DESCRIPTION

The MP2623 is a monolithic, DC-DC, step-down, switching charger for a 1-or-2-cell serial LiFePO4 battery. It has an integrated high-side power MOSFET that can output up to a 2A charge current. It also has peak-current-mode control for fast loop response and easy compensation.

The MP2623 uses a sense resistor to control a programmable charge current, and accurately regulates the charge current and the charge voltage using two control loops.

The MP2623 has multiple fault-condition protections that include cycle-by-cycle current limiting and thermal shutdown. Other safety features include battery temperature monitoring and protection, charge status indication and a programmable timer to halt charging after a set time period.

The MP2623 requires a minimal number of readily-available external components.

The MP2623 is available in a 4mm×4mm 16-pin QFN package.

FEATURES

- Charges 1- and 2-Cell LiFePO4 Battery Packs
- Wide Operating-Input Range
- Programmable Charging Current of up to 2A
- ±0.75% \( V_{\text{BATT}} \) Accuracy
- 0.2Ω Integrated Power MOSFET
- Up to 90% Efficiency
- Fixed 1.1MHz Frequency
- Preconditioning for Fully-Depleted Batteries
- Charging Status Indicator
- Input Supply Fault Indicator
- Thermal Shutdown
- Cycle-by-Cycle Over-Current Protection
- Battery Temperature Monitor and Protection

APPLICATIONS

- Power Tools and Portable Equipment
- Handheld Terminals
- LiFePO4 Battery Chargers

All MPS parts are lead-free and adhere to the RoHS directive. For MPS green status, please visit MPS website under Quality Assurance. "MPS" and "The Future of Analog IC Technology" are Registered Trademarks of Monolithic Power Systems, Inc.
ORDERING INFORMATION

<table>
<thead>
<tr>
<th>Part Number*</th>
<th>Package</th>
<th>Top Marking</th>
</tr>
</thead>
<tbody>
<tr>
<td>MP2623GR</td>
<td>QFN16 (4×4mm)</td>
<td>MP2623</td>
</tr>
</tbody>
</table>

*For Tape & Reel, add suffix –Z (e.g. MP2623GR–Z)

ABSOLUTE MAXIMUM RATINGS (1)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Voltage</td>
<td>VCC, VIN: 0 to 26V</td>
</tr>
<tr>
<td></td>
<td>VSW: -0.3V to (VIN + 0.3V)</td>
</tr>
<tr>
<td></td>
<td>VBST: -0.3V to +18V</td>
</tr>
<tr>
<td></td>
<td>VACOK, VCHGOK: -0.3V to +26V</td>
</tr>
<tr>
<td></td>
<td>All Other Pins: -0.3V to +6V</td>
</tr>
</tbody>
</table>

Continuous Power Dissipation (TA = 25°C) (2)

2.7W

Junction Temperature

150°C

Lead Temperature

260°C

Storage Temperature

-65°C to +150°C

Recommended Operating Conditions (3)

Supply Voltage VIN: 5V to 24V

Operating Junction Temp. (TJ): -40°C to +125°C

Thermal Resistance (4) θJA: 46°C/W

Notes:

1) Exceeding these ratings may damage the device.

2) The maximum allowable power dissipation is a function of the maximum junction temperature Tj(MAX), the junction-to-ambient thermal resistance θJA, and the ambient temperature TA. The maximum allowable continuous power dissipation at any ambient temperature is calculated by:

   PD(MAX) = (Tj(MAX) - TA) / θJA

   Exceeding the maximum allowable power dissipation will cause excessive die temperature, and the regulator will go into thermal shutdown. Internal thermal shutdown circuitry protects the device from permanent damage.

3) The device is not guaranteed to function outside of its operating conditions.

