NCP1835B

Integrated Li−Ion Charger

NCP1835B is an integrated linear charger specifically designed to charge 1−cell Li−Ion batteries with a constant current, constant voltage (CCCV) profile.

Its low input voltage capability, adjustable charge current, ability to maintain regulation without a battery, and its onboard thermal foldback make it versatile enough to charge from a variety of wall adapters. The NCP1835B can charge from a standard wall adapter or from the USB port. It has been optimized to charge low capacity batteries such as those found in wireless headsets and flash memory−based MP3 players.

Features

- Integrated Voltage and Current Regulation
- No External MOSFET, Sense Resistor or Blocking Diode Required
- Charge Current Thermal Foldback
- €

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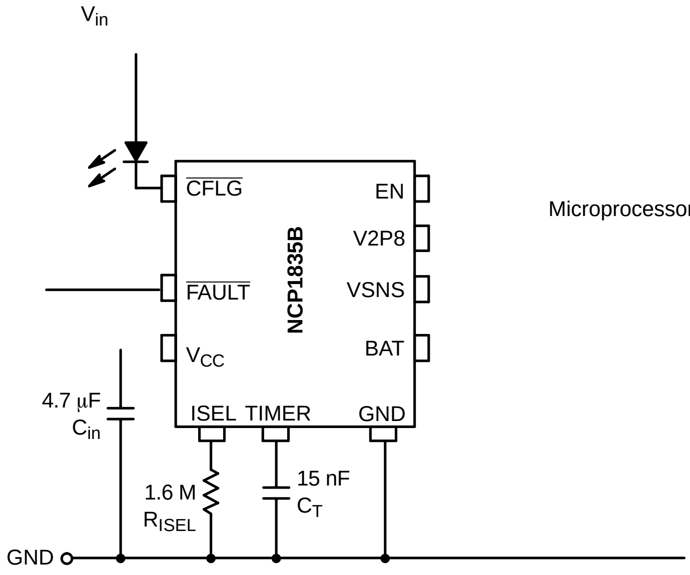
Publication Order Number:
NCP1835B/D


V_in
CFLG
FAULT
V_CC
NCP1835B
EN
V2P8
VSNS
BAT
ISEL TIMER
GND
Microprocessor
4.7 μF
C_in
1.6 M
R_ISEL
15 nF
C_T
GND

