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Spec No: 002-17968

Spec Title: AN217968 - DESIGNING A POWER MANAGEMENT SYSTEM WITH MB3800 BOOST TOPOLOGY

Replaced by: None

Designing a Power Management System with MB3800 Boost Topology

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Associated Part Family: MB3800
Related Documents: MB3800 Datasheet

AN217968 explains how to select components for a power management system with MB3800, Cypress's one-channel power management IC (PMIC.)

1 Introduction

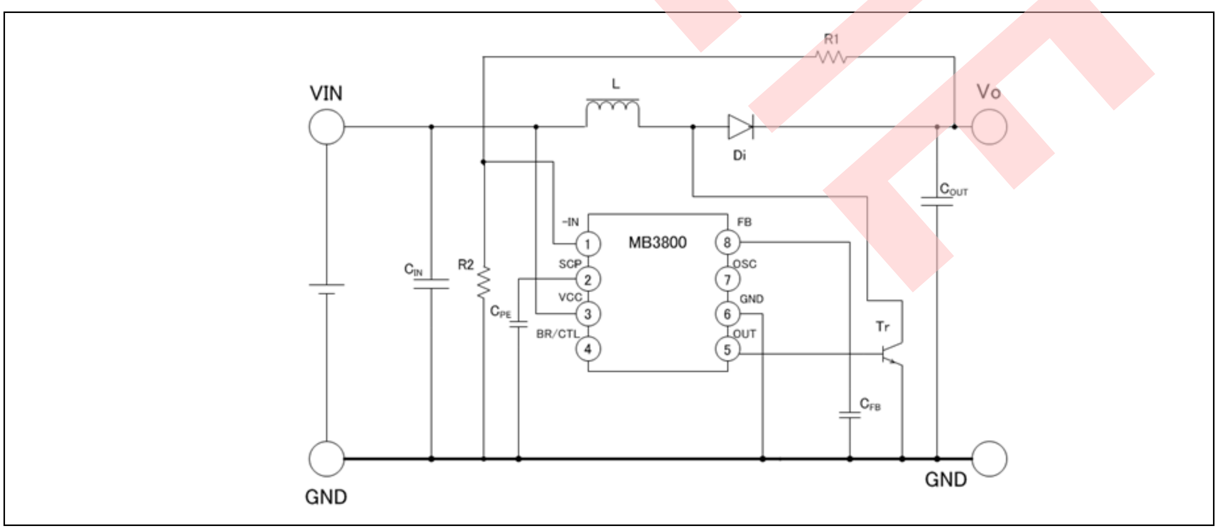
MB3800 is 1-ch low-voltage PMIC with a built-in soft-start function and short-circuit detection function. The minimum operating voltage is as low as 1.8 V that helps provide optimum power to battery-powered electronic devices. The output voltage can be set by an external resistor. Figure 1 shows a block diagram of 1-ch boost DC/DC controller using MB3800. You should keep certain considerations in mind when you design a power supply system with MB3800.

Figure 1. Power Management System Block Diagram

2 Component Selection for Boost DC/DC Converter

Figure 2 depicts the boost DC/DC converter circuit as an MB3800 application example. This section explains how to choose each component shown in the figure.

Figure 2. Boost Circuit



2.1 Output Setting Resistors (R1, R2)

A pair of voltage-dividing resistors (R1 and R2) configures the output voltage (V_O) according to Equation 1.

Equation 1

$$V_O = V_T \times \frac{R1 + R2}{R2}$$

Where:

R1, R2: Output voltage setting resistance (Ω)

V_T: Input threshold voltage at -IN pin = 0.5 (V)

V_O: Output setting voltage (V)

2.2 Inductor (L)

Generally, the inductance of the inductor will be selected along with the value of the E6 series. You should calculate the maximum current value using Equation 2 to confirm whether the electric current that flows through the inductor is within the rated parameters for the inductor.

Equation 2

$$IL_{MAX} \geq \frac{Vo \times I_{O\_MAX}}{V_{IN\_MIN}} + \frac{\Delta I_L}{2}, \quad \Delta I_L = \frac{V_{IN\_MIN}}{L} \times \frac{V_O - V_{IN\_MIN}}{V_O \times f_{OSC}}$$

Where:

IL_{MAX}: Rated current of inductor (A)

I_{O_MAX}: Maximum load current (A)

ΔI_L: Ripple current peak-to-peak value of inductor (A)

L: Inductance of inductor (H)

V_{VIN_MIN}: Minimum power supply voltage (V)

V_O: Output setting voltage (V)

f_{OSC}: Switching frequency (Hz)

2.3 Input Capacitor (C_{IN})

A ceramic capacitor that has a low equivalent series resistance (ESR), typically less than 10 mΩ, and excellent frequency characteristics—that is, the capacitance is not reduced up to the switching frequency—should be used. Generally, the capacitance will be selected along with the value of the E6 series. A value greater than 20 µF is recommended. Calculate the necessary rated voltage of the input capacitor by using Equation 3.

Equation 3

$$V_{CIN} > V_{IN}$$

Where

V_{CIN}: Rated voltage of input capacitor (V)

V_{IN}: Power supply voltage (V)

2.4 Output Capacitor (C_{OUT})

A ceramic capacitor that has a low ESR and excellent frequency characteristics should be used. Generally, the capacitance will be selected along with the value of the E6 series. A value greater than 20 µF is recommended. When considering a ceramic capacitor, you should take into account the reduction of capacitance due to the DC bias characteristics of the capacitor itself. Generally, a large capacitor has a stable DC bias characteristic. Calculate the necessary rated voltage of the output capacitor by using Equation 4.