4) Measured on JESD51-7 4-layer board.
### ELECTRICAL CHARACTERISTICS

\( V_{IN} = 19V, \ T_A = 25°C, \ \text{CELLS}=0V, \) unless otherwise noted.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Symbol</th>
<th>Condition</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Battery-terminal voltage</td>
<td>( V_{BATT} )</td>
<td>( \text{CELLS}=0V )</td>
<td>3.573</td>
<td>3.6</td>
<td>3.627</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>( \text{CELLS}=\text{Float} )</td>
<td>7.146</td>
<td>7.2</td>
<td>7.254</td>
<td>V</td>
</tr>
<tr>
<td>CSP, BATT current</td>
<td>( I_{CSP,IBATT} )</td>
<td>Charging disabled</td>
<td>1</td>
<td></td>
<td></td>
<td>( \mu A )</td>
</tr>
<tr>
<td>Switch-on resistance</td>
<td>( R_{DS(ON)} )</td>
<td></td>
<td>0.2</td>
<td></td>
<td></td>
<td>( \Omega )</td>
</tr>
<tr>
<td>Switch leakage</td>
<td></td>
<td>( EN=4V, \ V_{SW}=0V )</td>
<td>0</td>
<td>1</td>
<td></td>
<td>( \mu A )</td>
</tr>
<tr>
<td>Peak-current limit</td>
<td></td>
<td>( \text{CC}(5) )</td>
<td>4.1</td>
<td></td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>CC current</td>
<td>( I_{CC} )</td>
<td>( RS1=100m\Omega )</td>
<td>1.8</td>
<td>2.0</td>
<td>2.2</td>
<td>A</td>
</tr>
<tr>
<td>Trickle-charge current</td>
<td>( I_{TRICKLE} )</td>
<td></td>
<td>10%</td>
<td></td>
<td></td>
<td>( I_{CC} )</td>
</tr>
<tr>
<td>Trickle-charge voltage threshold</td>
<td>( V_{TC} )</td>
<td></td>
<td>2.52</td>
<td></td>
<td></td>
<td>V/cell</td>
</tr>
<tr>
<td>Trickle-charge hysteresis</td>
<td></td>
<td></td>
<td>300</td>
<td></td>
<td></td>
<td>mV/cell</td>
</tr>
<tr>
<td>Termination current threshold</td>
<td>( I_{BF} )</td>
<td></td>
<td>5%</td>
<td>10%</td>
<td>15%</td>
<td>( I_{CC} )</td>
</tr>
<tr>
<td>Oscillator frequency</td>
<td>( f_{SW} )</td>
<td>( \text{CELLS}=0V, \ V_{BATT}=3.2V )</td>
<td>1100</td>
<td></td>
<td></td>
<td>kHz</td>
</tr>
<tr>
<td>Fold-back frequency</td>
<td>( V_{BATT}=0V )</td>
<td></td>
<td>350</td>
<td></td>
<td></td>
<td>kHz</td>
</tr>
<tr>
<td>Maximum duty cycle</td>
<td></td>
<td></td>
<td>90</td>
<td></td>
<td></td>
<td>%</td>
</tr>
<tr>
<td>Maximum current-sense voltage (CSP to BATT)</td>
<td>( V_{SENSE} )</td>
<td></td>
<td>170</td>
<td>200</td>
<td>230</td>
<td>mV</td>
</tr>
<tr>
<td>Minimum ON time (^{(5)})</td>
<td>( t_{ON} )</td>
<td></td>
<td>100</td>
<td></td>
<td></td>
<td>ns</td>
</tr>
<tr>
<td>Under-voltage lockout threshold, rising</td>
<td>( V_{IN} )</td>
<td></td>
<td>3.1</td>
<td>3.3</td>
<td>3.5</td>
<td>V</td>
</tr>
<tr>
<td>Under-voltage lockout threshold, hysteresis</td>
<td></td>
<td></td>
<td>300</td>
<td>1000</td>
<td></td>
<td>mV</td>
</tr>
<tr>
<td>Open-drain sink current</td>
<td>( V_{DRAIN}=0.3V )</td>
<td></td>
<td>5</td>
<td></td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td>Dead battery indicator</td>
<td></td>
<td>In trickle mode ( C_{TMR}=0.1\mu F )</td>
<td>30</td>
<td></td>
<td></td>
<td>min</td>
</tr>
<tr>
<td>Recharge threshold for ( V_{BATT} )</td>
<td>( V_{RECHG} )</td>
<td></td>
<td>3.42</td>
<td></td>
<td></td>
<td>V/cell</td>
</tr>
<tr>
<td>Recharge hysteresia</td>
<td></td>
<td></td>
<td>100</td>
<td></td>
<td></td>
<td>mV</td>
</tr>
<tr>
<td>NTC low-temp rising threshold</td>
<td>( R_{NTC}=\text{NCP18X103, 0°C} )</td>
<td></td>
<td>70.5</td>
<td>73.5</td>
<td>76.5</td>
<td>% of VREF33</td>
</tr>
<tr>
<td>NTC high-temp falling threshold</td>
<td>( R_{NTC}=\text{NCP18X103, 50°C} )</td>
<td></td>
<td>27.5</td>
<td>29.5</td>
<td>31.5</td>
<td>% of VREF33</td>
</tr>
<tr>
<td>VIN min. head-room (reverse blocking)</td>
<td>( V_{IN}-V_{BATT} )</td>
<td></td>
<td>180</td>
<td></td>
<td></td>
<td>mV</td>
</tr>
</tbody>
</table>
ELECTRICAL CHARACTERISTICS (continued)

