONAL PIN DESCRIPTION

Name	Description
BAT	Battery – Connect to a single cell Lithium Ion Battery.
CMP	Compensation – Connect the series combination of a 1k resistor and a 0.47µF capacitor from CMP to IN.
$\overline{DCOK}$	Power status logic pin and LED driver – This pin is an open drain output that can sink 20mA of current to drive an external LED. This pin is low impedance to GND when the Input voltage is high enough to charge the Battery.
GND	Ground – Connect to the system ground plane. Use sufficient via copper area to allow for thermal conduction from the IC to the GND plane.
HCP	High Current Programming (and Termination Current Programming) – Connect a resistor to ground to set the constant current high level. The termination current is set to 1/10 of the High Current Programming Level. For a value of 19.6K, the High Current is 460mA and the Termination Current is 46mA.
H/$\overline{L}$	High or Low load select logic input – A logic high selects the constant charge current level set by the HCP pin resistor and a logic low selects the constant charge current level set by the LCP pin resistor
IN	Input Power – Connect to a wall adapter or a USB power plug.
LCP	Low Current Programming – Connect a resistor to ground to set the constant current low level. For a value of 110K, the Low Current is 92mA.
SD	Shutdown – A logic high places the LX2206 in sleep mode; can also be used for USB suspend.
STAT	Charging status logic pin and LED driver – This pin can source or sink 10mA of current to drive an external LED in either output state. This pin is low (current sinking mode) when the battery is in charging mode and becomes high (current sourcing mode) when the charge cycle is finished. It becomes a high impedance when the input power is removed.
TMP	Battery Temperature Monitor – This sense pin determines the battery temperature for charging out of temperature range lockout and is connected to a resistor network as defined in the Applications section. The TMP pin is grounded if this function is not used.

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ELECTRICAL CHARACTERISTICS

Unless otherwise specified, the following specifications apply over the operating ambient temperature -40°C $\leq$ T_A $\leq$ 85°C except where otherwise noted and the following test conditions:. IN = 5.0V; SD = Low; H/L = High; BAT = 3.6V; H_{CP} =19.6k, LCP=110k; TMP = 0V.

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
INPUT CIRCUITRY						
Input Voltage	VIN		4.35		6	V
Battery Voltage	V_{BAT}				4.3	V
Under Voltage Charging Lockout	VIN_{UVLO}	Rising input V_{BAT} = 3.2V	3.5	3.8	4	V
UVLO Hysteresis				300		mV
Input Supply Current	IIN	V_{BAT} = 4.2V; battery charged		1	2	mA
		SHDN = High		35	50	µA
BATTERY CHARGER						
Constant Voltage Charging	V_{CVL}	I_{BAT} < 100mA	4.16	4.2	4.24	V
Constant Voltage Charging	V_{CVL}	I_{BAT} < 100mA @ 25C	4.18	4.2	4.22	V
HCP Bias Voltage	V_{HCP}	I_{BAT} > 100mA		1.25		V
LCP Bias Voltage	V_{LCP}			1.25		V
Battery Charge Current	I_{BAT}	HCP = 12.1k	650	710	750	mA
			420	460	483	mA
		H/L = Low	87	92	97	mA
Conditioning Current	I_{COND}	V_{BAT} < VCCT; HCP = 19.6k	13	23	33	mA
Conditioning Current	I_{COND}	V_{BAT} < VCCT; HCP = 110k	2.6	5.0	7.5	mA
Cond. Current Threshold	V_{CCT}		2.5	2.7	2.9	V
Charge Termination Current	I_{BAT}	HCP = 19.6k	34	46	59	mA
Charge Termination Current	I_{BAT}	HCP = 110k		9		mA
Charge Termination Current	I_{BAT}	HCP = 210k		5		mA
Top Off Threshold	V_{TOT}		96	97	98	% V_{BAT}/V_{CVL}
Battery Drain Current	I_{BAT}	V_{BAT} = 4.2V; battery charged		1	30	µA
		V_{BAT} > V_{IN}		5	30	µA
		SD = High (Shutdown Mode)		1	5	µA
LOGIC						
STAT Logic High Output	V_{DRV}	V_{IN} = 5.0V, I_{DRV} = -10mA	4.2	4.5	5	V
STAT Logic Low Output	V_{DRV}	V_{IN} = 5.0V, I_{DRV} = 10mA			0.5	V
Input Logic : SD, H/L	$V_{LOG(IN)}$	Logic Hi,	1.2			V
		Logic Lo			0.4	
Input Current : SD, H/L	$I_{LOG(IN)}$	Logic Hi, V_{LOG} = 2V	0	2	4	µA
		Logic Lo, V_{LOG} = 0V	-2	0	2	
Output Logic : $\overline{DCOK}$	$V_{LOG(OUT)}$	Logic Hi, I_{LOG} = 10k pullup to 3.3V	3.1			V
		Logic Lo, I_{LOG} = 20mA			0.5	
BATTERY TEMPERATURE MONITOR						
Cold Temp Fault Threshold	VCOLD	Rising Threshold		0.75 x VIN		V
		Falling Threshold		0.72 x VIN		V
Hot Temp Fault Threshold	VHOT	Falling Threshold		0.28 x VIN		V
		Rising Threshold		0.30 x VIN		V
TFB Disable Voltage	VDIS		75	100	150	mV