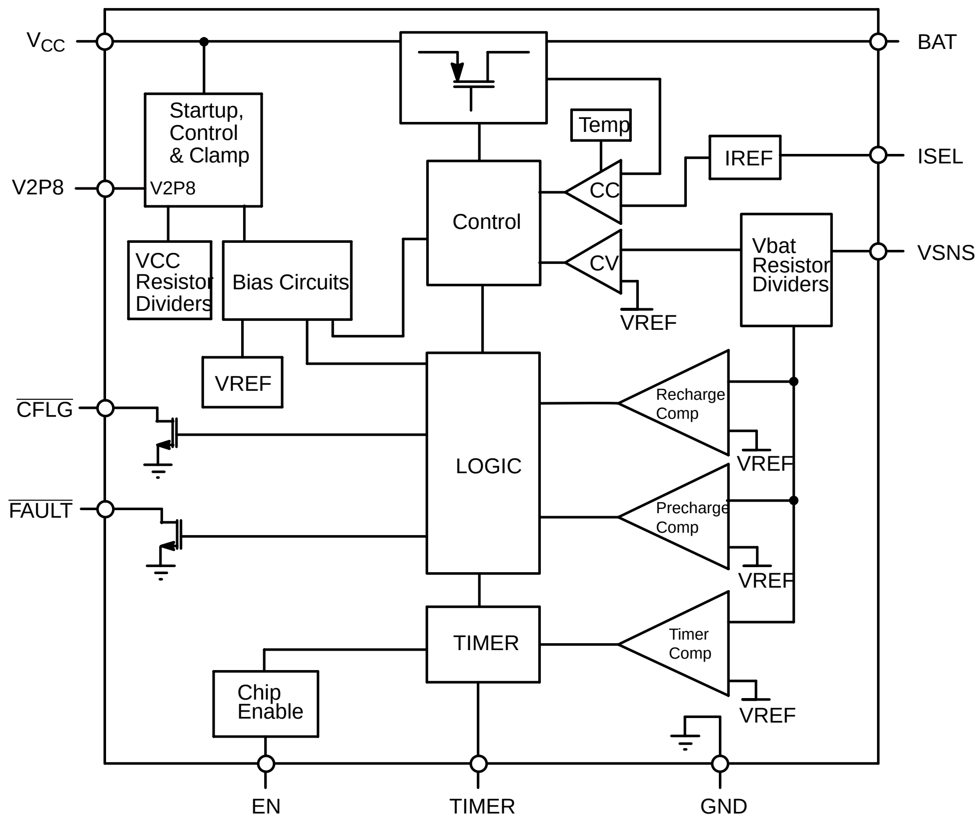


Figure 2. Detailed Block Diagram

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Supply Voltage	V_{CC}	7.0	V
Status Flag Output Pins	$V_{\overline{FAULT}}$, $V_{\overline{CFLG}}$	7.0	V
Voltage Range for Other Pins	V_{io}	5.5	V
Current Out from BAT Pin	I_O	1.2	A
Thermal Characteristics Thermal Resistance, Junction−to−Air (Note 3) Power Dissipation, T_A = 25°C (Note 3)	 $R_{\theta JA}$ P_D	 68.5 1.09	 °C/W W
Moisture Sensitivity (Note 4)	MSL	Level 1	
Operating Ambient Temperature	T_A	−20 to 70	°C
Storage Temperature	T_{stg}	−55 to 125	°C
ESD Human Body Model Machine Model	 HBM MM	 2000 200	 V V

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

1. This device series contains ESD protection and is tested per the following standards:
   Human Body Model (HBM) per JEDEC standard: JESD22−A114.
   Machine Model (MM) per JEDEC standard: JESD22−A115.
2. Latchup Current Maximum Rating: 150 mA per JEDEC standard: JESD78.
3. Measure on 1 inch sq. of 1 oz. copper area. $R_{\theta JA}$ is highly dependent on the PCB heatsink area. For example, $R_{\theta JA}$ can be 38°C/W on 1 inch sq. of 1 oz. copper area on 4 layer PCB that has 1 single signal layer with the additional 3 solid ground or power planes. The maximum package power dissipation limit must not be exceeded:

$$P_D = \frac{T_{J(max)} - T_A}{R_{\theta JA}}$$

   with $R_{\theta JA}$ = 68.5°C/W, $T_{J(max)}$ = 100°C, P_D = 1.09 W.
4. Moisture Sensitivity Level per IPC/JEDEC standard: J−STD−020A.

