How Overcurrent Protection Works in the MAX77812

Abstract: The MAX77812 is a quad-phase, high-current, step-down (buck) converter for high-end gaming consoles, VR/AR headsets, DSLR cameras, drones, network switches and routers, and FPGA systems that use multi-core processors. This application note explains the MAX77812 overcurrent protection scheme and provides $I_{PLIM}/I_{VLIM}$ selection guidelines for a given maximum load current.

Introduction

The MAX77812 provides cycle-by-cycle peak and valley current limit protection by monitoring the current through high- and low-side MOSFETs. The programmable peak current limit ($I_{PLIM}$) and valley current limit ($I_{VLIM}$) allows the customer to set the inductor current limit based on the application.

Overcurrent Protection Scheme

When the output is a short to ground, the output voltage collapses and the average inductor current increases rapidly, which results in hitting the $I_{PLIM}$ threshold. When the fault condition persists, the inductor current can increase the staircase beyond the $I_{PLIM}$ threshold due to the minimum on-time requirement.

In order to address this issue, the MAX77812 introduces the $I_{VLIM}$ threshold. When the inductor current reaches the $I_{PLIM}$ threshold, the high-side MOSFET turns off immediately, allowing the inductor current to discharge its energy through the low-side MOSFET. Until the inductor current falls down to the $I_{VLIM}$ threshold, the high-side MOSFET is not allowed to turn on. Thus, the short circuit current is limited way below the $I_{PLIM}$ threshold.

In the event of a short circuit, the MAX77812 does not terminate its operation. When the output is a short to ground, the output voltage collapses, and a POK interrupt is generated by the MAX77812. Then, an application processor or a microcontroller unit can handle this interrupt signal to recover the system.

Figure 1 shows the overcurrent protection scheme.
I_{PLIM} and I_{VLIM} Selection

The MAX77812 supports the programmable I_{PLIM} and I_{VLIM} thresholds. Each master has its own configuration registers, and there are eight options of I_{PLIM}/I_{VLIM} pairs, as shown in Table 1.

<table>
<thead>
<tr>
<th>Mx_ILIM[2:0] in Mx_CFG Registers</th>
<th>I_{PLIM}</th>
<th>I_{VLIM}</th>
<th>I_{LOADMAX}</th>
</tr>
</thead>
<tbody>
<tr>
<td>000b</td>
<td>3.0A</td>
<td>2.0A</td>
<td>2.5A</td>
</tr>
<tr>
<td>001b</td>
<td>3.6A</td>
<td>2.4A</td>
<td>3.0A</td>
</tr>
<tr>
<td>010b</td>
<td>4.2A</td>
<td>2.8A</td>
<td>3.5A</td>
</tr>
<tr>
<td>011b</td>
<td>4.8A</td>
<td>3.2A</td>
<td>4.0A</td>
</tr>
<tr>
<td>100b</td>
<td>5.4A</td>
<td>3.6A</td>
<td>4.5A</td>
</tr>
<tr>
<td>101b*</td>
<td>6.0A</td>
<td>4.0A</td>
<td>5.0A</td>
</tr>
<tr>
<td>110b</td>
<td>6.6A</td>
<td>4.4A</td>
<td>5.5A</td>
</tr>
<tr>
<td>111b</td>
<td>7.2A</td>
<td>4.8A</td>
<td>6.0A</td>
</tr>
</tbody>
</table>

*POR Default

The following equations and examples are guides to choosing the optimal I_{PLIM}/I_{VLIM} setting. Consider the maximum required load current to determine the I_{PLIM} thresholds. The following equation shows how to decide a proper I_{PLIM}:

\[ I_{PLIM} > I_{LOADMAX} + \frac{\Delta I_L}{2} \]

where I_{LOADMAX} is the maximum load current and \( \Delta I_L \) is the inductor current ripple.

Derive the inductor current ripple by using the following equation:
\[
\Delta I_L = \frac{(V_{IN} - V_{OUT}) \times D \cdot T}{L}
\]
\[
= \frac{(V_{IN} - V_{OUT}) \times (V_{OUT}/V_{IN})}{L \times f_{SW}}
\]

For example, a device has the following operating conditions:

\[V_{IN} = 3.8\text{V}\]
\[V_{OUT} = 1.0\text{V}\]
\[f_{SW} = 2.0\text{MHz}\]
\[L = 220\text{nH}\]

The calculated inductor current ripple is 1.675A. If the maximum required load current is 5.0A, \(I_{PLIM}\) should be higher than 5.84A, as shown by the following calculation:

\[I_{PLIM} > 5.0\text{A} + \frac{1.675\text{A}}{2}\]

Then, the \(I_{PLIM}/I_{VLIM}\) pair can be set to 6.6A/4.4A with some margin.

When the output short occurs, the maximum output current is limited by the \(I_{PLIM}/I_{VLIM}\) thresholds, as expressed by the following equation:

\[I_{OUTMAX} = \frac{I_{PLIM} + I_{VLIM}}{2}\]

For example, when the \(I_{PLIM}/I_{VLIM}\) thresholds are set to 6.6A/4.4A, the maximum output current is limited to 5.5A.

<table>
<thead>
<tr>
<th>Related Parts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MAX77812</strong></td>
</tr>
</tbody>
</table>

More Information
For Samples: [https://www.maximintegrated.com/en/samples](https://www.maximintegrated.com/en/samples)
Other Questions and Comments: [https://www.maximintegrated.com/en/contact](https://www.maximintegrated.com/en/contact)

APPLICATION NOTE 6820, AN6820, AN 6820, APP6820, Appnote6820, Appnote 6820