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APPLICATION NOTE 6820

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.

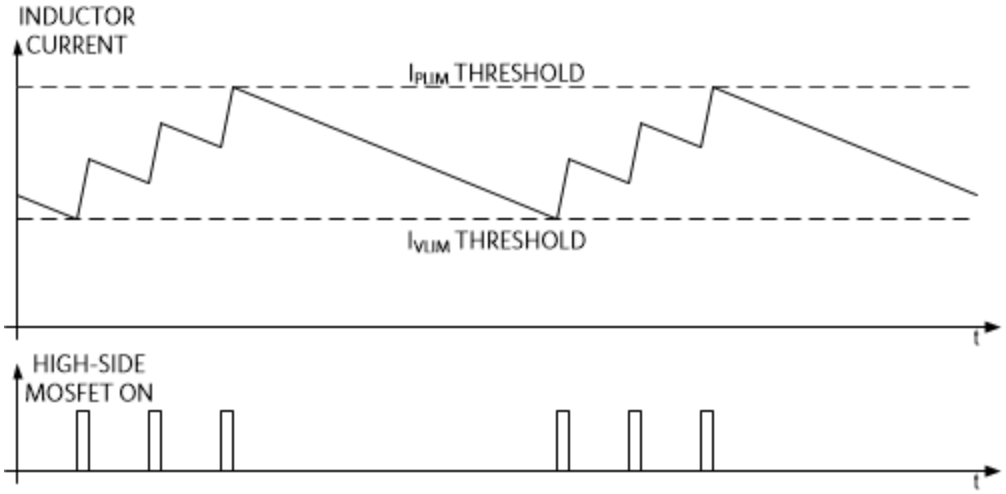

Figure 1. Overcurrent protection scheme with I_{PLIM} and I_{VLIM}.

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 1. I_{PLIM} and I_{VLIM} Selection Register

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

**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 ΔI_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.

Related Parts		
MAX77812	20A User-Configurable Quad-Phase Buck Converter	Samples

More Information
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