Features:

- Complete Linear Charge Management Controller:
  - Integrated Pass Transistor
  - Integrated Current Sense
  - Integrated Reverse Discharge Protection
- Constant Current/Constant Voltage Operation
- High Accuracy Preset Voltage Regulation:
  - 4.20V ± 0.75%
- Programmable Charge Current:
  - MCP73830L: 20 mA – 200 mA
  - MCP73830: 100 mA – 1000 mA
- Soft-Start to avoid In-Rush Current
- Preconditioning:
  - 10% and no preconditioning
- Fixed Elapsed Timer: 4 Hours
- Fixed Preconditioning Timer: 1 Hour
- Automatic Recharge: No Auto-Recharge is also available with Selected Options
- Automatic End-of-Charge Control Termination:
  - 7.5% and 10%
- Automatic Power-Down when Input Power Removed
- Undervoltage Lockout (UVLO)
- Chip/Charge Enable Pin (CE)
- Packaging:
  - TDFN-6 (2x2 mm)
- Temperature Range: -40°C to +85°C

Applications:

- Bluetooth Headsets
- Portable Media Players
- Rechargeable 3D Glasses
- Toy and Gaming Controllers

Description:

The MCP73830/L are highly integrated, Li-ion battery charge management controllers for use in space-limited applications. The MCP73830/L devices provide specific charge algorithms for single-cell Li-ion/Li-Polymer batteries to achieve optimal capacity and safety in the shortest charging time possible. Along with its small physical size, the low number of external components makes the MCP73830/L ideally suitable for portable applications.

The MCP73830L employs a constant current/constant voltage charge algorithm. The minimum 20 mA regulated constant, fast-charge current enables the design in small Li-ion batteries and low-supply current applications. The fast-charge, constant current value is set with one external resistor from 20 mA to 200 mA. The MCP73830/L allows up to 1000 mA charge current for applications that require faster constant current.

The MCP73830/L provides a thermal foldback function that limits the charge current based on die temperature during high-power or high-ambient conditions. This thermal regulation optimizes the charge cycle time while maintaining device reliability.

The MCP73830/L is fully specified over the ambient temperature range of -40°C to +85°C. The MCP73830/L is available in a 6 lead, TDFN package.

Package Types (Top View)

* Includes Exposed Thermal Pad (EP); see Table 3-1.

### TABLE 1: AVAILABLE FACTORY PRESET OPTIONS

<table>
<thead>
<tr>
<th>Charge Voltage</th>
<th>Preconditioning Charge Current</th>
<th>End-of-Charge Control</th>
<th>Auto-Recharge</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.2V</td>
<td>10%/Disabled</td>
<td>7.5%/ 10%</td>
<td>Yes/No</td>
</tr>
</tbody>
</table>
Typical Application

Functional Block Diagram
1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings†

VDD...................................................................................7.0V
All Inputs and Outputs w.r.t. VSS...........-0.3 to (VDD+0.3)V
Maximum Junction Temperature, Tj........Internally Limited
Storage temperature .................................................................-65°C to +150°C
ESD protection on all pins
Human Body Model (1.5 kW in Series with 100 pF)........2 kV
Machine Model (200 pF, No Series Resistance)............300V

† Notice: Stresses above those listed under “Maximum Ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device at those or any other conditions above those indicated in the operational listings of this specification is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

DC CHARACTERISTICS

Electrical Specifications: Unless otherwise indicated, all limits apply for VDD= [VREG(Typical) + 0.3V] to 6V, TA = -40°C to +85°C. Typical values are at +25°C, VDD = [VREG (Typical) + 1.0V]