Equation 4

$$V_{COUT} > V_O$$

Where:

V_{COUT}: Rated voltage of output capacitor (V)

V_O: Output setting voltage (V)

2.5 NPN Switching Transistor (Tr)

Calculate the maximum collector current value using Equation 5 to confirm whether the collector current of the NPN switching transistor is within the rated parameters for the transistor.

Equation 5

$$I_C \geq \frac{Vo \times I_{O\_MAX}}{V_{IN\_MIN}} + \frac{V_{IN\_MIN}}{2L} \times \frac{V_O - V_{IN\_MIN}}{V_O \times f_{OSC}}$$

Where:

I_C: Rated current of transistor (A)

I_{O_MAX}: Maximum load current (A)

L: Inductance of inductor (H)

V_{VIN_MIN}: Minimum Power supply voltage (V)

V_O: Output setting voltage (V)

f_{OSC}: Switching frequency (Hz)

Calculate the required hfe value using Equation 6 to confirm whether the peak collector current can be supplied by the base current of the NPN switching transistor.

Equation 6

$$hfe \geq \frac{1}{I_B} \times \left(\frac{V_O \times I_{O\_MAX}}{V_{IN\_MIN}} + \frac{V_{IN\_MIN}}{2L} \times \frac{V_O - V_{IN\_MIN}}{V_O \times f_{OSC}} \right)$$

Where:

hfe: hfe of NPN switching transistor (A)

I_B: Base current that can be supplied from MB3800=0.02 (A)

I_{O_MAX}: Maximum load current (A)

L: Inductance of inductor (H)

V_{VIN_MIN}: Minimum Power supply voltage (V)

V_O: Output setting voltage (V)

f_{OSC}: Switching frequency (Hz)

Calculate the necessary rated voltage of the transistor by using Equation 7.

Equation 7

$$V_{CEO} > V_O$$

Where:

V_{CEO}: Voltage between Tr collector -emitter (V)

V_O: Output setting voltage (V)

2.6 Flyback Diode (Di)

Calculate the necessary rated voltage of the flyback diode by using Equation 8.

Equation 8

$$V_R > V_O$$

Where

V_R: DC reverse voltage (V)

V_O: Output setting voltage (V)

Calculate the necessary rated average current of the diode by using Equation 9.

Equation 9

$$I_{Di} \geq I_O$$

Where

I_{Di}: Diode average current (A)

I_O: Load current (A)

Calculate the necessary rated peak current of the diode by using Equation 10.

Equation 10

$$I_{Dip} \geq \frac{Vo \times Io}{V_{IN\_MIN}} + \frac{V_{IN\_MIN}}{2L} \times \frac{V_O - V_{IN\_MIN}}{V_O \times f_{OSC}}$$

Where

I_{Dip}: Diode peak current (A)

V_O: Output setting voltage (V)

I_O: Load current (A)

V_{VIN_MIN}: Minimum Power supply voltage (V)

L: Inductance of inductor (H)

f_{OSC}: Switching frequency (Hz)

The reverse recovery time of diode ($t_{rr\ (Di)}$) should be earlier than the turn-on time of the switching Tr ($t_{on\ (Tr)}$). Calculate the reverse recovery time of diode ($t_{rr\ (Di)}$) by using Equation 11.

Equation 11

$$t_{on(Tr)} > t_{rr(Di)}$$

Where:

$t_{on(Tr)}$: Turn-on time of the switching Tr (ns)

$t_{rr(Di)}$: Reverse recovery time of diode (ns)

2.7 FB Capacitor (C_{FB})

A ceramic capacitor that has a low ESR and excellent frequency characteristics should be used. Calculate the necessary rated voltage of the capacitor by using Equation 12.

Equation 12

$$V_{CFB} > V_{IN}$$

Where:

V_{IN}: Power supply voltage (V)

V_{CFB}: Rated voltage of FB capacitor (V)

2.8 SCP Capacitor (C_{PE})

The soft-start time and short detection time can be set by the SCP capacitor (C_{PE}).

2.8.1 Soft Start

At power on, the capacitor CPE connected to the SCP pin (pin 2) starts charging. The PWM comparator compares the soft start setting voltage as a proportion of the voltage at the SCP pin with the sawtooth waveform. The comparison controls the ON duty of the OUT pin (pin 5), causing the soft start operation. On completion of the soft start operation, the voltage at the SCP pin stays low, the soft start setting voltage stays high, and the circuit enters the output short circuit detection wait state. Soft start time is the time until the output ON duty reaches approximately 50%.

Equation 13

$$t_S \approx 0.35 \times C_{PE}$$

Where:

t_S: Soft start time (s)

C_{PE}: SCP capacitor value (µF)

A ceramic capacitor that has a low ESR and excellent frequency characteristics should be used for SCP capacitor. Calculate the necessary rated voltage of the capacitor by using Equation 14.

Equation 14

$$V_{CPE} > V_{IN}$$

Where:

V_{IN}: Power supply voltage (V)

V_{CPE}: Rated voltage of SCP capacitor (V)

2.8.2 Short Circuit Protection

Calculate the short-circuit detection time by using Equation 15.

Equation 15

$$t_{PE} \approx 0.8 \times C_{PE}$$

Where:

t_{PE}: Short circuit detection time (s)

C_{PE}: SCP capacitor value (µF)

A ceramic capacitor that has a low ESR and excellent frequency characteristics should be used for SCP capacitor. Calculate the necessary rated voltage of the capacitor by using Equation 16.

Equation 16

$$V_{CPE} > V_{IN}$$

Where:

V_{IN}: Power supply voltage (V)

V_{CPE}: Rated voltage of SCP capacitor (V)

Document History

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Revision	ECN	Orig. of Change	Submission Date	Description of Change
**	5744956	ATTS	05/26/2017	New application note
*A	6460001	SSAS	01/25/2019	Obsoleted

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