$V_{IN} = 19V$, $T_A = 25^\circ C$, $CELLS=0V$, unless otherwise noted.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Symbol</th>
<th>Condition</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>$EN$ input low voltage</td>
<td>EN</td>
<td></td>
<td>0.4</td>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$EN$ input high voltage</td>
<td>EN</td>
<td></td>
<td>1.8</td>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$EN$ input current</td>
<td>$EN=0V$</td>
<td></td>
<td>0.2</td>
<td>μA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$EN=4V$</td>
<td>$EN=4V$</td>
<td></td>
<td>4</td>
<td>μA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supply current (shutdown)</td>
<td></td>
<td>$EN=4V$, Consider VREF33 pin</td>
<td>0.5</td>
<td>mA</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>output current, $R_J=10k, R_{NTC}=10k$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$EN=0V$, $CELLS=0V$</td>
<td>2.0</td>
<td>mA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal shutdown (5)</td>
<td>EN</td>
<td>$=0V$, $CELLS=0V$</td>
<td>150</td>
<td>°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VREF33 output voltage</td>
<td></td>
<td></td>
<td>3.3</td>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VREF33 load regulation</td>
<td>$I_{LOAD}=0$ to 10mA</td>
<td></td>
<td>30</td>
<td>mV</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes:
5) Guaranteed by design.
## PIN FUNCTIONS