ELECTRICAL CHARACTERISTICS (Typical values are tested at V_{CC} = 5.0 V and room temperature, maximum and minimum values are guaranteed over 0°C to 70°C with a supply voltage in the range of 4.3 V to 6.5 V, unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
V_{CC} SUPPLY					
Operating Supply Range	V_{CC}	2.8	−	6.5	V
Rising V_{CC} Threshold	V_{RISE}	3.0	3.4	3.95	V
Falling V_{CC} Lockout Threshold	V_{FALL}	2.0	2.4	2.8	V
Quiescent V_{CC} Pin Supply Current Shutdown (EN = Low) Normal Operation (EN = High)	 I_{VCC} I_{VCC}	 − −	 30 600	 − −	 μA μA
Battery Drain Current Manual Shutdown (V_{CC} = 5.0 V, VSNS = 4.0 V, EN = Low)	I_{BMS}	−	−	3.0	μA
CHARGING PERFORMANCE					
Regulated Output Voltage in Constant Voltage (CV) Mode, I_{CHG} = 10 mA	V_{REG}	4.158	4.200	4.242	V
Dropout Voltage (V_{BAT} = 3.7 V, I_{CHG} = 0.1 A)	−	−	80	120	mV
Pre−Charge Threshold Voltage	V_{PC}	2.52	2.8	3.08	V
Pre−Charge Current (R_{ISEL} = 2.7 MΩ, V_{BAT} = 2.0 V)	I_{PC}	1.0	20	30	mA
Pre−Charge Current (R_{ISEL} = 270 kΩ, V_{BAT} = 2.0 V)	I_{PC}	30	50	65	mA
Recommended Full Charge Current	I_{FCHG}	30	−	300	mA
Full−Charge Current in Constant Current (CC) Mode (R_{ISEL} = 2.7 MΩ, V_{BAT} = 3.7 V)	I_{FCHG}	30	45	58	mA
Full−Charge Current in Constant Current (CC) Mode (R_{ISEL} = 270 kΩ, V_{BAT} = 3.7 V)	I_{FCHG}	280	310	360	mA
End−of−Charge Threshold (R_{ISEL} = 2.7 MΩ, V_{BAT} = V_{REG})	I_{EOC}	1.0	4.0	11	mA
End−of−Charge Threshold (R_{ISEL} = 270 kΩ, V_{BAT} = V_{REG})	I_{EOC}	26	34	42	mA
Recharge Voltage Threshold	V_{RECH}	3.80	4.03	4.155	V
Thermal Foldback Limit (Junction Temperature) (Note 5)	T_{LIM}	−	100	−	°C
OSCILLATOR					
Oscillation Period (C_{TIME} = 15 nF)	T_{OSC}	2.4	3.0	3.6	ms
STATUS FLAGS					
$\overline{CFLG}$ Pin Recommended Maximum Operating Voltage	$V_{\overline{CFLG}}$	−	−	6.5	V
$\overline{FAULT}$ Pin Recommended Maximum Operating Voltage	$V_{\overline{FAULT}}$	−	−	6.5	V
$\overline{CFLG}$ Pin Sink Current (V_{CFLG} = 0.8 V)	$I_{\overline{CFLG}}$	5.0	−	−	mA
$\overline{FAULT}$ Pin Sink Current (V_{FAULT} = 0.8 V)	$I_{\overline{FAULT}}$	5.0	−	−	mA

5. Guaranteed by design. Not tested in production.

TYPICAL OPERATING CHARACTERISTICS

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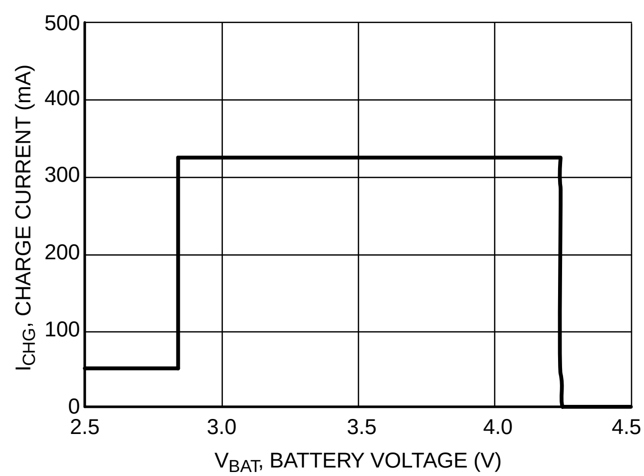
Figure 8. V2P8 Voltage vs. Input Voltage

Figure 9. Trickle Charge Current vs. Input Voltage

Figure 10. Trickle Charge Current vs.