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Sym.</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Units</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Input</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input Voltage Range</td>
<td>VDD</td>
<td>3.75</td>
<td>—</td>
<td>6</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Supply Current</td>
<td>I&lt;sub&gt;SS&lt;/sub&gt;</td>
<td>—</td>
<td>0.6</td>
<td>2</td>
<td>µA</td>
<td>Shutdown; VDD ≤ VSTOP - 300 mV</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>—</td>
<td>500</td>
<td>900</td>
<td>µA</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>—</td>
<td>25</td>
<td>50</td>
<td>µA</td>
</tr>
<tr>
<td>Battery Discharge Current</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output Reverse Leakage Current</td>
<td>I&lt;sub&gt;DISCHARGE&lt;/sub&gt;</td>
<td>—</td>
<td>10</td>
<td>15</td>
<td>µA</td>
<td>Charge Complete; VDD is Present</td>
</tr>
<tr>
<td></td>
<td></td>
<td>—</td>
<td>0.5</td>
<td>—</td>
<td>µA</td>
<td>Shutdown (VDD ≤ V&lt;sub&gt;BAT&lt;/sub&gt;, or VDD &lt; VSTOP)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>—</td>
<td>0.5</td>
<td>—</td>
<td>µA</td>
<td>Standby; CE = VDD</td>
</tr>
<tr>
<td>Undervoltage Lockout</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UVLO Start Threshold</td>
<td>V&lt;sub&gt;START&lt;/sub&gt;</td>
<td>3.45</td>
<td>3.6</td>
<td>3.75</td>
<td>V</td>
<td>VDD Low-to-High</td>
</tr>
<tr>
<td>UVLO Stop Threshold</td>
<td>V&lt;sub&gt;STOP&lt;/sub&gt;</td>
<td>3.15</td>
<td>3.3</td>
<td>3.45</td>
<td>V</td>
<td>VDD High-to-Low</td>
</tr>
<tr>
<td>UVLO Hysteresis</td>
<td>V&lt;sub&gt;HYST&lt;/sub&gt;</td>
<td>—</td>
<td>300</td>
<td>—</td>
<td>mV</td>
<td></td>
</tr>
<tr>
<td>Voltage Regulation (Constant Voltage Mode)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regulated Output Voltage Options</td>
<td>V&lt;sub&gt;REG&lt;/sub&gt;</td>
<td>—</td>
<td>4.20</td>
<td>—</td>
<td>V</td>
<td>VDD = [VREG(Typical)+1V]</td>
</tr>
<tr>
<td>Output Voltage Tolerance</td>
<td>V&lt;sub&gt;RTOL&lt;/sub&gt;</td>
<td>-0.75</td>
<td>—</td>
<td>0.75</td>
<td>%</td>
<td>T&lt;sub&gt;A&lt;/sub&gt; = -5°C to +55°C</td>
</tr>
<tr>
<td>Line Regulation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>—</td>
<td>0.2</td>
<td>0.3</td>
<td>%/V</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>—</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>—</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Load Regulation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>—</td>
<td>0.2</td>
<td>0.3</td>
<td>%</td>
<td>I&lt;sub&gt;OUT&lt;/sub&gt; = 30 mA - 150 mA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>—</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supply Ripple Attenuation</td>
<td>PSRR</td>
<td>—</td>
<td>52</td>
<td>—</td>
<td>dB</td>
<td>I&lt;sub&gt;OUT&lt;/sub&gt; = 30 mA, 10 Hz to 1 kHz</td>
</tr>
<tr>
<td></td>
<td></td>
<td>—</td>
<td>47</td>
<td>—</td>
<td>dB</td>
<td>I&lt;sub&gt;OUT&lt;/sub&gt; = 30 mA, 10 Hz to 10 kHz</td>
</tr>
</tbody>
</table>

Note 1: Not production tested. Ensured by design.
**DC CHARACTERISTICS (CONTINUED)**