<table>
<thead>
<tr>
<th>Pin #</th>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>VCC</td>
<td>IC Supply Voltage.</td>
</tr>
<tr>
<td>2</td>
<td>NTC</td>
<td>Thermistor Input. Connect a resistor from this pin to VREF33, and the thermistor from this pin to ground.</td>
</tr>
<tr>
<td>3</td>
<td>ACOK</td>
<td>Valid Input Supply Indicator. Open drain output. Add a pull-up resistor. Logic LOW indicates the presence of a valid input supply.</td>
</tr>
<tr>
<td>4</td>
<td>CHGOK</td>
<td>Charging Status Indicator. Open drain output. Add a pull-up resistor. Logic LOW indicates normal charging. Logic HIGH indicates either a completed charge process or a fault-suspended process.</td>
</tr>
<tr>
<td>5</td>
<td>VREF33</td>
<td>Internal Linear Regulator, 3.3V Reference Output. Bypass to GND with a 1μF ceramic capacitor.</td>
</tr>
<tr>
<td>6</td>
<td>EN</td>
<td>On/Off Control Input.</td>
</tr>
<tr>
<td>7</td>
<td>CELLS</td>
<td>Command Input. Indicates the number of LiFePO₄ battery cells. Connect to VREF33 or float for 2-cell operation. Ground for 1-cell operation.</td>
</tr>
<tr>
<td>8</td>
<td>COMPV</td>
<td>V-LOOP Compensation. Decouple this pin with a capacitor and a resistor.</td>
</tr>
<tr>
<td>9</td>
<td>COMPI</td>
<td>I-LOOP Compensation. Decouple this pin with a capacitor and a resistor.</td>
</tr>
<tr>
<td>10</td>
<td>BATT</td>
<td>Positive Battery Terminal.</td>
</tr>
<tr>
<td>11</td>
<td>CSP</td>
<td>Battery-Charge Current-Sense–Positive Input. Connect a resistor RS1 between CSP and BATT. The full charge current is: ( I_{CHG}(A) = \frac{200mV}{RS1(\Omega)} ).</td>
</tr>
<tr>
<td>12</td>
<td>GND</td>
<td>Ground. Voltage reference for the regulated output voltage. Place this node outside of the path of the switching diode (D2) to the input ground to prevent switching current spikes from inducing voltage noise.</td>
</tr>
<tr>
<td>13</td>
<td>TMR</td>
<td>Set-Safe–Time Period. A 0.1μA current charges and discharges the external capacitor decoupled to GND. The capacitor value programs the time period.</td>
</tr>
<tr>
<td>14</td>
<td>BST</td>
<td>Bootstrap. Requires a charged capacitor to drive the power switch’s gate above the supply voltage. Connect a capacitor between SW and BST pins to form a floating supply across the power switch driver.</td>
</tr>
<tr>
<td>15</td>
<td>SW</td>
<td>Switch Output.</td>
</tr>
<tr>
<td>16</td>
<td>VIN</td>
<td>Regulator Input Voltage. The MP2623 regulates a 5V-to-24V input to a voltage suitable for charging either a 1- or 2-cell LiFePO₄ battery. Requires capacitors to prevent large voltage spikes from appearing at the input.</td>
</tr>
</tbody>
</table>
TYPICAL PERFORMANCE CHARACTERISTICS

$V_{in}=5V/9V$, $C1=4.7\mu F$, $C2=22\mu F$, $L=4.7\mu H$, $RS1=100m\Omega$, Real/Simulation Battery Load, $T_A=25^\circ C$, unless otherwise noted.

1 Cell Battery Charge Curve

1 Cell Charge Current vs. Battery Voltage

2 Cells Battery Charge Curve

2 Cells Charge Current vs. Battery Voltage

NTC Control Window

Breakdown Voltage

Efficiency vs. Battery Voltage

Efficiency vs. $I_{CHG}$

Efficiency vs. $V_{IN}$
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

$V_{IN}=5V/9V$, $C1=4.7\mu F$, $C2=22\mu F$, $L=4.7\mu H$, $RS1=100m\Omega$, Real/Simulation Battery Load, $T_A=25^\circ C$, unless otherwise noted.
TYPICAL PERFORMANCE CHARACTERISTICS (continued)

$V_{IN}=5\text{V/9\text{V}}, C_1=4.7\mu\text{F}, C_2=22\mu\text{F}, L=4.7\mu\text{H}, R_S1=100\text{m}\Omega$, Real/Simulation Battery Load, $T_A=25\degree\text{C}$, unless otherwise noted.

Steady State Waveform
1 Cell, $V_{\text{BATT}}=2\text{V}$

Power On Waveform
1 Cell, $I_{\text{CHG}}=2\text{A}, V_{\text{BATT}}=3\text{V}$

EN Off Waveform
1 Cell, $I_{\text{CHG}}=2\text{A}, V_{\text{BATT}}=3\text{V}$

NTC Control
1 Cell, $I_{\text{CHG}}=2\text{A}, V_{\text{BATT}}=2.5\text{V}$, Battery Simulator

Timer Out
1 Cell, $I_{\text{CHG}}=2\text{A}, V_{\text{BATT}}=3.5\text{V}$, $C_{\text{TIMER}}=47\text{pF}$, Battery Simulator
FUNCTIONAL BLOCK DIAGRAM

Figure 1: Functional Block Diagram
OPERATION

The MP2623 is a peak-current–mode controlled switching charger for use with LiFePO₄ batteries. At the beginning of each cycle, M1 is off and the COMP voltage exceeds the output of the current-sense amplifier (A1). The PWM comparator’s output is low, and the rising edge of the 1.1MHz CLK signal sets the RS flip-flop that turns on M1; this connects the SW pin and the inductor to the input supply.