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ELECTRICALS

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SIMPLIFIED BLOCK DIAGRAM

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CONTROL LOGIC DIAGRAM

APPLICATIONS

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APPLICATION CIRCUITS
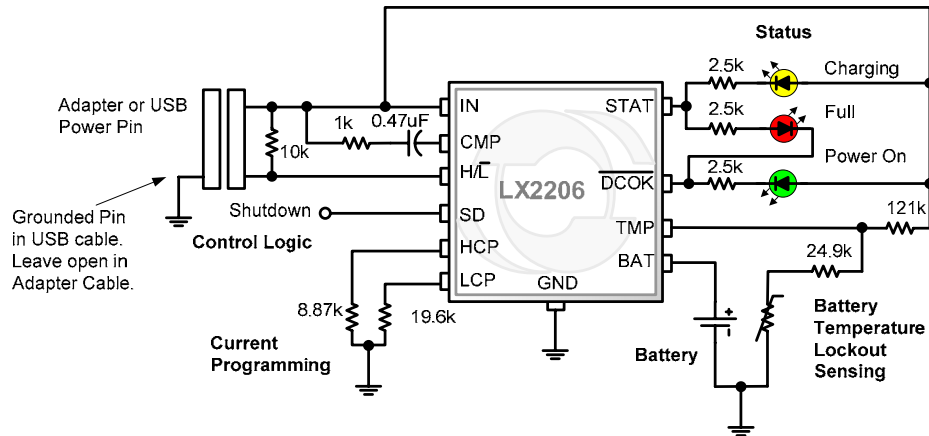
Figure 1 – Typical Application – 1A or 500mA maximum charge currents with three indicators and battery temperature lockout. A grounded spare pin in the USB power cable can be used to sense when the 500mA USB current power source is being used.
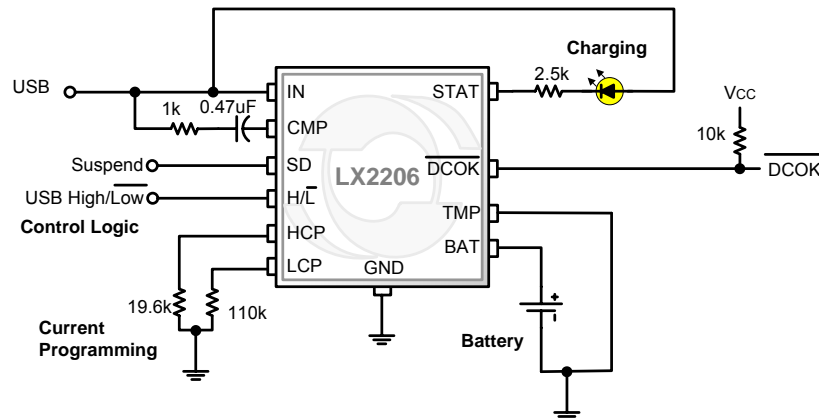
Figure 2– Typical USB Application – 500mA or 100mA maximum charge currents with charge indicator.
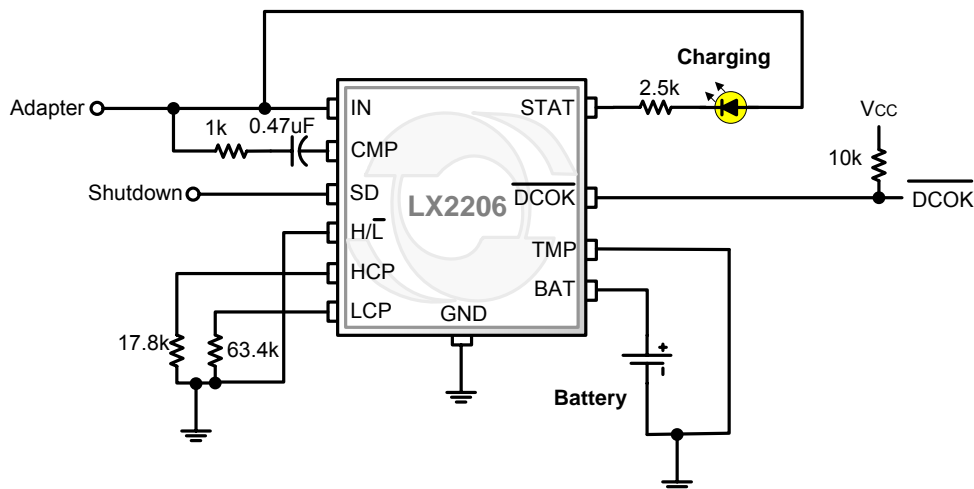
Figure 3 – Typical Low current application – 150mA charge current and 50mA termination current.