**Electrical Specifications:** Unless otherwise indicated, all limits apply for \(V_{DD} = [V_{REG} \text{(Typical)} + 0.3V]\) to 6V, \(T_A = -40°C \text{ to } +85°C\). Typical values are at \(+25°C\), \(V_{DD} = [V_{REG} \text{(Typical)} + 1.0V]\)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Sym.</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Units</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fast Charge Current Regulation (MCP73830L)</td>
<td>(I_{REG})</td>
<td>20</td>
<td>—</td>
<td>200</td>
<td>mA</td>
<td>(PROG = 10 \text{ k}\Omega)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>—</td>
<td>20</td>
<td>—</td>
<td>mA</td>
<td>(PROG = 1 \text{ k}\Omega)</td>
</tr>
<tr>
<td>Fast Charge Current Regulation (MCP73830)</td>
<td>(I_{REG})</td>
<td>100</td>
<td>—</td>
<td>1000</td>
<td>mA</td>
<td>(PROG = 10 \text{ k}\Omega)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>—</td>
<td>100</td>
<td>—</td>
<td>mA</td>
<td>(PROG = 1 \text{ k}\Omega)</td>
</tr>
<tr>
<td>Charge Current Tolerance</td>
<td>(I_{RTOL})</td>
<td>—</td>
<td>10</td>
<td>—</td>
<td>%</td>
<td>(V_{DD} = 4.5V, T_A = -5°C \text{ to } +55°C)</td>
</tr>
<tr>
<td>Preconditioning Current Regulation (Trickle Charge Constant Current Mode)</td>
<td>(I_{PREG/REG})</td>
<td>—</td>
<td>10</td>
<td>—</td>
<td>%</td>
<td>(PROG = 1 \text{ k}\Omega \text{ to } 10 \text{ k}\Omega)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>—</td>
<td>100</td>
<td>—</td>
<td>%</td>
<td>No Preconditioning</td>
</tr>
<tr>
<td></td>
<td>Precondition Voltage Threshold Ratio</td>
<td>(V_{PTH/VREG})</td>
<td>70</td>
<td>72</td>
<td>75</td>
<td>%</td>
</tr>
<tr>
<td></td>
<td>Precondition Hysteresis</td>
<td>(V_{PHYS})</td>
<td>—</td>
<td>100</td>
<td>—</td>
<td>mV</td>
</tr>
<tr>
<td>Charge Termination</td>
<td>(I_{TERM/REG})</td>
<td>5.6</td>
<td>7.5</td>
<td>9.4</td>
<td>%</td>
<td>(PROG = 1 \text{ k}\Omega \text{ to } 10 \text{ k}\Omega)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8</td>
<td>10</td>
<td>12</td>
<td>%</td>
<td>(V_{DD} = 4.5V, T_A = -5°C \text{ to } +55°C)</td>
</tr>
<tr>
<td>Automatic Recharge</td>
<td>Recharge Voltage Threshold Ratio</td>
<td>(V_{RTH/VREG})</td>
<td>94.5</td>
<td>96.5</td>
<td>98.5</td>
<td>%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>—</td>
<td>0</td>
<td>—</td>
<td>%</td>
<td>No Automatic Recharge</td>
</tr>
<tr>
<td>Pass Transistor ON-Resistance</td>
<td>(R_{DSON})</td>
<td>—</td>
<td>500</td>
<td>—</td>
<td>m(\Omega)</td>
<td>(V_{DD} = 4.5V, T_J = 105°C) (Note 1)</td>
</tr>
<tr>
<td>Status Indicator – STAT</td>
<td>Sink Current</td>
<td>(I_{SINK})</td>
<td>—</td>
<td>16</td>
<td>30</td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td>Low Output Voltage</td>
<td>(V_{OL})</td>
<td>—</td>
<td>0.4</td>
<td>1</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>Input Leakage Current</td>
<td>(I_{LK})</td>
<td>—</td>
<td>0.01</td>
<td>1</td>
<td>\mu A</td>
</tr>
<tr>
<td>PROG Input</td>
<td>Charge Impedance Range</td>
<td>(R_{PROG})</td>
<td>1</td>
<td>—</td>
<td>10</td>
<td>k(\Omega)</td>
</tr>
<tr>
<td>Automatic Power Down</td>
<td>Automatic Power Down Entry Threshold</td>
<td>(V_{PDENTRY})</td>
<td>—</td>
<td>(V_{BAT} + 50 \text{ mV})</td>
<td>—</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>Automatic Power Down Exit Threshold</td>
<td>(V_{PDEXIT})</td>
<td>—</td>
<td>(V_{BAT} + 150 \text{ mV})</td>
<td>—</td>
<td>V</td>
</tr>
<tr>
<td>Charge Enable (CE)</td>
<td>Input High Voltage Level</td>
<td>(T_{SD})</td>
<td>1.5</td>
<td>—</td>
<td>—</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>Input Low Voltage Level</td>
<td>(V_{IL})</td>
<td>—</td>
<td>—</td>
<td>0.8</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>Input Leakage Current</td>
<td>(I_{LK})</td>
<td>—</td>
<td>5</td>
<td>8</td>
<td>\mu A</td>
</tr>
</tbody>
</table>

**Note 1:** Not production tested. Ensured by design.
DC CHARACTERISTICS (CONTINUED)

**Electrical Specifications:** Unless otherwise indicated, all limits apply for $V_{DD} = [V_{REG(Typical)} + 0.3V]$ to 6V, $T_A = -40°C$ to +85°C. Typical values are at +25°C, $V_{DD} = [V_{REG(Typical)} + 1.0V]$

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Sym.</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Units</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal Shutdown</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Die Temperature</td>
<td>$T_{SD}$</td>
<td>—</td>
<td>150</td>
<td>—</td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td>Die Temperature</td>
<td>$T_{SDHYS}$</td>
<td>—</td>
<td>10</td>
<td>—</td>
<td>°C</td>
<td></td>
</tr>
</tbody>
</table>

**Note 1:** Not production tested. Ensured by design.

AC CHARACTERISTICS

**Electrical Specifications:** Unless otherwise specified, all limits apply for $V_{DD} = [V_{REG(Typical)} + 0.3V]$ to 6V, $T_A = -40°C$ to +85°C. Typical values are at +25°C, $V_{DD} = [V_{REG(Typical)} + 1.0V]$

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Sym.</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Units</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elapsed Timer</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elapsed Timer Period</td>
<td>$t_{ELAPSED}$</td>
<td>3.5</td>
<td>4.0</td>
<td>4.5</td>
<td>Hours</td>
<td></td>
</tr>
<tr>
<td>Preconditioning Timer</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preconditioning Timer Period</td>
<td>$t_{PRECHG}$</td>
<td>0.8</td>
<td>1</td>
<td>1.2</td>
<td>Hours</td>
<td></td>
</tr>
<tr>
<td>Status Indicator</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Status Output Turn-Off</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Status Output Turn-On</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note 1:** Not production tested. Ensured by design.

