DESCRIPTION
The MP3302 is a step-up converter designed for driving arrays of WLEDs from a single cell Lithium Ion battery. The MP3302 uses current mode, fixed frequency architecture to regulate the LED current, which is measured through an external current sense resistor. Its low 200mV feedback voltage reduces power loss and improves efficiency. The MP3302 is turned off if an over-voltage condition is present due to an open circuit condition.

The MP3302 includes under-voltage lockout, current limiting and thermal overload protection preventing damage in the event of an output overload.

The MP3302 is available in small 5-pin TSOT23 and 8-pin QFN (2mm x 3mm) packages.

FEATURES
- Internal Power MOSFET
- Drives up to 10 Series White LEDs
- Up to 87% Efficiency
- Single Wire Dimming Control
- 1.3MHz Fixed Switching Frequency
- Open Load Shutdown
- Low 200mV Feedback Voltage
- UVLO, Thermal Shutdown
- Internal 1.3A Current Limit
- Available in TSOT23-5 and 2mm x 3mm QFN8 Packages

APPLICATIONS
- 5” ~ 7” LCD Panels
- Handheld Computers and PDAs
- Digital Still Cameras
- Small LCD Displays

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TYPICAL APPLICATION

![Efficiency vs Input Voltage Graph]

**Efficiency vs Input Voltage**

- 3 WLEDs, 9 Strings
- Efficiency (%)
- Input Voltage (V)
- 3 WLEDs,9 Strings
- 60 to 95 Efficiency (%)
ORDERING INFORMATION

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Package</th>
<th>Top Marking</th>
<th>Free Air Temperature (T_A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MP3302DJ*</td>
<td>TSOT23-5</td>
<td>N6</td>
<td>–40°C to +85°C</td>
</tr>
<tr>
<td>MP3302DD**</td>
<td>QFN8 (2mm x 3mm)</td>
<td>N7</td>
<td>–40°C to +85°C</td>
</tr>
</tbody>
</table>

* For Tape & Reel, add suffix –Z (e.g. MP3302DJ–Z);
** For Tape & Reel, add suffix –Z (e.g. MP3302DD–Z);
For RoHS Compliant Packaging, add suffix –LF (e.g. MP3302DJ–LF–Z);
For RoHS Compliant Packaging, add suffix –LF (e.g. MP3302DD–LF–Z)

PACKAGE REFERENCE

ABSOLUTE MAXIMUM RATINGS (1)

- SW Pin: –0.5V to +44V
- All Other Pins: –0.3V to +6.5V

Continuous Power Dissipation (T_A = +25°C) (2)

- TSOT23-5: 0.57W
- QFN8 (2mm x 3mm): 1.56W

Storage Temperature: –55°C to +150°C

Recommended Operating Conditions (3)

- IN Supply Voltage: 2.5V to 6V
- SW Pin: V_IN to 36V
- Operating Junction Temp. (T_J): –40°C to +125°C

Thermal Resistance (4)

- TSOT23-5: θ_JA = 220°C/W
- QFN8 (2mm x 3mm): θ_JC = 80°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 T_J (MAX), the junction-to-ambient thermal resistance θ_JA, and the ambient temperature T_A. The maximum allowable continuous power dissipation at any ambient temperature is calculated by P_D (MAX) = (T_J (MAX) - T_A) / θ_JA. 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 approximately 1” square of 1 oz copper.
### ELECTRICAL CHARACTERISTICS

\( V_{\text{IN}} = V_{\text{EN}} = 5\,\text{V}, \, T_A = +25^\circ\text{C}, \) 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>Operating Input Voltage</td>
<td>( V_{\text{IN}} )</td>
<td></td>
<td>2.5</td>
<td>6</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>Supply Current (Shutdown)</td>
<td>( V_{\text{EN}} = 0,\text{V} )</td>
<td></td>
<td>4</td>
<td>8</td>
<td></td>
<td>µA</td>
</tr>
<tr>
<td>Supply Current (Quiescent)</td>
<td>( V_{\text{FB}} = 0.15,\text{V} )</td>
<td></td>
<td>690</td>
<td>850</td>
<td></td>
<td>µA</td>
</tr>
<tr>
<td>Switching Frequency</td>
<td>( f_{\text{SW}} )</td>
<td></td>
<td>1.0</td>
<td>1.3</td>
<td>1.5</td>
<td>MHz</td>
</tr>
<tr>
<td>Maximum Duty Cycle</td>
<td>( V_{\text{FB}} = 0,\text{V} )</td>
<td></td>
<td>92</td>
<td></td>
<td></td>
<td>%</td>
</tr>
</tbody>
</table>

#### Under Voltage Lockout

<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>IN Under Voltage Lockout</td>
<td>UVLO</td>
<td>( V_{\text{IN}} ) Rising</td>
<td>2.25</td>
<td>2.45</td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>Under Voltage Lockout Hysteresis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>mV</td>
</tr>
<tr>
<td>Open Lamp Shutdown Threshold</td>
<td>( V_{\text{OV}} )</td>
<td>( V_{\text{OV}} ) Rising</td>
<td>40</td>
<td>42</td>
<td>44</td>
<td>V</td>
</tr>
</tbody>
</table>

