LM3743 High Performance Controller with Comprehensive Fault Protection Features Designed for High Reliability Systems

National Semiconductor
Application Note 1669
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June 2007

Introduction

The LM3743 is a DC-DC voltage mode PWM buck controller featuring synchronous rectification at 300 kHz or 1 MHz. It can deliver current as high as 20A and step down from an input voltage between 3V and 5.5V down to a minimum output voltage of 0.8V. It is a highly integrated device in a small MSOP-10 package. Features include; pre-biased soft-start, tracking capability, and comprehensive fault protection features suitable for high reliability systems such as rack mounted servers and telecom base station subsystems.

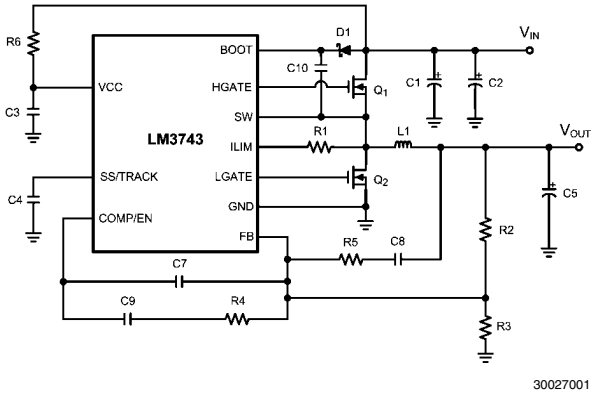

FIGURE 1. Typical Application Circuit

Data center facilities and telecom base station subsystems must manage the balance of two essential commodities - power and cooling capacity. For example, processors in rack mounted servers demand large amounts of power and are one of the greatest sources of heat during normal operation. Substantial increases in heat during normal operation and fault conditions will reduce the reliability of many components in the server racks including semiconductor components, hard drives, and fans. The LM3743 will minimize power consumption during fault conditions thereby reducing thermal loads and increasing reliability.

LM3743 Comprehensive Fault Protection Features

The LM3743 provides the following comprehensive fault protection features: high side current limit (HSCL), output undervoltage protection (UVP), and low side current limit (LSCL). When engaged, these three features can each independently initiate a hiccup protection mode which disables both the high-side and low-side FETs and begin a cool down period of 5.5 ms, see Figure 2. At the conclusion of this cool down period, the LM3743 performs an internal 3.6 ms soft-start to check for the removal of the fault condition and to continue normal operation. Hiccup protection mode enables the system designer to avoid the need to over design components due to thermal runaway during fault conditions resulting in a lower bill of material cost.

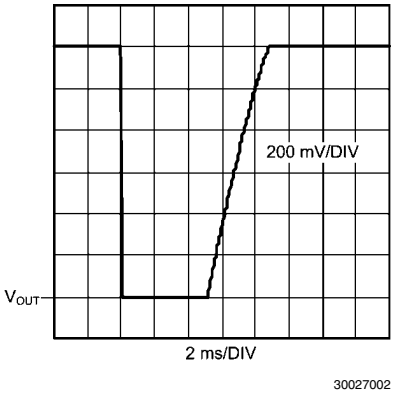

FIGURE 2. Hiccup Time Out and Internal Soft-Start

To help quantify the power consumption during a persistent fault condition, let us examine an application with a 10A low-side current limit. Once in overload, the low-side current limit controls the valley current and only allows an average of 10A plus the ripple current to pass through the inductor and MOSFETs. Hiccup mode initializes after 15 switching cycles allowing only a very small temperature rise. Once in hiccup mode, the average current through the high-side FET is:

$$I_{HSF\text{-}AVE} = (I_{CLIM} + \Delta I) \times [D(15 \text{ cycles} \times T_{SW})] / 5.5 \text{ ms} = 71 \text{ mA}$$

With an arbitrary D = 60%, ripple current of 3A, and a 300 kHz switching frequency.

The average current through the low-side FET is:

$$I_{LSF\text{-}AVE} = (I_{CLIM} + \Delta I) \times [(1–D) \times (15 \text{ cycles} \times T_{SW})] / 5.5 \text{ ms} = 47 \text{ mA}$$

And the average current through the inductor is:

$$I_{L\text{-}AVE} = (I_{CLIM} + \Delta I) \times [(15 \text{ cycles} \times T_{SW})] / 5.5 \text{ ms} = 118 \text{ mA}$$

Protecting Typical Fault Conditions in High-Reliability Systems

Server racks and telecom base station subsystems require high reliability to enable uninterrupted flow of data and communication. When unexpected failures occur, the LM3743 fault protection features can help to prevent further electrical and thermal stress. Examining some typical system fault conditions, we can elaborate on the protection modes of the LM3743 device and the operational benefit:

1. A capacitor such as a POS-cap located at the output of the LM3743 fails as a short circuit after an over-voltage surge exceeds the maximum capacitor voltage rating, refer to Figure 3. In such a situation duty cycle and the inductor current increase cycle by cycle, but fortunately input current is decreased because the LM3743s' UVP initializes Hiccup-Mode.
2. A small piece of metal falling into the product from the outside or a piece of metal that was loose in the product changes positions during shipment and lands across the

switch node (V_{SW}) and ground, see Figure 4. High side current limit immediately senses the short circuit fault condition.

3. Excessive load and/or incorrect selection of the MOSFET results in an open circuit failure. For example; if the low side MOSFET (Q2) fails, depicted in Figure 5, the inductor current will not flow during the time Q2 should be on, thus the inductor current will increase cycle by cycle. The high side current limit will capture the over current event, thereby protecting the high side MOSFET (Q1) from over heating and failure.

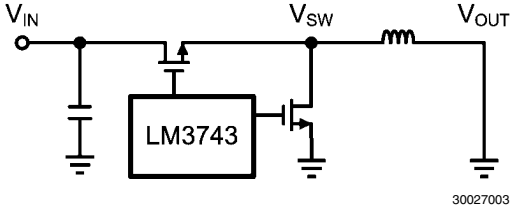

FIGURE 3. Output Short-Circuit to Ground

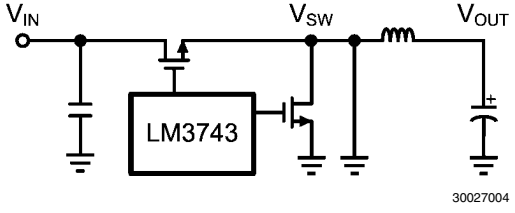

FIGURE 4. Switch Node Short-Circuit to Ground

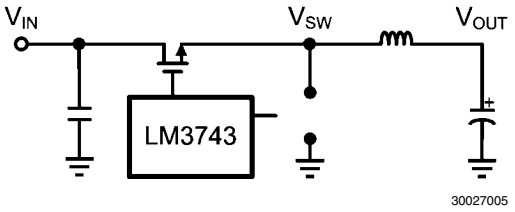

FIGURE 5. Low Side MOSFET Open-Circuit Failure

In all these situations the LM3743 provides fault protection, reduces the average input current and relieves the power components from thermal stress during persistent fault conditions. After the removal of the fault condition, the LM3743 performs an automatic self test and recovery sequence. User intervention is not required, in so reduces maintenance cost and designed in circuit complexity.

The LM3743 provides comprehensive fault protection and a reduction in server power consumption during fault conditions. It also combines high efficiency with high drive capabilities for loads up to 20A. With the LM3743, the balance between power and cooling capacity are much more manageable during device failure and short circuit conditions.

For datasheet, evaluation board, application note, and reference design information go to: www.national.com/pf/LM/LM3743.html.

Notes

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