TEMPERATURE SPECIFICATIONS

**Electrical Specifications:** Unless otherwise indicated, all limits apply for $V_{DD} = [V_{REG(Typical)} + 0.3V]$ to 6V. Typical values are at +25°C, $V_{DD} = [V_{REG(Typical)} + 1.0V]$

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Sym.</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Units</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature Ranges</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Specified Temperature Range</td>
<td>$T_A$</td>
<td>-40</td>
<td>—</td>
<td>+85</td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td>Operating Temperature Range</td>
<td>$T_J$</td>
<td>-40</td>
<td>—</td>
<td>+125</td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td>Storage Temperature Range</td>
<td>$T_A$</td>
<td>-65</td>
<td>—</td>
<td>+150</td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td>Thermal Package Resistances</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal Resistance, TDFN-6 (2x2)</td>
<td>$\theta_{JA}$</td>
<td>—</td>
<td>91</td>
<td>—</td>
<td>°C/W</td>
<td>4-Layer JC51-7 Standard Board, Natural Convection</td>
</tr>
<tr>
<td></td>
<td>$\theta_{JC}$</td>
<td>—</td>
<td>19</td>
<td>—</td>
<td>°C/W</td>
<td></td>
</tr>
</tbody>
</table>
2.0 TYPICAL PERFORMANCE CURVES

**Note:** The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only. The performance characteristics listed herein are not tested or guaranteed. In some graphs or tables, the data presented may be outside the specified operating range (e.g., outside specified power supply range) and therefore outside the warranted range.

**Note:** Unless otherwise indicated, $V_{DD} = [V_{REG}(\text{Typical}) + 1V]$, $I_{OUT} = 30 \text{ mA}$ and $T_A = +25^\circ\text{C}$, Constant Voltage mode.

**FIGURE 2-1:** Battery Regulation Voltage ($V_{BAT}$) vs. Supply Voltage ($V_{DD}$).

**FIGURE 2-2:** Battery Regulation Voltage ($V_{BAT}$) vs. Ambient Temperature ($T_A$).

**FIGURE 2-3:** Battery Regulation Voltage ($V_{BAT}$) vs. Ambient Temperature ($T_A$).

**FIGURE 2-4:** Battery Regulation Voltage ($V_{BAT}$) vs. Charge Current ($I_{OUT}$).

**FIGURE 2-5:** Charge Current ($I_{OUT}$) vs. Programming Resistor ($R_{PROG}$), MCP73830L.

**FIGURE 2-6:** Output Leakage Current ($I_{DISCHARGE}$) vs. Ambient Temperature ($T_A$).
Note: Unless otherwise indicated, $V_{DD} = [V_{REG}(\text{Typical}) + 1V], I_{OUT} = 10 \text{ mA}$ and $T_A = +25^\circ\text{C}$, Constant Voltage mode.

**FIGURE 2-7:** Output Leakage Current ($I_{DISCHARGE}$) vs. Ambient Temperature ($T_A$).

**FIGURE 2-8:** Output Leakage Current ($I_{DISCHARGE}$) vs. Battery Regulation Voltage ($V_{BAT}$).

**FIGURE 2-9:** Charge Current ($I_{OUT}$) vs. Ambient Temperature ($T_A$), MCP73830.

**FIGURE 2-10:** Charge Current ($I_{OUT}$) vs. Ambient Temperature ($T_A$), MCP73830.

**FIGURE 2-11:** Charge Current ($I_{OUT}$) vs. Supply Voltage ($V_{DD}$), MCP73830.

**FIGURE 2-12:** Charge Current ($I_{OUT}$) vs. Supply Voltage ($V_{DD}$), MCP73830.
3.0 PIN DESCRIPTION

The descriptions of the pins are listed in Table 3-1.

TABLE 3-1: PIN FUNCTION TABLES

<table>
<thead>
<tr>
<th>MCP73830/L Symbol</th>
<th>I/O</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>TDFN</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 VSS</td>
<td>—</td>
<td>Battery management 0V reference.</td>
</tr>
<tr>
<td>2 STAT</td>
<td>O</td>
<td>Battery charge status output.</td>
</tr>
<tr>
<td>3 VBAT</td>
<td>I/O</td>
<td>Charge control output. Regulates the charge current and battery voltage. The pin is disconnected during Shutdown mode.</td>
</tr>
<tr>
<td>4 VDD</td>
<td>I</td>
<td>Input power supply.</td>
</tr>
<tr>
<td>5 CE</td>
<td>I</td>
<td>Charge Enable pin. Pull the pin high to disable the device. It is internally pulled down. Leave the pin float if not used.</td>
</tr>
<tr>
<td>6 PROG</td>
<td>I/O</td>
<td>Battery charge current regulation program.</td>
</tr>
<tr>
<td>7 EP</td>
<td>—</td>
<td>Exposed pad.</td>
</tr>
</tbody>
</table>

3.1 Battery Management 0V Reference (VSS)

Connect to the negative terminal of the battery and input supply.

3.2 Status Output (STAT)

STAT is an open-drain logic output for connection to an LED for charge status indication in stand-alone applications. Alternatively, a pull-up resistor can be applied for interfacing to a host microcontroller. Refer to Table 5-1 for a summary of the status output during a charge cycle.

3.3 Battery Charge Control Output (VBAT)

Connect to the positive terminal of the battery. Bypass to VSS with a minimum of 1 µF to ensure loop stability when the battery is disconnected.