#### Enable

<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 OFF Threshold</td>
<td>( V_{\text{EN}} )</td>
<td>( V_{\text{EN}} ) Falling</td>
<td>0.4</td>
<td></td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>EN ON Threshold</td>
<td>( V_{\text{EN}} )</td>
<td>( V_{\text{EN}} ) Rising</td>
<td>0.6</td>
<td></td>
<td></td>
<td>V</td>
</tr>
<tr>
<td>Minimum EN Dimming Threshold</td>
<td>( V_{\text{FB}} = 0,\text{V} )</td>
<td></td>
<td>0.655</td>
<td>0.7</td>
<td>0.845</td>
<td>V</td>
</tr>
<tr>
<td>Maximum EN Dimming Threshold</td>
<td>( V_{\text{FB}} = 0.2,\text{V} )</td>
<td></td>
<td>1.275</td>
<td>1.4</td>
<td>1.425</td>
<td>V</td>
</tr>
</tbody>
</table>

#### Feedback

<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>FB Voltage</td>
<td>( V_{\text{EN}} = 1.5,\text{V} )</td>
<td></td>
<td>185</td>
<td>200</td>
<td>215</td>
<td>mV</td>
</tr>
<tr>
<td>FB Input Bias Current</td>
<td>( V_{\text{FB}} = 0.1,\text{V} )</td>
<td></td>
<td>-600</td>
<td>-300</td>
<td></td>
<td>nA</td>
</tr>
</tbody>
</table>

#### Output Switch

<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>SW On-Resistance (5)</td>
<td>( R_{\text{ON}} )</td>
<td></td>
<td>0.5</td>
<td></td>
<td></td>
<td>Ω</td>
</tr>
<tr>
<td>SW Current Limit (5)</td>
<td></td>
<td>Duty Cycle = 60%</td>
<td>1.33</td>
<td></td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>Thermal Shutdown (5)</td>
<td></td>
<td></td>
<td>150</td>
<td></td>
<td></td>
<td>°C</td>
</tr>
</tbody>
</table>

**Notes:**

5) Guaranteed by design.
### PIN FUNCTIONS

<table>
<thead>
<tr>
<th>Pin #</th>
<th>Pin #</th>
<th>Name</th>
<th>Pin Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8</td>
<td>SW</td>
<td>Power Switch Output. SW is the drain of the internal MOSFET switch. Connect</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>the power inductor and output rectifier to SW. SW can swing between GND</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>and 36V.</td>
</tr>
<tr>
<td>2</td>
<td>1, 5</td>
<td>GND, Exposed</td>
<td>Ground. Connect exposed pad to GND plane for proper thermal performance.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pad</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>6</td>
<td>FB</td>
<td>Feedback Input. The MP3302 regulates the voltage across the current sense</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>resistor between FB and GND. Connect a current sense resistor from the</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>bottom of the LED string to GND. Connect the bottom of the LED string to FB.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>The regulation voltage is 200mV.</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>EN</td>
<td>ON/OFF Control and Dimming Command Input. A voltage greater than 0.6V</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>will turn the part on and less than 0.4V will turn the part off. If the EN</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>pin voltage is between 0.7V and 1.4V, $V_{FB}$ is regulated between 0V and</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>200mV. To use PWM dimming, apply a 200Hz to 1KHz square wave signal with</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>amplitude greater than 1.5V to this pin.</td>
</tr>
<tr>
<td>5</td>
<td>2</td>
<td>IN</td>
<td>Input Supply Pin. Must be locally bypassed.</td>
</tr>
<tr>
<td>3</td>
<td>NC</td>
<td>No Connect.</td>
<td></td>
</tr>
</tbody>
</table>
TYPICAL PERFORMANCE CHARACTERISTICS

Vin = 5V, 3WLEDs 9Strings, unless otherwise noted.

Efficiency vs Input Voltage

Steady State Operation

Enable Startup

Enable Shutdown

Start Up into Openload

PWM Dimming

Output Current vs Analog Dimming Voltage

Output Current vs PWM Dimming Duty

Efficiency vs Input Voltage

Steady State Operation

Enable Startup

Enable Shutdown

Start Up into Openload

PWM Dimming

Output Current vs Analog Dimming Voltage

Output Current vs PWM Dimming Duty
OPERATION

The MP3302 uses a constant frequency, peak current mode boost regulator architecture to regulate the series string of white LEDs. The operation of the MP3302 can be understood by referring to the block diagram of Figure 1.

At the start of each oscillator cycle the FET is turned on through the control circuitry. To prevent sub-harmonic oscillations at duty cycles greater than 50 percent, a stabilizing ramp is added to the output of the current sense amplifier and the result is fed into the positive input of the PWM comparator. When this voltage equals the output voltage of the error amplifier the power FET is turned off.

The voltage at the output of the error amplifier is an amplified version of the difference between the 200mV reference voltage and the feedback voltage. In this way the peak current level keeps the output in regulation.