A1 senses and amplifies the inductor current: The PWM comparator then compares the sum of this signal and the ramp compensator signal against the COMP signal. When the sum of the A1 output and the ramp compensator exceeds the COMP voltage, the RS flip-flop resets and turns M1 off. The external switching diode (D2) then conducts the inductor current. If the sum of the A1 output and the ramp compensator does not exceed the COMP voltage, then the falling edge of the CLK resets the flip-flop.

The MP2623 uses COMP to select the smaller value of GMI and GMV to implement either current-loop control or voltage-loop control. Current-loop control triggers when the battery voltage goes low, which results in the GMV output saturating. The GMI compares the charge current (as a voltage sensed through RS1) against the reference voltage to regulate the charge current to a constant value. When the battery voltage charges up to the reference voltage, the output of GMV goes low and initiates voltage loop control to control the duty cycle to regulate the output voltage.

The MP2623 has an internal linear regulator—VREF33—to power internal circuitry. It can also power external circuitry as long as the load does not exceed the maximum current (30mA). Connect a 1µF bypass capacitor from VREF33 to GND to ensure stability.

Charge Cycle (Mode change: Trickle→ CC→ CV)

At the start of a charging cycle, the MP2623 monitors V_BATT. If V_BATT is lower than the trickle-charge threshold, V_TC (typically 2.52V/cell), the charging cycle will start in trickle-charge mode (10% of the RS1-programmed constant-charge current, I_CC) until the battery voltage reaches V_TC. If the charge stays in the trickle-charge mode until the time-out condition triggers, charging terminates and will not resume until either the input power or the EN signal refreshes. Otherwise, GMI regulates the charge current to the level set by RS1. The charger operates in constant-current–charging mode. The COMPI voltage—regulated by GMI—determines the switching duty cycle.

When the battery voltage triggers constant-voltage mode, GMV regulates the COMP pin and the duty cycle. When the charge current drops to the battery-full threshold, I_BF (typically 10% I_CC), the battery is defined as fully-charged, and CHGOK goes high to indicate the charge-full condition. If the total charge time exceeds the timer period, charging terminates at once and will resume when either the input power or EN signal can restart the charger.

Figure 2 shows the typical charge profile of the MP2623.

Automatic Recharge

After the battery completely recharges, the charger removes all the blocks besides the battery voltage monitor to reduce the leakage current from the input or the battery. If the battery voltage drops below 3.42V/Cell, the circuit will automatically recharge the battery using soft-start. The timer will then restart to avoid triggering a false fault.
Charger Status Indication

MP2623 has two open-drain status outputs: ACOK and CHGOK. The ACOK pin goes low when the IC supply voltage (VCC) exceeds the under-voltage lockout threshold and the regulated voltage VIN is 300mV higher than VBATT to make sure the regulator can operate normally. CHGOK indicates charge status. Table 1 describes ACOK and CHGOK outputs under different charge conditions.

Table 1—Charging Status Indication

<table>
<thead>
<tr>
<th>ACOK</th>
<th>CHGOK</th>
<th>Charger Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td>low</td>
<td>In charging</td>
</tr>
<tr>
<td>low</td>
<td>high</td>
<td>End of charge, NTC fault, timer out, thermal shutdown, EN disable</td>
</tr>
<tr>
<td>high</td>
<td>high</td>
<td>VIN–VBATT&lt;0.3V. VCC&lt;UVLO</td>
</tr>
</tbody>
</table>

Timer Operation

MP2623 uses an internal timer to limit the charge period during both the trickle charge and the total charge cycle. The MP2623 terminates charging once the charge time exceeds the time limit. A good battery should fully recharge within the allotted time period; otherwise the battery has a fault. An external capacitor at the TMR pin programs the time period.