DETAILED OPERATING DESCRIPTION

Overview

Rechargeable Li−Ion/Polymer batteries are normally charged with a constant current (CC) until the terminal voltage reaches a fixed voltage threshold, at which point a constant voltage (CV) is applied and the current drawn by the battery decays. The charging rate is determined by the specific rating of the battery. For example, if the battery is rated at 800 mA−hours, then the recommended maximum charge rate is 800 mA. For a severely discharged cell, it takes approximately 2.5−3.5 hours to recharge the battery at the maximum rate. So, when one charges at less than the maximum charge rate, the recharge time increases. Also, the battery should not be continuously charged or the battery could age faster than necessary. Because of this, Li−Ion charging systems need to stop charging within a prescribed time limit regardless of the charge rate.

The NCP1835B is a fully integrated, stand−alone 1−cell Li−Ion charger which performs the primary battery charging functions and includes a timer which will terminate charging if the battery has not completed charging within a prescribed time period. The charging rate is user programmable up to 1.0 A and the end−of−charge timer is also programmable. The NCP1835B has a thermal foldback loop which reduces the charge rate if the junction temperature is exceeded. The device also includes several outputs which can be used to drive LED indicators or interface to a microprocessor to provide status information. The adapter providing power to the charger can be a standard fixed output voltage such as a 5.0 V wall adapter or it can be a simple current limited adapter.

The NCP1835B comes in two versions with output voltage regulation thresholds of 4.2 or 4.242 V depending on the requirements of the specific battery pack being used. The user determines the charge current by selecting the resistor R_{ISEL} and determines the length of the end−of−charge timeout timer by selecting the capacitor, C_{TIME}.

Charging Operation

Figure 13 outlines the charging algorithm of the NCP1835B and Figure 14 graphically illustrates this. When the charger is powered up and the input voltage rises above the power−on, rising threshold (nominally 3.4 V), the charger initiates the charging cycle.

The NCP1835B first determines the cell voltage. If it is less than the pre−charge threshold (2.8 V), the IC recognizes the battery as severely discharged. In this state, the NCP1835B pre−conditions (trickle charges) the battery by charging it at 10% of the full charge rate (I_{PC}). This slow charge prevents the battery from being damaged from high fast charge currents when it is in a deeply discharged state. The battery voltage should be trickle charged up to 2.8 V before 1/8 of the preset end−of−charge time is expired. If it cannot reach this voltage, than the battery is possibly shorted or damaged. Therefore, the 3a61 4.32Roral

Charge Status Indicator ($\overline{\text{CFLG}}$)

$\overline{\text{CFLG}}$ is an open−drain output that indicates battery charging or End−of−Charge (EOC) status. It is pulled low when charging in constant current mode and constant

APPLICATION INFORMATION

Input and Output Capacitor Selection

A 4.7 μF or higher value ceramic capacitor is recommended for the input bypass capacitor. For the output capacitor, when there is no battery inserted and the NCP1835B is used as an LDO with 4.2 V or 4.242 V output voltage, a 4.7 μF or higher value tantalum capacitor is recommended for stability. With the battery attached, the output capacitor can be any type with the value higher than 0.1 μF.

R_{ISEL} Resistor Selection for Programming Charge Current

A single resistor, R_{ISEL}, between the ISEL pin and ground, programs the pre−charge current, full−charge current, and end−of−charge detection threshold. The nominal voltage of ISEL is 0.8 V.