If the feedback voltage starts to drop, the output of the error amplifier increases. This results in more current flowing through the power FET, thus increasing the power delivered to the output.

Figure 1—Functional Block Diagram
APPLICATION INFORMATION

Figure 2—Circuit for Driving 9 Strings of 3 WLEDs

A typical application circuit can be seen in Figure 2. The 9 strings of 3 white LEDs can be driven from a voltage supply range of 3.3V to 6V at an output current of 180mA. A 0.47µF output capacitor is sufficient for most applications. A 4.7µH inductor with low DCR (Inductor DC resistance) is recommended to improve efficiency. A 10µF ceramic capacitor is recommended for the input capacitance in the real system. Schottky diodes have fast recovery and a low forward voltage and are recommended. Schottky diodes rated with 500mA are sufficient for the MP3302. The MP3302 has internal soft-start to limit the amount of current through VIN at startup and to also limit the amount of overshoot on the output.

The ramped voltage that is added to the current sense amplifier reduces the current output as the duty cycle increases. As more LEDs are added, the output voltage rises but the current that can be delivered to the load is reduced as well.

Setting the LED Current

The LED current is controlled by the feedback resistor, R1. The current through the LEDs is given by the equation 200mV/R1. Table 1 shows the selection of resistors for a given LED current.

<table>
<thead>
<tr>
<th>ILED (mA)</th>
<th>R1 (Ω)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>200</td>
</tr>
<tr>
<td>5</td>
<td>40</td>
</tr>
<tr>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>60</td>
<td>3.33</td>
</tr>
<tr>
<td>180</td>
<td>1.11</td>
</tr>
</tbody>
</table>
LED Current Programming
Applying a DC voltage between 0.7V and 1.4V to EN pin programs a feedback voltage between 0V and 200mV. Thus the analog dimming of LED current can be achieved. The DC dimming voltage must be locally bypassed to prevent noise interfering with the feedback reference level.

PWM Dimming
Apply a 200Hz to 1kHz square waveform to the EN pin to implement PWM dimming of the LEDs. The minimum recommended amplitude of the PWM signal is 1.5V.

For high frequency PWM dimming (>1kHz), it is also recommended that the dimming control be implemented as shown in Figure 3. The cut off frequency of the RC filter should be 10 times lower than that of the input PWM signal. For example, when the PWM frequency is 20kHz, a 20kΩ resistor and 100nF capacitor can be used. The DC voltage on EN pin is then equal to the PWM high level voltage multiplies the PWM duty. The DC voltage from 0.7V to 1.4V programs the output current from 0~100%.

Open Load Protection
Open Load protection will shut off the MP3302 if the output voltage goes too high. In some cases an LED may fail, this will result in the feedback voltage always being zero. The part will run at maximum duty cycle boosting the output voltage higher and higher. If the output ever exceeds 42V, the MP3302 will shut down. The part will not switch again until the power is recycled.

Layout Considerations
Careful attention must be paid to the PCB board layout and components placement. Proper layout of the high frequency switching path is critical to prevent noise and electromagnetic interference problems. The current loop of IC, output diode, and output capacitor should be as short as possible.

The IN pin of the IC must be locally bypassed. A RC filter is highly recommended for eliminating the noise on IN pin. It could be implemented as shown in Figure 4.

Figure 3—High Frequency PWM Dimming Control

Figure 4—Input Bias Filtering
Figure 5 — Driving 27 WLEDs (9 WLEDs in Series and 3 Strings Paralleled) with 3.3V—18V Input Voltage

In order to improve the MOSFET on-resistance at low input voltage and make the chip compatible for high input voltage, the additional bias circuit should be used.

Figure 6 — Wide Input Voltage Sepic Converter for 27 WLEDs (3 WLEDs in Series and 9 Strings Paralleled)
Figure 7 — Driving 10 WLEDs in Series with 3V—6V Input Voltage

Figure 8 — Driving 27 WLEDs (3 WLEDs in Series and 9 Strings) with 3 V Input Voltage
PACKAGE INFORMATION

TSOT23-5

TOP VIEW

RECOMMENDED LAND PATTERN

FRONT VIEW

SIDE VIEW

NOTE:

1) ALL DIMENSIONS ARE IN MILLIMETERS.
2) PACKAGE LENGTH DOES NOT INCLUDE MOLD FLASH, PROTRUSION OR GATE BURR.
3) PACKAGE WIDTH DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSION.
4) LEAD COPLANARITY (BOTTOM OF LEADS AFTER FORMING) SHALL BE 0.10 MILLIMETERS MAX.
5) DRAWING CONFORMS TO JEDEC MO-193, VARIATION AA.
6) DRAWING IS NOT TO SCALE.

DETAIL “A”
QFN8 (2mm x 3mm)

**TOP VIEW**

**BOTTOM VIEW**

**SIDE VIEW**

**DETAIL A**

**RECOMMENDED LAND PATTERN**

**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) DRAWING CONFORMS TO JEDEC MO-229, VARIATION VCED-2.
5) DRAWING IS NOT TO SCALE.