The trickle mode charge time is:

$$t_{TRICKLE\_TMR} = 30 \text{ min} \times \frac{C_{TMR}}{0.1 \mu F}$$

The total charge time is:

$$t_{TOTAL\_TMR} = 3 \text{ hours} \times \frac{C_{TMR}}{0.1 \mu F}$$

When time-out occurs, the charger is suspended. Only refreshing the input power or EN signal can restart the charge cycle.

Negative Thermal Coefficient (NTC) Thermistor

The MP2623 has a built-in NTC-resistance window comparator that allows the MP2623 to sense the battery temperature through the thermistor included in the battery pack. Connect a resistor with an appropriate value from VREF33 to the NTC pin, and connect the thermistor from the NTC pin to GND. A resistor divider determines the voltage on the NTC pin as a function of the battery temperature. Charging halts when the NTC voltage falls below the lower NTC window threshold. Charging resumes when the voltage is within the NTC window range.

Application with Power Selector

MP2623 is a stand-alone, switching charger. Typically, VIN receives power from the adapter input, VIN, through a diode that blocks the battery voltage to VCC. For power selector application, however, VIN powers the system and charges the battery simultaneously so the user can start-up a device with a drained battery when it is connected to an adapter. Replace the diode from the stand-alone switching charger circuit with a MOSFET to improve system efficiency and reduce voltage drop of the block device.

An additional MOSFET between VIN and the battery allows the battery to charge even in the absence of an adapter or connection to an invalid adapter. Figure 3 shows a typical application circuit with power-path management. When the adapter input is invalid or absent, the block diode is replaced by a MOSFET controlled by ACOK signal.
Figure 3: MP2623 with Power Selector
OPERATION FLOW CHART

Figure 4: Normal Charging Operation Flow Chart

Normal Operation
Charger “ON”
CHGOK is low

Charge Mode?

V_{BATT} > V_{BATT_{FULL}}
V_{BATT_{TC}} < V_{BATT < V_{BATT_{FULL}}}
V_{BATT} < V_{BATT_{TC}}

C.C.C

T.C.C

V_{BATT} > V_{BATT_{FULL}}
V_{BATT} > V_{BATT_{FULL}}
V_{BATT} > V_{BATT_{FULL}}

C.V.C

I_{CHG} < I_{CHG}_{BATTERY FULL}

Charger “OFF”
CHGOK is high

V_{BATT} < V_{BATT_{RECCHG}}

Cells = V_{REF33/float}

V_{BATT_{TC}} = 5.04V
V_{BATT_{FULL}} = 7.2V
V_{BATT_{RECCHG}} = 6.84V

V_{BATT_{TC}} = 2.52V
V_{BATT_{FULL}} = 3.6V
V_{BATT_{RECCHG}} = 3.42V

Charging Set up?

Yes

CELLS Status?

No

SYS powered by BATT

ACOK is low & SYS powered by IN

No

POR

V_{ULOC < V_{IN}}
V_{IN} > V_{BATT} + 0.3V?

Yes

No

V_{BATT < V_{BATT_{RECCHG}}}

© 2013 MPS. All Rights Reserved.
Normal Operation

Charger "ON" CHGOK is low

Charge Mode?

$V_{\text{BATT}} > V_{\text{BATT full}}$

$V_{\text{BATT}} < V_{\text{BATT low}}$

C.V.C

No

Battery Full?

Yes

Charger "OFF" CHGOK is high

No

$V_{\text{BATT}} < V_{\text{BATT Recovery}}$

Fault Protection

Timer Out?

Yes

NTC Fault?

No

Yes

Charge Termination, CHGOK is high

Charge Suspend, CHGOK is high

Charge Current: Thermal Shutdown, CHGOK is high

Yes

No

NTC OK?