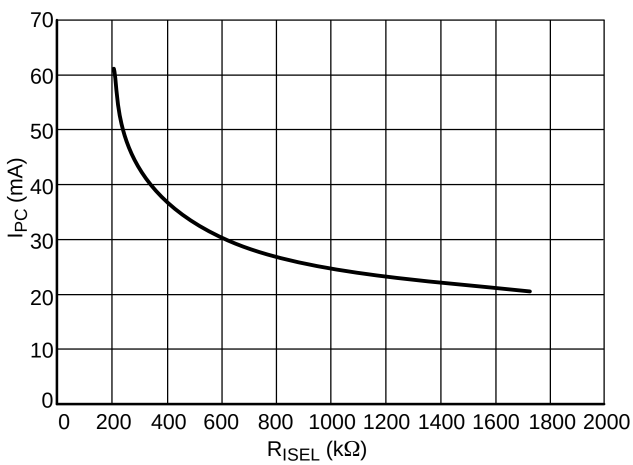


Figure 17. NCP1835 Pre−charge Current

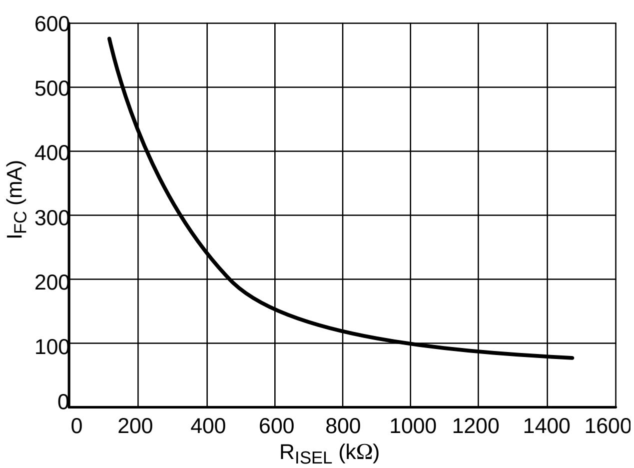


Figure 18. NCP1835 Full Charge Current

C_{TIME} Selection for Programming Charge Time

The NCP1835B offers an end−of−charge timeout timer to prevent the battery from continuously charging which can cause premature aging or safety issues. The timing capacitor between TIMER pin and ground, C_{TIME}, sets the end−of−charge time, TIMEOUT, and the pre−charge timeout. This capacitor is required for proper device operation.

The internal oscillator charges C_{TIME} to 1.2 V and then discharges it to 0.6 V with 6 μA current in one period. Therefore, the period of the oscillator is:

$$T_{OSC} = 2 \times \frac{C_{TIME} \times dV_C}{I_C} = 0.2 \times 10^6 \times C_{TIME} \text{ (sec)} \quad \text{(eq. 1)}$$

A 22−binary counter counts every oscillator period until it reaches the maximum number corresponding to end−of−charge time, TIMEOUT.

$$\text{TIMEOUT} = 2^{22} \times T_{OSC} = 14 \times \frac{C_{TIME}}{1\text{ nF}} \text{ (minute)} \quad \text{(eq. 2)}$$

The NCP1835B will terminate charging and give a timeout signal if the battery has not completed charging within the TIMEOUT period. The timeout signal then forces the $\overline{\text{FAULT}}$ pin low.

The following Table 2 shows the desired TIMEOUT vs. C_{TIME} sizes. The C_{TIME} is required for proper device operation.

Table 2. TIMEOUT vs. C_{TIME} Size

C_{TIME} (nF)	TIMEOUT (minute)
0.47	6.6
1	14
5.6	78
8.2	115
10	140
15	210
33	462
56	784

Thermal Considerations

The NCP1835B is housed in a thermally enhanced 3x3 mm DFN package. In order to deliver the maximum power dissipation under all conditions, it is very important that the user solders exposed metal pad under the package to the ground copper area and then connect this area to a ground plane through thermal vias. This can greatly reduce the thermal impedance of the device and further enhance its power dissipation capability and thus its output current capability.

Charging with Constant Voltage Adapters or Current Limited Adapters

The NCP1835B can be powered from two types of regulated adapters: a traditional constant voltage type or a current limited type. Figure 19 illustrates the operation of the linear charger powered with a standard constant voltage adapter. The power dissipation in the linear charger is:

$$P_{dis} = (V_{CC} - V_{BAT}) \times I_{CHG} \qquad \text{(eq. 3)}$$

The maximum power dissipation P1 happens at the beginning of a full current charge, since this is the point that the power supply and the battery voltage have the largest difference. As the battery voltage rises during charging, the power dissipation drops. After entering the constant voltage mode, the power dissipation drops further due to the decreasing charge current. The maximum power that