3.4 Battery Management Input Supply (VDD)

A supply voltage of [VREG (Typical) + 0.3V] to 6.0V is recommended. Bypass to VSS with a minimum of 1 µF.

3.5 Charge Enable (CE)

The MCP73830/L is always enabled with an internal pull-down resistor. Pulling the CE pin high will enter Standby mode.

3.6 Current Regulation Set (PROG)

The fast charge current is set by placing a resistor from PROG to VSS during Constant Current (CC) mode. Refer to Section 5.4 “Constant Current Mode – Fast Charge” for details.

3.7 Exposed Pad (EP)

The Exposed Thermal Pad (EP) should be connected to the exposed copper area on the Printed Circuit Board (PCB) for thermal enhancement purposes. Additional vias on the copper area under the MCP73830/L device can improve the performance of heat dissipation and simplify the assembly process.
4.0 DEVICE OVERVIEW

The MCP73830/L are simple, but fully integrated, linear charge management controllers. Figure 4-1 depicts the operational flow algorithm.

![Figure 4-1: The MCP73830/L Flowchart.](image)
5.0 DETAILED DESCRIPTION

5.1 Undervoltage Lockout (UVLO)

An Internal Undervoltage Lockout (UVLO) circuit monitors the input voltage and keeps the charger in Shutdown mode until the input supply rises above the UVLO threshold. In the event a battery is present when the input power is applied, the input supply must rise approximately 150 mV above the battery voltage before the MCP73830/L devices become operational.

The UVLO circuit places the device in Shutdown mode if the input supply falls to approximately 150 mV above the battery voltage. The UVLO circuit is always active. Any time the input supply is below the UVLO threshold, or approximately 150 mV of the voltage at the VBAT pin, the MCP73830/L devices are placed in Shutdown mode.

5.2 Charge Qualification

When the input power is applied, the input supply must rise 150 mV above the battery voltage before the MCP73830/L becomes operational.

The automatic power-down circuit places the device in Shutdown mode if the input supply falls to within +50 mV of the battery voltage.

The automatic circuit is always active. Any time the input supply is below the UVLO threshold, or approximately 150 mV of the voltage at the VBAT pin, the MCP73830/L devices are placed in Shutdown mode.

5.2.1 BATTERY MANAGEMENT INPUT SUPPLY (VDD)

The VDD input is the input supply to the MCP73830/L. The MCP73830/L automatically enters Power-Down mode if the voltage on the VDD input falls to within +50 mV of the battery voltage. This feature prevents draining the battery pack when the VDD supply is not present.

5.2.2 BATTERY CHARGE CONTROL OUTPUT (VBAT)

The battery charge control output is the drain terminal of an internal P-channel MOSFET. The MCP73830/L provides constant current and voltage regulation to the battery pack by controlling this MOSFET in the linear region. The battery charge control output should be connected to the positive terminal of the battery pack.

5.2.3 BATTERY DETECTION

The MCP73830/L device detects the battery presence by monitoring the voltage at VBAT. The charge flow will initiate when the voltage on VBAT is pulled below the VRECHARGE threshold. Refer to Section 1.0 “Electrical Characteristics” for VRECHARGE values. The value will be the same for non-rechargeable devices.

When VBAT > VREG + Hysteresis, the charge will be suspended or not started, depending on the condition, to prevent the overcharge that may occur.

5.3 Preconditioning

If the voltage at the VBAT pin is less than the preconditioning threshold, the MCP73830/L devices enter Preconditioning mode. The preconditioning threshold is factory set. Refer to Section 1.0 “Electrical Characteristics” for preconditioning threshold options.

In this mode, the MCP73830/L devices supply 10% of the fast charge current (established with the value of the resistor connected to the PROG pin) to the battery.

When the voltage at the VBAT pin rises above the preconditioning threshold, the MCP73830/L device enters the Constant Current (Fast Charge) mode.

Notes:
The MCP73830/L devices also offer options with no preconditioning.

5.3.1 TIMER EXPIRED DURING PRECONDITIONING MODE

If the internal timer expires before the voltage threshold is reached for Fast Charge mode, a timer fault is indicated, and the charge cycle terminates. The MCP73830/L devices remain in this condition until the battery is removed, the input power is cycled, or CE is toggled. If the battery is removed, the MCP73830/L devices enter Standby mode, where they remain until a battery is reinserted.

Notes:
The typical preconditioning timers for the MCP73830/L are 60 minutes.
5.4 Constant Current Mode – Fast Charge

During Constant Current mode, the programmed charge current is supplied to the battery or load.