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THEORY OF OPERATION

GENERAL DESCRIPTION

The LX2206 is designed to charge a single cell Lithium Ion battery using two steps: a constant current mode followed by a constant voltage mode. The maximum charging current during the Constant Current Mode of the charging profile can be logically set (using H/L) to two preprogrammed levels set by resistors connected to HCP and LCP (High and Low current). The charger will terminate constant voltage charging once the current drops below the taper current setting which is 10% of the high charge current setting (determined by HCP resistor value).

CONDITIONING CURRENT CHARGE MODE

A conditioning current is applied to batteries that are deeply discharged and have a terminal voltage less than 60% of the constant voltage level. The conditioning current is 5% of the HCP programmable constant current level. Once the battery terminal voltage exceeds the conditioning current threshold, the full constant current level is applied (unless charging current is limited by one of the other charger control loops).

CHARGE TERMINATION MODE

To increase system battery life and avoid float charging, the LX2206 turns off the pass element once the battery has been fully charged. The charge termination state occurs at the end of constant voltage mode. The termination current is set by the value of the resistor connected to the HCP programming pin. The STAT pin changes state when charging is completed.

TOP OFF CHARGE MODE

Once the charger has completed a charge cycle, if power remains applied, the LX2206 enters a Voltage Monitoring mode. In this mode the LX2206 monitors the battery terminal voltage and applies a top off charge if the battery voltage drops below the top of threshold.

ADAPTER OR USB SELECTION

The LX2206 supports battery charging from a system that provides adapter power or USB power using the same external connector. Figure 1 shows one example of a system using a special USB adapter cable to determine whether the power source is USB or Wall Adapter. Similarly, if the system processor senses the absence of USB data, it can logically set the H/L logic level high to allow a higher charge current to be used.

