Using a Current Mode PWM Controller in Voltage Mode

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Over the years, power supply designers have been persuaded that current mode is superior to its voltage-mode counterpart. As a result, the major PWM controller manufacturers have neglected the voltage mode controller's development. Thus, it's much easier to find a suitable current-mode device than a voltage-mode controller. However, each controller mode has both advantages and disadvantages [1], [2], and therefore must be chosen as appropriate for each individual case.

Note that two cases aren't mentioned in [1] and [2] when use of current mode isn't recommended: when using half-bridge topology, and when converting very low input voltages and inserting additional impedance in primary of the circuit, thereby severely affecting efficiency.

In the first case, using a controller with push-pull outputs is imperative (unless special windings are added to the main transformer). In the second case, it's important to keep peak currents at input switches to a minimum—especially with very low input voltages operating near 100% duty cycle.

Knowing the Background

This design idea will show how easy it is to configure current-mode controller UCC2808A to operate in voltage mode with adding virtually no extra components.

The UCC2808A is a unique PWM controller offering several features from a single package, including: available in a small TSSOP 8-pin package (UCC2808APW); push-pull outputs; available in a version operating below 5 V (UCC2808-2), thereby allowing it to be powered directly from switch logic-level MOSFETs; and relatively low quiescent current (1 mA typical).

In addition, the developers at Unitrode have packed inside it another transistor, which makes it possible to use this current-mode controller in voltage mode, turning it into a dual-mode controller.

The following is a short description of pins as applicable to D or N packages:

Pin 1 (Comp): Output of Error Amplifier (E/A) and the input to PWM comparator.

Pin 2 (FB): This is a negative input of E/A, which is fed by a portion of output voltage (feedback voltage). This input is compared internally to a 2-V on-board reference voltage, which is applied to a positive input of E/A in order to regulate output voltage.

Pin 3 (CS): This is input of current-sense comparator, to which current of the main switch of the switching power supply, converted to voltage by current-sense resistor, is fed.