The charge current is established using a single resistor from PROG to V\textsubscript{SS}. The program resistor and the charge current are calculated using the following equation:

\begin{align*}
EQUATION 5-1: & \quad MCP73830L \\
I\text{REG} & = \frac{200}{R\text{PROG}} \\
\text{Where:} & \\
R\text{PROG} & = \text{kilo-ohms (k}\Omega) \\
I\text{REG} & = \text{milliampere (mA)}
\end{align*}

\begin{align*}
EQUATION 5-2: & \quad MCP73830 \\
I\text{REG} & = \frac{1000}{R\text{PROG}} \\
\text{Where:} & \\
R\text{PROG} & = \text{kilo-ohms (k}\Omega) \\
I\text{REG} & = \text{milliampere (mA)}
\end{align*}

Constant Current mode is maintained until the voltage at the V\textsubscript{BAT} pin reaches the regulation voltage, V\textsubscript{REG}. When Constant Current mode is invoked, the internal timer is reset.

5.4.1 TIMER EXPIRED DURING CONSTANT CURRENT – FAST CHARGE MODE

If the internal 4-hour timer expires before the recharge voltage threshold is reached, a timer fault is indicated and the charge cycle terminates. The MCP73830/L devices remain in this condition until the battery is reinserted, or the input power or CE is cycled.

5.5 Constant Voltage Mode

When voltage at the V\textsubscript{BAT} pin reaches the regulation voltage, V\textsubscript{REG}, the constant voltage regulation begins. The regulation voltage is factory set to 4.2V, with a tolerance of ±0.75%.

5.6 Charge Termination

The charge cycle is terminated when, during Constant Voltage mode, the average charge current diminishes below a threshold established with the value of 7.5%, 10% of fast charge current, or the internal timer has expired. A 1 ms filter time on the termination comparator ensures that transient load conditions do not result in premature charge cycle termination. The timer period is factory set and no timer option is available.

5.7 Automatic Recharge

MCP73830/L devices with automatic recharge options continuously monitor the voltage at the V\textsubscript{BAT} pin during the Charge Complete mode. If the voltage drops below the recharge threshold, another charge cycle begins, and current is once again supplied to the battery or load. The recharge threshold is factory set. Refer to Section 1.0 “Electrical Characteristics” for recharge threshold options.

Note: The MCP73830/L also offer options with no automatic recharge.

For the MCP73830/L with no recharge option, the devices will go into Standby mode when a termination condition is met. The charge will not restart until one of the following conditions is met:

- Battery is removed from the system and inserted again.
- VDD is removed and plugged in again.
- CE is cycled.

5.8 Thermal Regulation

The MCP73830/L should limit the charge currents based on the die temperature. The thermal regulation optimizes the charge cycle time while maintaining device reliability. Figure 5-1 depicts the thermal regulation for the MCP73830/L devices. Refer to Section 1.0 “Electrical Characteristics” for thermal package resistances, and Section 6.1.1.3 “Thermal Considerations” for calculating power dissipation.

Refer to Section 1.0 “Electrical Characteristics” for timer period value.
5.9 Thermal Shutdown

The MCP73830/L suspends charging if the die temperature exceeds +150°C. Charging will resume when the die temperature has cooled by approximately 10°C. The thermal shutdown is a secondary safety feature in the event that there is a failure within the thermal regulation circuitry.

5.10 Status Indicator

The charge status output of the MCP73830/L is open-drain, and, as such, has two different states: Low (L), and High-Impedance (High Z). The charge status outputs can be used to illuminate the LEDs. Optionally, the charge status output can be used as an interface to a host microcontroller. The faulty indication of a preconditioning timer also indicates defective batteries, when it fails to pass preconditioning threshold during the given time.

Table 5-1 summarizes the state of the status outputs during a charge cycle.

TABLE 5-1: STATUS OUTPUTS

<table>
<thead>
<tr>
<th>Charge Cycle State</th>
<th>STAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shutdown</td>
<td>High Z</td>
</tr>
<tr>
<td>No Battery Present</td>
<td>High Z</td>
</tr>
<tr>
<td>Preconditioning</td>
<td>L</td>
</tr>
<tr>
<td>Constant Current Fast Charge</td>
<td>L</td>
</tr>
<tr>
<td>Constant Voltage</td>
<td>L</td>
</tr>
<tr>
<td>Charge Complete</td>
<td>High Z</td>
</tr>
<tr>
<td>Timer Fault</td>
<td>High Z</td>
</tr>
<tr>
<td>Preconditioning Timer Fault</td>
<td>Flashing (2 Hz)</td>
</tr>
</tbody>
</table>
6.0 APPLICATIONS

The MCP73830 is designed to operate in conjunction with a host microcontroller or in stand-alone applications. The MCP73830/L provides the preferred charge algorithm for dual Lithium-Ion or Lithium-Polymer cell’s constant current, followed by constant voltage. Figure 6-1 depicts a typical stand-alone application circuit, while Figure 6-2 depicts the accompanying charge profile.

6.1 Application Circuit Design

Due to the low efficiency of linear charging, the most important factors are thermal design and cost, which are a direct function of the input voltage, output current and thermal impedance between the battery charger and the ambient cooling air. The worst-case situation is when the device has transitioned from Preconditioning mode to Constant Current mode. In this situation, the battery charger has to dissipate the maximum power. A trade-off must be made between the charge current, cost and thermal requirements of the charger.