USB CHARGE MODE AND CURRENT LIMIT

The LX2206 is fully compliant with, and supports, the USB specifications – the Low Power Peripheral (100mA) and High Power Peripherals (500mA). USB current levels can be set using the appropriate values for the HCP and LCP programming resistors. H/L logic input selects USB high/low charge currents. When the SD pin is pulled high, the USB input enters Suspend mode and will not present a load to the IN pin.

DCOK

The IN input is monitored and DCOK is set to a logic low to report the presence of the power source with sufficient voltage to charge the battery. The DCOK threshold is the larger of the UVLO threshold or the battery voltage.

PROTECTION FEATURES

Conditioning Current Mode – If the battery terminal voltage is less than 2.7V, the battery charger will reduce the charge current to 5%. This also protects the appliance from overheating by trying to drive the full charging current into a short circuited battery.

Under Voltage Lockout – The charge cycle will not start until the IN voltage rises above 3.8V. Hysteresis helps alleviate chattering on and off.

Thermal Control loop – If the power dissipation of the charger becomes excessive, the charge current will be reduced to prevent the die temperature from getting above 140°C. This does not cause the charge cycle to stop.

Reverse current blocking – If IN input is grounded, current will not flow from the BAT pin through the charger. No external blocking diode is required on the input.

Sleep Mode – If the SD pin is a logic high, the charger enters a sleep mode where a very low quiescent current prevents drain from the battery.

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APPLICATION NOTE

LAYOUT

In the layout of the Printed Circuit Board (PCB) it is important to provide a solid path from the IC power and ground pins to the power and ground planes of the PCB to provide a good conduction path for heat. This insures the LX2206 stays cool and can provide the maximum charge current to minimize the time required to charge the battery.

For stability purposes and to reduce voltage switching transients it is important to place capacitors close to the IN and BAT pins. A 10µF capacitor (X5R or X7R dielectric) is recommended.

CURRENT PROGRAMMING RESISTORS

The LX2206 has two programming resistors to control the battery charging current during the constant current charging mode of the battery charging cycle. When the H/L pin is high (selecting the High Current charging mode), the charge current is determined by the value of the HCP programming resistor. The maximum charge current is determined by the programming current at either the HCP or LCP programming pins (depending on the state of H/L); the range of each of these channels is identical. The programming current is the HCP or LCP pin voltage (typically 1.25V) divided by the value of the programming resistor. For example, the HCP current with a 110K resistor to GND is:

$$I_{HCP} = \frac{1.25}{R_{HCP}} = \frac{1.25}{110k} = 11.4\mu A$$
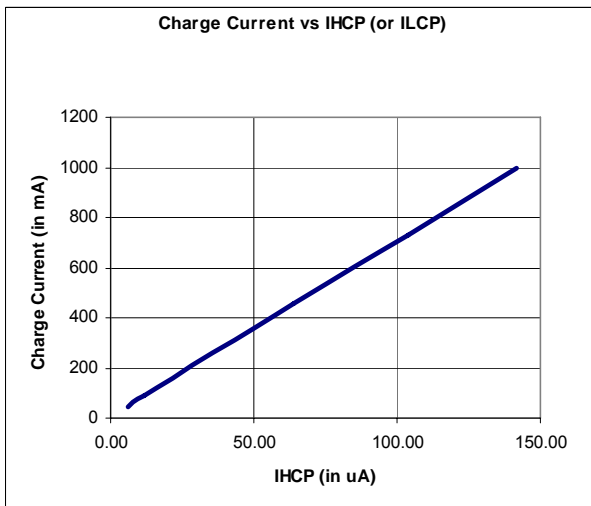
Using the table below it can be seen that for a programming current value of 11.4µA, the corresponding maximum charge current is 92mA.
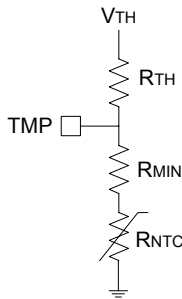
The termination current determines the point at which the charge cycle is terminated and the battery is determined to be fully charged. The termination current is determined by the value of the HCP programming current as determined by the HCP programming resistor. For a value of IHCP = 11.4µA (as was used in the previous example), the termination current from the chart below can be seen to be 9mA.

