



Low Voltage Feedback in PWM Applications

Application Note

Low Voltage Feedback in PWM Applications

Steven Mappus

Power Supply Control Products

ABSTRACT

Normally the output voltage of a switching power supply is higher than the error amplifier reference, and so a simple resistive divider between V_{OUT} and ground at the non-inverting input of the PWM error amplifier is all that's required to set the regulation voltage. However, when V_{OUT} is less than the error amplifier reference voltage, the feedback voltage must be *divided* up instead of down. A simple technique for feeding back an output voltage lower than the PWM internal error amplifier reference voltage is shown. Practical design equations are developed and applied to a simple application schematic.

1 Introduction

For low-voltage, high-current power supply applications, the gate drive requirements of a switching power supply become especially critical. As several MOSFET devices are often placed in parallel to meet the high current specifications of a particular design, the convenience of a single device controller and driver solution is no longer a viable option. MOSFETs are placed in parallel to lower the overall drain-to-source on resistance, resulting in lower conduction losses. However, as more devices are placed in parallel, the gate charge requirements quickly add up. Since the internal impedance of the MOSFET is much lower than the internal impedance of the driver stage, most of the power losses associated with driving parallel combinations of MOSFETs are seen in the form of dissipated heat within the controller device. As such, the driver stages of many single chip solutions simply are not adequate for efficiently driving higher gate charges resulting from parallel combinations of MOSFETs.

In response, the industry has recently seen an increase in advanced MOSFET driver product offerings. Many of these new drivers include drive current capability much higher than otherwise available in a single chip solution. With the driver device placed closer to the MOSFET gates, higher drive current means more parallel MOSFETs can be driven more efficiently. In addition to increased drive current, many of today's advanced MOSFET drivers also use sophisticated control techniques to precisely control the timing between two switches, such as those found in a synchronous buck application.

Using an external MOSFET driver along with a separate pulse width modulator (PWM) controller allows power supply designers the flexibility needed to meet the high performance gate drive demands of these types of low voltage, high current power converters. The combinations of features that can arise from this approach are seemingly endless given the variety of currently available PWM controllers and drivers.

As output voltages approach the sub 1-V level, power supply control manufacturers have responded by recently introducing products that include appropriate internal low-voltage references. But what if a designer wishes to use a high performance driver along with a PWM that includes an internal reference higher than the feedback voltage? In other words, to regulate an output voltage of 1 V would normally require a voltage reference of 1 V or less, available at the non-inverting input of the PWM internal error amplifier.

2 Application Example

The application circuit shown in Figure 1 proposes an alternate method for feeding back an output voltage lower than the PWM internal error amplifier reference voltage. Normally the output voltage is higher than the error amplifier reference, and so a simple resistive divider between V_{OUT} and ground sets the regulated voltage at the non-inverting input of the PWM error amplifier. However, when V_{OUT} is less than the error amplifier reference voltage, the feedback voltage must be *divided up* instead of down. Dividing up implies that some additional voltage must be added to the feedback from another regulated voltage source.

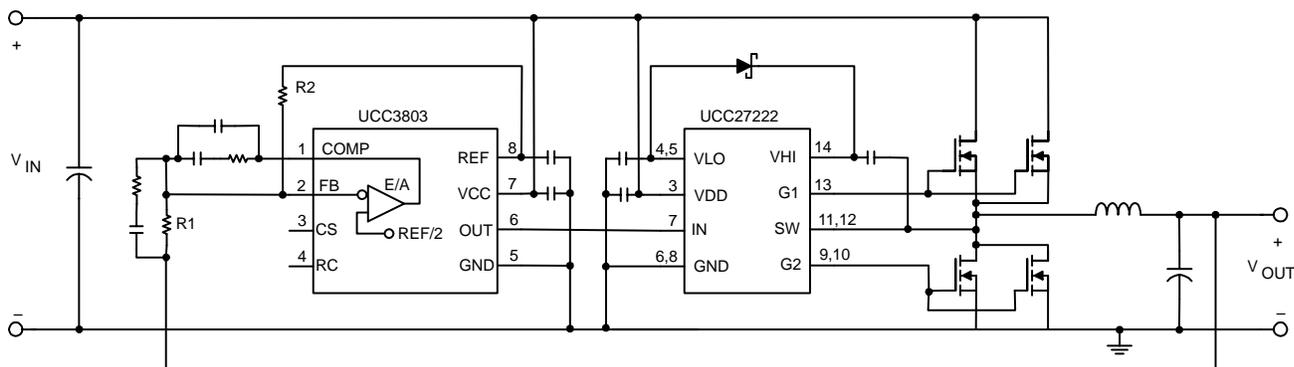


Figure 1. Low-Voltage Synchronous Buck Feedback Solution

The UCC3803, shown in Figure 1 makes the 4-V internal voltage reference available on pin 8 of the device. Also, the internal voltage at the non-inverting input of the PWM error amplifier is $V_{REF}/2$, or 2 V. By feeding back 100% of V_{OUT} through R_1 and a portion of V_{REF} through R_2 , the principle of superposition can be applied to the UCC3803 feedback node at pin 2:

$$\frac{V_{REF}}{2} = \left(\frac{R_1}{R_2 + R_1} \right) \times V_{REF} + \left(\frac{R_2}{R_2 + R_1} \right) \times V_{OUT} \quad (1)$$

Equation 1 can be simplified and expressed as a ratio of R_2 to R_1 to give:

$$\frac{R_2}{R_1} = \frac{V_{REF}}{V_{REF} - 2 \times V_{OUT}} \quad (2)$$

For the application circuit of Figure 1, the UCC3803 is configured for voltage-mode operation, so a type-three compensation scheme was appropriately chosen. Since R_1 is part of the control loop compensation, this value must be calculated first, and then R_2 is selected based upon:

$$R_2 = \left(\frac{V_{REF}}{V_{REF} - 2 \times V_{OUT}} \right) \times R_1 \quad (3)$$

As an example, if R_1 was first determined to be 1 k Ω and V_{OUT} is 1 V, R_2 can then be calculated from equation (3) as:

$$R_2 = \left(\frac{4 \text{ V}}{4 \text{ V} - 2 \times 1 \text{ V}} \right) \times (1 \times 10^3 \Omega) = 2 \text{ k}\Omega \quad (4)$$

For applications involving PWM controllers that do not make the reference voltage available external to the device, this technique can still be applied but the additional voltage, supplied by V_{REF} in Figure 1, would need to come from some other regulated source.

3 Conclusion

Whether to use a single PWM controller with an integrated driver stage, or consider a dual chip solution with an external driver device separate from the PWM controller, the choice is not always clear. The added performance benefits of a dual chip solution must be weighed closely against the cost and simplicity of a single device approach. Still, when optimal performance for low-voltage, high-current and high-frequency power conversion is absolutely necessary, the choice of which PWM controller to consider does not have to be limited by the error amplifier reference voltage.

4 References

1. *UCC27221/2 High-Efficiency Predictive Synchronous Buck Driver* Datasheet, Texas Instruments Literature No. SLUS486A.
2. *UCC3800/1/2/3/4/5 Low-Power BiCMOS Current-Mode PWM* Datasheet, Texas Instruments Literature No. SLUS270A.
3. *12-V to 1.8-V, 20-A High-Efficiency Synchronous Buck Converter Using UCC27222 with Predictive Gate Drive Technology*, User's Guide to accommodate UCC27222EVM, Texas Instruments Literature No. SLUU140.

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Mailing Address:

Texas Instruments
Post Office Box 655303
Dallas, Texas 75265