6.1.1 COMPONENT SELECTION

Selection of the external components in Figure 6-1 is crucial to the integrity and reliability of the charging system. The following discussion is intended as a guide for the component selection process.

6.1.1.1 Charge Current

The preferred fast charge current for Li-ion/Li-Poly cells is below the 1C rate, with an absolute maximum current at the 2C rate. The recommended fast charge current should be obtained from the battery manufacturer. For example, a 500 mAh battery pack with 0.7C preferred fast charge current has a charge current of 350 mA. Charging at this rate provides the shortest charge cycle times without degradation to the battery pack performance or life.

6.1.1.2 Input Over Voltage Protection (IOVP)

Input over voltage protection must be used when the input power source is hot-pluggable. This includes USB cables and wall-type power supplies. The cabling of these supplies acts as an inductor. When the supplies are connected/disconnected from the system, large voltage transients are created which may damage the system circuitry. These transients should be snubbed out. A transzorb - unidirectional or bidirectional - connected from the V+ input supply connector to the 0V ground reference will snub the transients. An example of this can be seen in Figure 6-3.

Note: Please consult with your battery supplier, or refer to the battery data sheet, for the preferred charge rate.
6.1.1.3 Thermal Considerations

The worst-case power dissipation in the battery charger occurs when the input voltage is at the maximum and the device has transitioned from Preconditioning mode to Constant Current mode. In this case, the power dissipation is:

\[
\text{Power Dissipation} = (V_{DD\text{MAX}} - V_{\text{PTHMIN}}) \times I_{\text{REGMAX}}
\]

Where:

- \( V_{DD\text{MAX}} \) = the maximum input voltage
- \( I_{\text{REGMAX}} \) = the maximum fast charge current
- \( V_{\text{PTHMIN}} \) = the minimum transition threshold voltage

Power dissipation with a 5V, ±10% input voltage source, 200 mA ±10%, and preconditioning threshold voltage at 6V is:

\[
\text{Power Dissipation} = (5.5V - 3.0V) \times 220mA = 0.55W
\]

This power dissipation with the battery charger in the 2x2 TDFN-6 package will result in a temperature of approximately 10.45°C (PCB mounted) above room temperature.

6.1.1.4 External Capacitors

The MCP73830 is stable with or without a battery load. In order to maintain good AC stability in Constant Voltage mode, a minimum capacitance of 1 µF is recommended to bypass the \( V_{\text{BAT}} \) pin to \( V_{\text{SS}} \). This capacitance provides compensation when there is no battery load. In addition, the battery and interconnections appear inductive at high frequencies. These elements are in the control feedback loop during Constant Voltage mode. Therefore, the bypass capacitance may be necessary to compensate for the inductive nature of the battery pack.

A minimum of 16V rated 1 µF is recommended to apply for output capacitor, and a minimum of 25V rated 1 µF is recommended to apply for input capacitor for typical applications.

<table>
<thead>
<tr>
<th>MLCC Capacitors</th>
<th>Temperature Range</th>
<th>Tolerance</th>
</tr>
</thead>
<tbody>
<tr>
<td>X7R</td>
<td>-55°C to + 125°C</td>
<td>±15%</td>
</tr>
<tr>
<td>X5R</td>
<td>-55°C to + 85°C</td>
<td>±15%</td>
</tr>
</tbody>
</table>

Virtually any good quality output filter capacitor can be used independent of the capacitor’s minimum Effective Series Resistance (ESR) value. The actual value of the capacitor (and its associated ESR) depends on the output load current. A 1 µF ceramic, tantalum or aluminum electrolytic capacitor at the output is usually sufficient to ensure stability.

6.1.1.5 Reverse-Blocking Protection

The MCP73830/L provides protection from a faulted or shorted input. Without the protection, a faulted or shorted input would discharge the battery pack through the body diode of the internal pass transistor.
6.2 PCB Layout Issues

For optimum voltage regulation, place the battery pack as close as possible to the device’s V\textsubscript{BAT} and V\textsubscript{SS} pins, which is recommended to minimize voltage drops along the high current carrying PCB traces.

If the PCB layout is used as a heat sink, adding many vias in the heat sink pad can help conduct more heat to the backplane of the PCB, thus reducing the maximum junction temperature. Figure 6-5 and Figure 6-6 depict a typical layout with PCB heat sinking.

FIGURE 6-4: Typical Layout (Top).

FIGURE 6-5: Typical Layout (Top Metal).

FIGURE 6-6: Typical Layout (Bottom).
7.0 PACKAGING INFORMATION

7.1 Package Marking Information

Legend:

- XX...X Customer-specific information
- Y Year code (last digit of calendar year)
- YY Year code (last 2 digits of calendar year)
- WW Week code (week of January 1 is week '01')
- NNN Alphanumeric traceability code
- 3 Designator for Matte Tin (Sn)
- * This package is Pb-free. The Pb-free JEDEC designator (3) can be found on the outer packaging for this package.

Note: In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for customer-specific information.