Termination Current vs IHCP
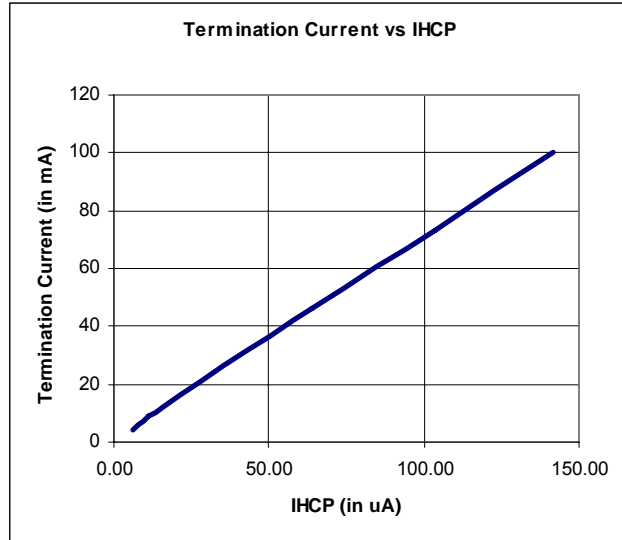
The termination current is always roughly 10% of the maximum charge current set by the HCP resistor.

Charge Current vs IHCP (or ILCP)

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APPLICATIONS

APPLICATION NOTE

BATTERY TEMPERATURE MONITOR

The LX2206 has an input to monitor the battery temperature during battery charging; this method assumes the battery pack contains a thermistor expressly for this purpose. A typical Lithium ion battery should only be charged from a range of 0°C to 60°C. For this calculation, a Vishay NTHS0402N01N1003J Thermistor was used. This thermistor is 327KΩ at 0°C, 100KΩ at 25°C and 24.9KΩ at 60°C. The thermistor must be biased with a Thevenin voltage source and series resistance to achieve the proper thresholds. A fixed value resistor is added in series with the thermistor to prevent it from becoming too low an impedance at high temperatures and causing the TMP input to default to off.

To finish the design it is necessary to create the Thevenin Voltage and resistance using a voltage divider from the input pin (IN).
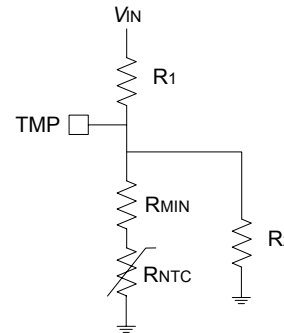
The values of R1 and R2 can be calculated as:

$$R_1 = \frac{R_{TH}}{K} = 122K$$

$$R_2 = \frac{R_1 \times R_{TH}}{R_1 - R_{TH}} = 14,800K$$

In this case, it is not necessary to use R2, because the value is so large it is insignificant. In this case, R1 = R_{TH}.

Using a value of R_{MIN} that is equal to the thermistor temperature at 60°C works well; therefore, for this example, set the value of R_{MIN} to 24.9K. This has the effect of adding 24.9K to the thermistor resistance values so it becomes 352KΩ at 0°C, 125KΩ at 25°C and 49.8KΩ at 60°C.
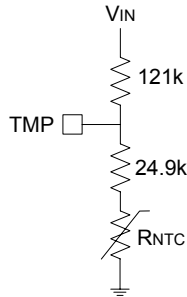
The equations for R_{TH} and V_{TH} are:

$$\frac{V_{TH}}{V_{IN}} = \frac{0.29 \times 0.74 \times (R_{T=0C} - R_{T=60C})}{(0.29 \times R_{T=0C}) - (0.74 \times R_{T=60C})} = K = 0.99$$

$$R_{TH} = \left(\frac{K}{0.74} - 1\right) \times R_{T=0C} = 121K$$

Where R at temperature is the sum of the thermistor plus R_{MIN}.