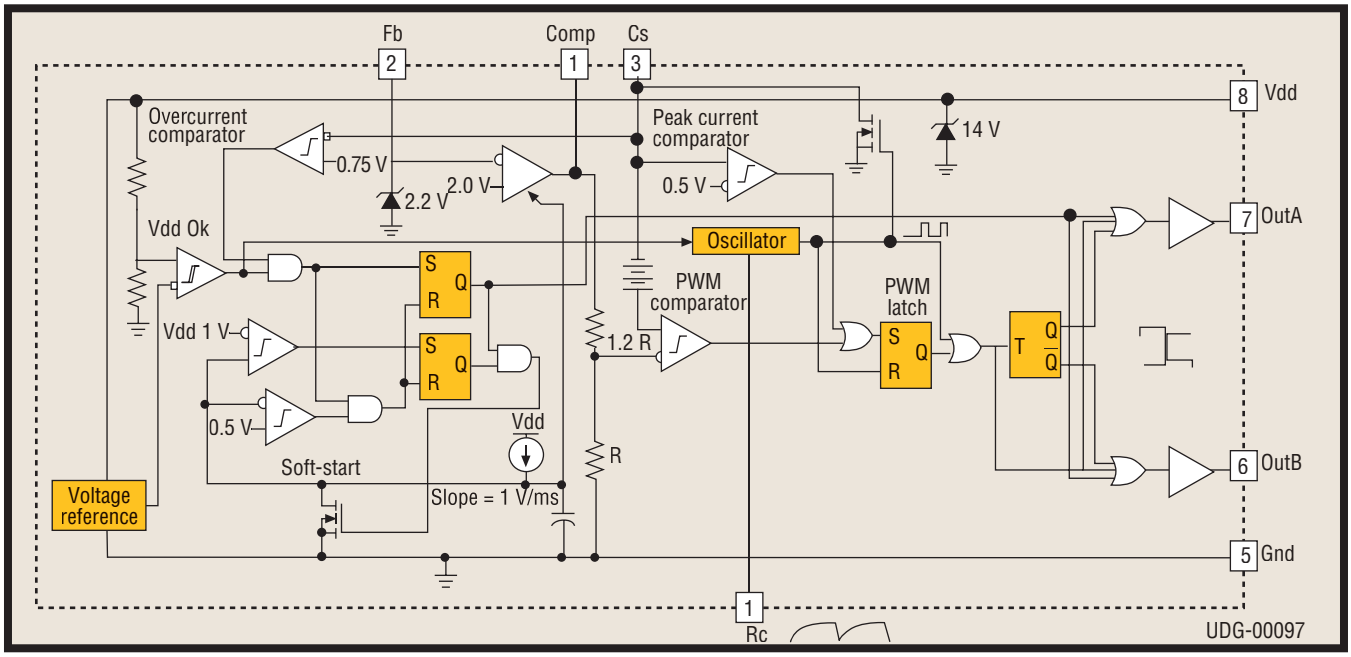

Fig. 1. *Block diagram of UCC2808A taken from a Unitrode data sheet [3].*

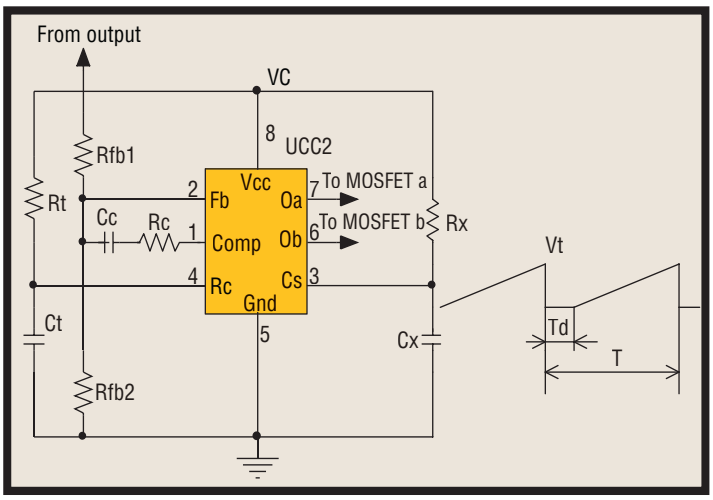

Fig. 2. *UCC2808A in voltage mode.*

Pin 4 (RC): Oscillator input. Rt and Ct, connected to this pin, set the switching frequency operation. The voltage at this pin is in a form of sawtooth.

Pin 5 (ground): Ground pin.

Pin 6, 7 (OUTB, OUTA): PWM push-pull outputs, which drive main switches.

Pin 8 (VDD): The power input connection.

Motivation

A controller was sought that operated at 2.5-W step-up from typically 0.5-V input to 5-V push-pull converter. Voltage mode was preferred, because primary needed as small impedance as possible. Operating with duty cycle near 100% would mean adding slope compensation, which would complicate loop stabilizing, moving it from pure current to voltage mode; a suitable voltage-mode controller couldn't be found. However, with careful examination of the UCC2808A, which otherwise is a typical current-mode controller, it is obvious the device offers an extra discharge transistor from CS pin to ground, which is activated each cycle. This feature, originally intended to minimize filter capacitance and filter delay, led to the conversion of the UCC2808A to a voltage-mode controller.

The Working Circuit

Fig. 2 shows how the UCC2808A was configured to operate in voltage mode. Rfb1, Cc and Rc represent feedback compensation network, which in practice was more complicated and suitable for voltage mode. Pin CS was connected to Rx, Cx network, which, in conjunction with the above-mentioned on-board transistor connected internally to this pin (**Fig. 1**), generated sawtooth ramp. This ramp is fed to internal PWM comparator and voltage mode is accomplished.

Naturally, Rx in **Fig. 2** can be connected to input voltage of the converter instead of to VCC, and feed-forward operation will be achieved. However, the designer must be cautious that voltage peak Vt under all operational conditions never exceeds 0.5 V. If Vt exceeds 0.5 V, peak current comparator will be activated, causing decrease of output voltage (**Fig. 1**). **PETech**

References

1. *Mammano, Robert, "Switching Power Supply Topology: Voltage Mode vs. Current Mode," DN-62 Unitrode Application Notes, Texas Instruments 1999.*

2. *Ridley, Dr. R., "Current Mode or Voltage mode?" Switching Power Magazine, October 2000, pp 4-9.*

3. *UCC2808A-1, UCC2808A-2, UCC3808A-1, UCC3808A-2 Low Power Current Mode Push-Pull PWM, Unitrode Products from Texas Instruments, SLUS456B, April 1999, Revised February 2001.*

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