---

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCP73830T-2AAI/MYY</td>
<td>2AA</td>
</tr>
<tr>
<td>MCP73830LT-0AAI/MYY</td>
<td>0AA</td>
</tr>
<tr>
<td>MCP73830LT-0BCI/MYY</td>
<td>0BC</td>
</tr>
</tbody>
</table>

Example: 0AA 256
6-Lead Plastic Thin Dual Flat, No Lead Package (MY) – 2x2x0.8 mm Body [TDFN]

Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging

Microchip Technology Drawing C04-078A Sheet 1 of 2
6-Lead Plastic Thin Dual Flat, No Lead Package (MY) – 2x2x0.8 mm Body [TDFN]

Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging

<table>
<thead>
<tr>
<th>Units</th>
<th>MILLIMETERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimension Limits</td>
<td>MIN</td>
</tr>
<tr>
<td>Number of Pins</td>
<td>N</td>
</tr>
<tr>
<td>Pitch</td>
<td>e</td>
</tr>
<tr>
<td>Overall Height</td>
<td>A</td>
</tr>
<tr>
<td>Standoff</td>
<td>A1</td>
</tr>
<tr>
<td>Contact Thickness</td>
<td>A3</td>
</tr>
<tr>
<td>Overall Width</td>
<td>E</td>
</tr>
<tr>
<td>Exposed Pad Width</td>
<td>E2</td>
</tr>
<tr>
<td>Overall Length</td>
<td>D</td>
</tr>
<tr>
<td>Exposed Pad Length</td>
<td>D2</td>
</tr>
<tr>
<td>Contact Width</td>
<td>b</td>
</tr>
<tr>
<td>Contact Length</td>
<td>L</td>
</tr>
<tr>
<td>Contact-to-Exposed Pad</td>
<td>K</td>
</tr>
</tbody>
</table>

Notes:
1. Pin 1 visual index feature may vary, but must be located within the hatched area.
2. Package may have one or more exposed tie bars at ends.
3. Package is saw singulated.
4. Dimensioning and tolerancing per ASME Y14.5M.
   BSC: Basic Dimension. Theoretically exact value shown without tolerances.
   REF: Reference Dimension, usually without tolerance, for information purposes only.

Microchip Technology Drawing C04-078A Sheet 2 of 2
APPENDIX A: REVISION HISTORY

Revision D (July 2014)
The following is the list of modifications:
1. Added the “Available Factory Preset Options” table.
2. Removed any mention of Fixed Elapse Timer having a disabled option.
3. Removed any mention of an option with no precondition timer.
4. Corrected the flow-chart in Figure 4-1, specifying STAT = High Z in the Charge Complete Mode text box.
5. Updated Table 5-1.
6. Added the Section 6.1.1.2, "Input Over Voltage Protection (IOVP)".
7. Added Figure 6-3.

Revision C (August 2013)
The following is the list of modifications:
1. Updated the “Temperature Specifications” table.
2. Updated Section 6.1.1.3, "Thermal Considerations".

Revision B (December 2011)
The following is the list of modifications:
1. Updated Figure 4-1.
2. Removed the MCP73830 and MCP73830L options from the “Product Identification System” section.

Revision A (September 2011)
• Original Release of this Document.
PRODUCT IDENTIFICATION SYSTEM

To order or obtain information, e.g., on pricing or delivery, refer to the factory or the listed sales office.

<table>
<thead>
<tr>
<th>PART NO.</th>
<th>XXX</th>
<th>X</th>
<th>XX</th>
</tr>
</thead>
<tbody>
<tr>
<td>Device:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard Options:</td>
<td>IREF (mA)</td>
<td>VREF (V)</td>
<td>IPRECONDITION (%)</td>
</tr>
<tr>
<td>MCP73830LT 0AA</td>
<td>200</td>
<td>4.2</td>
<td>10</td>
</tr>
<tr>
<td>MCP73830LT 0BC</td>
<td>200</td>
<td>4.2</td>
<td>100</td>
</tr>
<tr>
<td>MCP73830T 2AA</td>
<td>1000</td>
<td>4.2</td>
<td>10</td>
</tr>
</tbody>
</table>

Temperature Range:

\[ I = \text{-40°C to +85°C (Industrial)} \]

Package:

\[ \text{MY} = \text{Plastic Thin Dual Flat, No Lead Package, 2x2x0.8 mm Body (TDFN), 6-Lead} \]

* Y = nickel palladium gold manufacturing designator. Only available on the TDFN package.

Examples:

a) MCP73830T-2AAI/MYY: Tape and Reel, Single Cell Li-Ion/Li-Polymer Battery Device
b) MCP73830LT-0AAI/MYY: Tape and Reel, Single Cell Li-Ion/Li-Polymer Battery Device
c) MCP73830LT-0BCI/MYY: Tape and Reel, Single Cell Li-Ion/Li-Polymer Battery Device
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- Microchip believes that its family of products is one of the most secure families of its kind on the market today, when used in the intended manner and under normal conditions.
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Fax: 852-2401-3431

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