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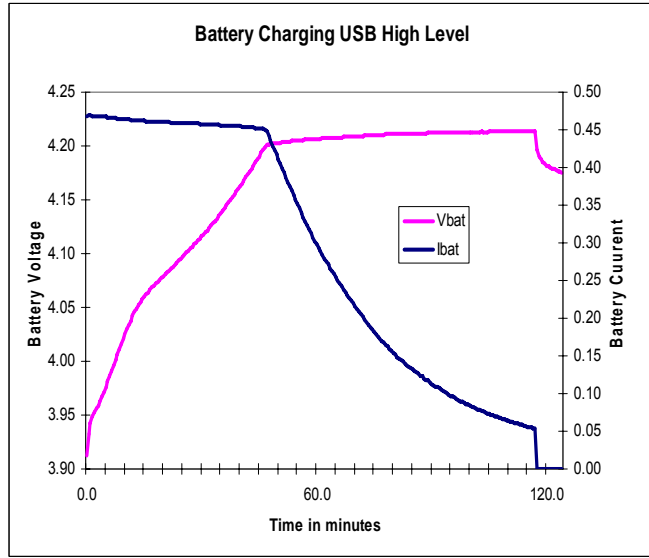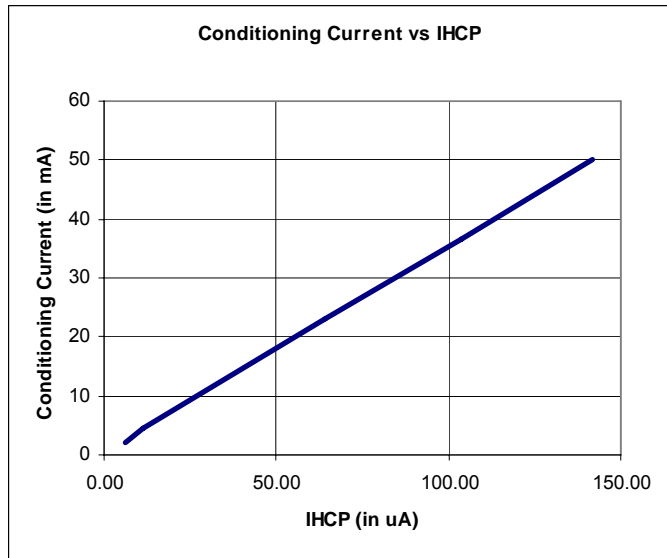
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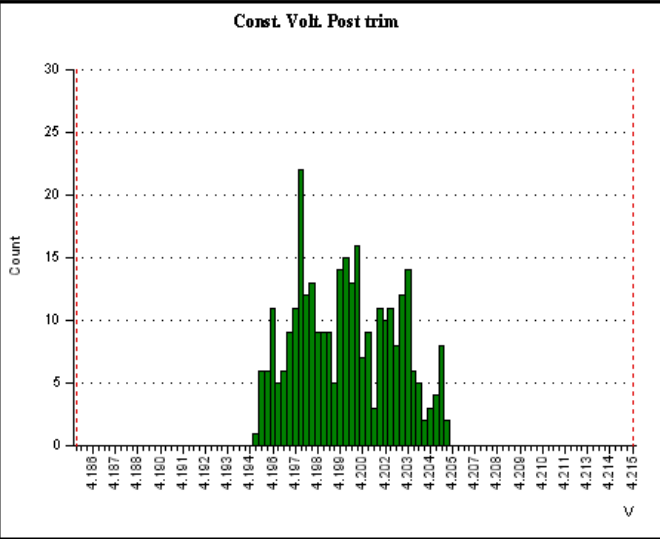## APPLICATION NOTE