$T_{J} = 150{\degree}C$

$T_{J} < 130{\degree}C$

Yes

No

Charger Recovery Return to Normal Operation

$T_{J} = 100{\degree}C$

Figure 5: Fault-Protection Flow Chart
APPLICATION INFORMATION

Setting the Charge Current
RS1 sets the MP2623 charge current (See Typical Application). Determine the current with the following equation:

\[ I_{\text{CHG}}(\text{mA}) = \frac{200\text{mV}}{R_{\text{S1}}(\text{m}\Omega)} \]  \hspace{1cm} (1)

Selecting the Inductor

Use a 1µH-to-10µH inductor for most applications. Calculate the inductance value from the following equation.

\[ L = \frac{V_{\text{OUT}} \times (V_{\text{IN}} - V_{\text{OUT}})}{V_{\text{IN}} \times \Delta I_L \times f_{\text{OSC}}} \]  \hspace{1cm} (2)

Where \( \Delta I_L \) is the inductor ripple current. Choose \( \Delta I_L \) to be approximately 30% of the maximum charge current, 2A. \( V_{\text{OUT}} \) is the 1- or 2-cell battery voltage.

The maximum inductor peak current is:

\[ I_{L\text{MAX}} = I_{\text{CHG}} + \frac{\Delta I_L}{2} \]  \hspace{1cm} (3)

Under light-load conditions (below 100mA), use a larger inductor value to improve efficiency.

Select an inductor with a DC resistance of less than 200mΩ to optimize efficiency.

NTC Function

Figure 6 shows that the low temperature threshold and high-temperature threshold are preset internally to 73.5%·VREF33 and 29.5%·VREF33, respectively, using a resistor divider. For a given NTC thermistor, we can select appropriate R3 and R6 resistors to set the NTC window.

For the thermistor (NCP18XH103) noted in the electrical characteristic previous,

At 0°C, \( R_{\text{NTC\_Cold}} = 27.445\text{k} \);
At 50°C, \( R_{\text{NTC\_Hot}} = 4.1601\text{k} \).

Assuming that the NTC window is between 0°C and 50°C, we can derive the following equations:

\[ \frac{R_6}{R_3 + R_6} = \frac{V_{\text{TH,Low}}}{V_{\text{TH,High}}} = 73.5\% \]  \hspace{1cm} (4)

According to equation (4) and equation (5), \( R_3 = 9.63k \) and \( R_6 = 505k \).

Simplifying, select \( R_3=10k \) and \( R_6 \) no connect to approximate the estimate.

Selecting the Input Capacitor

The input capacitor reduces the surge current drawn from the input and the switching noise from the device. Chose an input capacitor with an impedance at the switching frequency less than the input source impedance to prevent a high-frequency switching current. Use ceramic capacitors with X5R or X7R dielectrics with low ESR and small temperature coefficients. A 4.7µF capacitor is sufficient for most applications.

Selecting the Output Capacitor

The output capacitor limits output voltage ripple and ensures regulator-loop stability. The output capacitor impedance should be low at the switching frequency. Use ceramic capacitors with X5R or X7R dielectrics.

PC Board Layout

Connect the high frequency and high current paths (GND, IN, and SW) to the device with short, wide, and direct traces. Place the input capacitor as close as possible to the IN and GND pins. Place the external feedback resistors next to the FB pin. Keep the switching node SW short and away from the feedback network.
PACKAGE INFORMATION

QFN16 (4 x 4mm)

TOP VIEW

BOTTOM VIEW

SIDE VIEW

DETAIL A

NOTE:
1) ALL DIMENSIONS ARE IN MILLIMETERS
2) EXPOSED PADDLE SIZE DOES NOT INCLUDE MOLD FLASH
3) LEAD COPLANARITY SHALL BE 0.10 MILLIMETER MAX
4) JEDEC REFERENCE IS MO-220, VARIATION VG5C.
5) DRAWING IS NOT TO SCALE

RECOMMENDED LAND PATTERN

NOTICE: The information in this document is subject to change without notice. Please contact MPS for current specifications. Users should warrant and guarantee that third party Intellectual Property rights are not infringed upon when integrating MPS products into any application. MPS will not assume any legal responsibility for any said applications.