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APPLICATION NOTE 6823

GENERATING A HIGHER OUTPUT VOLTAGE THAN 1.525V USING 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 multicore processors. The maximum output voltage of the MAX77812 is 1.525V per register setting. However, the output voltage can be increased up to 2.7V with an external resistive voltage-divider. This document provides a formula that determines the external resistor values for a given output voltage and explains practical considerations for it.

Introduction

The MAX77812 supports programmable output voltage from 0.25V to 1.525V in 5mV steps through an I^2C interface. For some applications, an output voltage higher than 1.525V is required. The MAX77812 supports the higher output voltage with the addition of an external voltage-divider network.

External Voltage-Divider Network

A buck converter regulates the output voltage to the target value by comparing the sensed output voltage (V_{SNSxP}) to the internal reference. If V_{SNSxP} is lower than the actual output voltage (V_{OUTx}), V_{OUTx} will be higher than the nominal output voltage set through the I^2C interface.

As shown in **Figure 1**, the external voltage-divider network consists of feedback resistors (R_{FB1} and R_{FB2}) and a feed-forward capacitor (C_{FF}). The resistors divide V_{OUTx} to the lower value V_{SNSxP} at the remote sense input (SNSxP):

$$V_{SNSxP} = \frac{R_{FB2}||R_{SNS}}{R_{FB2}||R_{SNS} + R_{FB1}} \times V_{OUTx}$$

(Eq. 1)

The internal sensing resistor at SNSxP is R_{SNS}. Voltage V_{SNSxP} is then compared to the internal reference set by the output voltage setting register (Mx_VOUT[7:0]). Therefore, the relation between the actual and the nominal output voltages is:

$$V_{OUTx} = \frac{R_{FB2}||R_{SNS} + R_{FB1}}{R_{FB2}||R_{SNS}} \times V_{OUTx\_nominal}$$

(Eq. 2)

An output voltage higher than 1.525V can be achieved by adjusting Mx_VOUT[7:0], and the voltage-dividing ratio is:

$$\frac{R_{FB2}||R_{SNS}}{R_{FB2}||R_{SNS} + R_{FB1}}$$

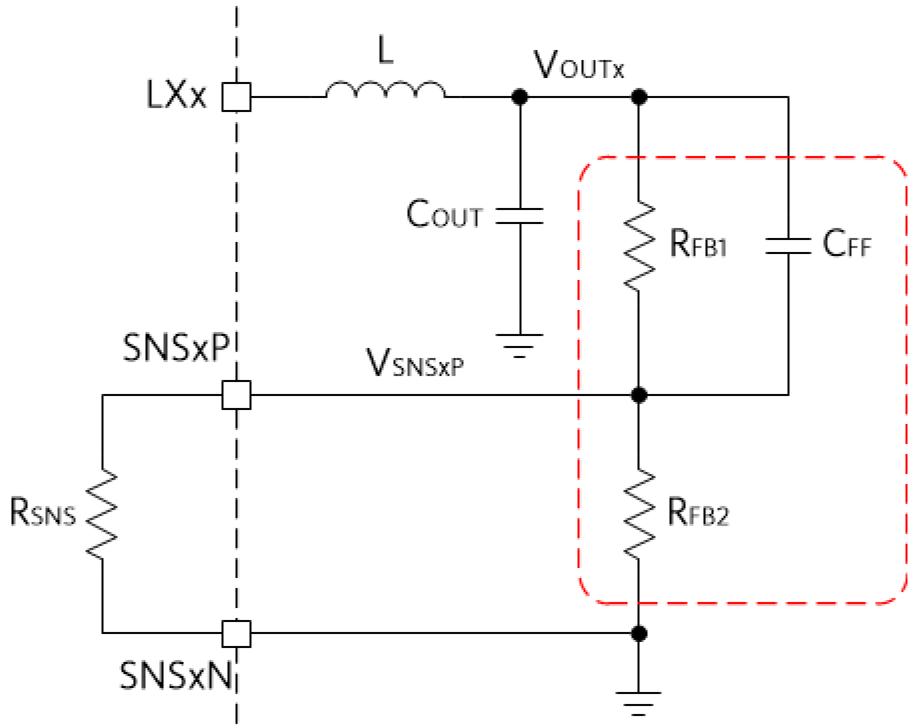

Figure 1. External voltage-divider network.

Value Selection

The selection of R_{FB1} and R_{FB2} must guarantee the accuracy of output regulation and minimize the power loss on these resistors. The resistance of R_{FB2} should be significantly smaller than R_{SNS} to be dominant. Because the resistance of R_{SNS} is approximately 350kΩ, the recommended value for R_{FB2} is around 51.1kΩ. To minimize the difference between the actual and the nominal output voltages, Mx_VOUT[7:0] is selected as close to 1.525V as possible. Once R_{FB2} and Mx_VOUT[7:0] are fixed, R_{FB1} can be selected based on equation (2). The accuracy of the output voltage highly relies on the accuracy of the voltage-dividing ratio, thus ±1% or better resistors are recommended for R_{FB1} and R_{FB2}.

The external voltage-divider network creates an additional pole and zero at (R_{FB2} ||R_{SNS}≈R_{FB2}) for simplified calculation:

$$f_p = \frac{1}{2\pi \times C_{FF} \times (R_{FB1}||R_{FB2})}$$

(Eq. 3)

$$f_z = \frac{1}{2\pi \times C_{FF} \times R_{FB1}}$$

(Eq. 4)

To maintain the loop stability, the recommended value for C_{FF} is around tens of picofarads and is determined by the values of R_{FB1} and R_{FB2}.

Table 1 shows a few examples of the value selection recommendation for common output voltages.

Table 1. Value Selection Recommendation and Measured Maximum Load Current

V_{OUTx} (V)	R_{FB1} (kΩ)	R_{FB2} (kΩ)	C_{FF} (pF)	Mx_VOUT[7:0]	Maximum Load Current (with a 0.22µH inductor)
1.8	9.09	51.1	100	0xF9 = 1.495V	4.0A at V_{IN} = 3.8V
2.4	27.4	51.1	39	0xF8 = 1.490V	2.5A at V_{IN} = 3.8V
2.7	34.8	51.1	27	0xFE = 1.520V	2.0A at V_{IN} = 3.8V

Considerations

Although the output voltage can be higher than 1.525V, it is still limited by the input voltage and load current. Theoretically speaking, the constant on-time is proportional to the ratio of the actual output voltage (V_{OUTx}) to the input voltage (V_{IN}). The MAX77812 calculates the on-time by sensing V_{SNSxP} and V_{IN}. Because V_{SNSxP} is lower than V_{OUTx}, the on-time is insufficient. As a result, more switching cycles are needed and thus the switching frequency (f_{SW}) increases. The constant on-time control architecture also exhibits higher f_{SW} when the load current increases. Therefore, supporting a high V_{OUTx} under the heavy load condition leads to a substantial increase of f_{SW}, which may be ultimately limited by the control architecture. For the same V_{IN}, the higher the actual output voltage is, the lower the maximum load current that can be supported. **Table 1** provides examples of the maximum load current measured on the bench. To mitigate the switching frequency increase, Mx_VOUT[7:0] needs to be selected as close to 1.525V as possible for a longer on-time.

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