The final circuit for this example is:

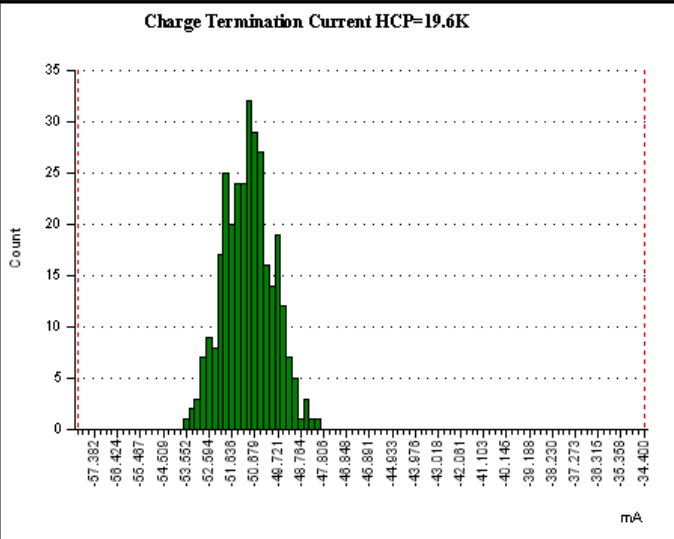The TMP voltages with this circuit are:

| TEMP (°C)	RNTC	VTMP (% VIN)
-20	971k	89%
0	327k	74%
25	100k	51%
60	24.9k	29%
80	12.6k	24%

POWER STATUS INDICATORS

The STAT pin is designed to source or sink current. LEDs can be configured to indicate charging or battery full. The battery full indicator can be connected to DCOK rather than GND to insure it is off when the input power is removed and the STAT pin and DCOK pin go to a high impedance state.

Conditions	STAT
Charge in process	Low
Charge completed	High
Input power removed	Hi Z

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CHARGING PROFILE

Battery Charging USB High Level

CONDITIONING CURRENT

Conditioning Current vs IHCP

FLOAT VOLTAGE

Const. Volt. Post trim

TERMINATION CURRENT

Charge Termination Current HCP=19.6K

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CHARTS

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CONSTANT CURRENT

Batt Chg Current High Curr Mode HCP=19.6K
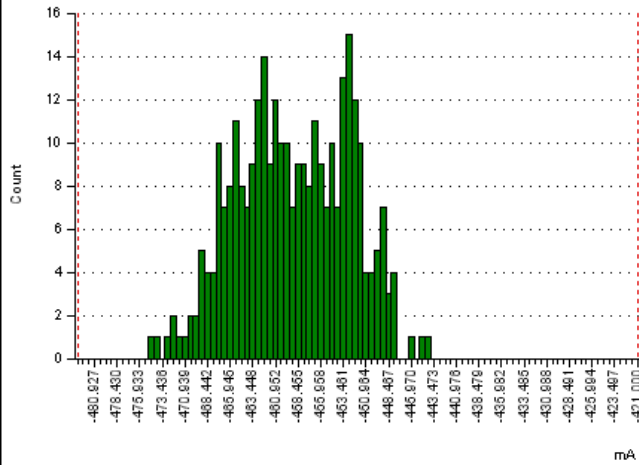
CONDITIONING CURRENT

Conditioning Current HCP=19.6K

CHARTS

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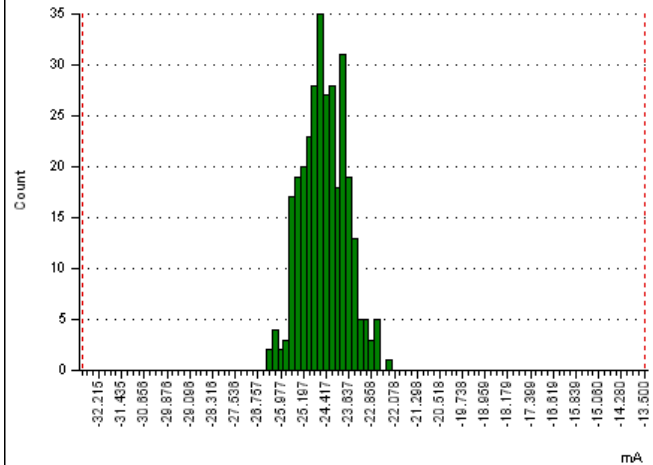
PACKAGE DIMENSIONS

LD — 10-Pin Plastic MLP Dual Exposed Pad

Top View

Bottom View
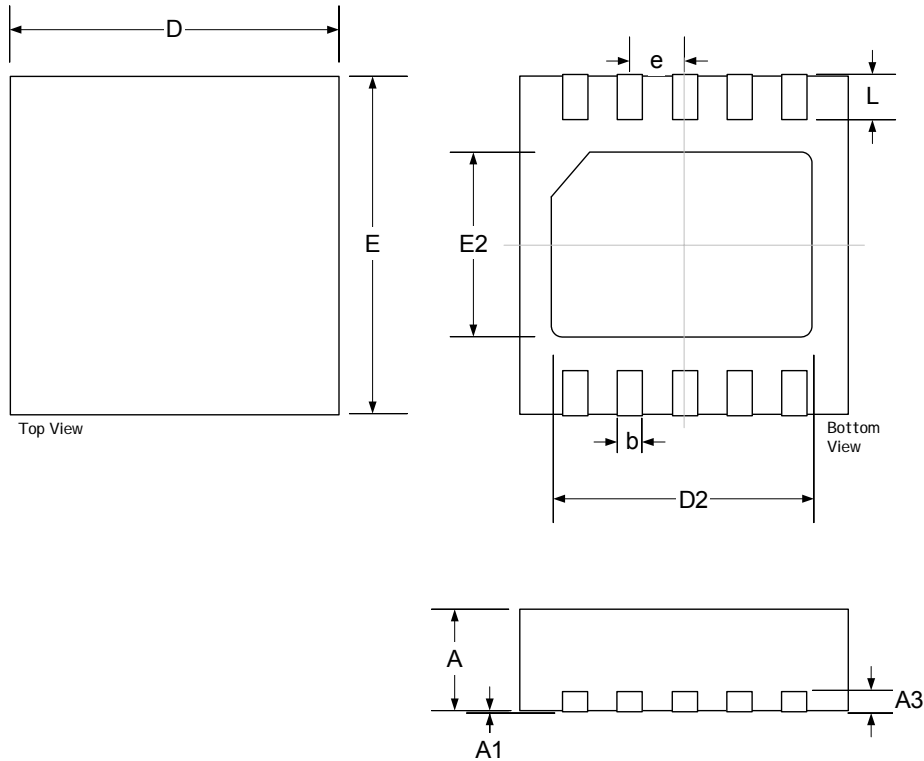
Dim	MILLIMETERS		INCHES	
	MIN	**MAX**	**MIN**	**MAX**
A	0.80	1.00	0.0315	0.0394
A1	0	0.05	0	0.0019
A3	0.20 REF		0.0079 REF	
b	0.18	0.30	0.0071	0.0118
D	3.00 BSC		0.1181 BSC	
D2	2.23	2.48	0.0878	0.0976
e	0.50 BSC		0.0197 BSC	
E	3.00 BSC		0.1181 BSC	
E2	1.49	1.74	0.0587	0.0685
L	0.30	0.50	0.0071	0.0197

Note:
1. Dimensions do not include mold flash or protrusions; these shall not exceed 0.155mm(.006") on any side. Lead dimension shall not include solder coverage.

MECHANICALS

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