Application Report
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Designing UCC28250 as a Secondary Side Control for Output Turn-On with a Pre-Bias Condition

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ABSTRACT

This application note addresses the considerations for using the UCC28250 as a secondary side controller. With voltage mode control, the UCC28250 can be used in a design that produces smooth turn-on performance with an output pre-bias condition. The design guidelines are summarized from various performance tests and examined particularly on a 100-W, dc-dc half bridge converter. This converter is designed for telecom input of 36 V to 75 V and an output voltage of 3.3 V. This document provides test results based on these guidelines, and also offers some test results that demonstrate the outcomes when the guidelines are not followed. Additional design details and test results can be found in the user's guide for the UCC28250EVM-564. For primary side control with the UCC28250, it is recommended to refer the UCC28250EVM-501 user's guide.

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1 Two Feedback Loops of UCC28250

Figure 1 illustrates the architecture of the UCC28250. This advanced pulse-width modulation (PWM) controller has two feedback loops, both of which sense the output voltage (V_{OUT}) for control.

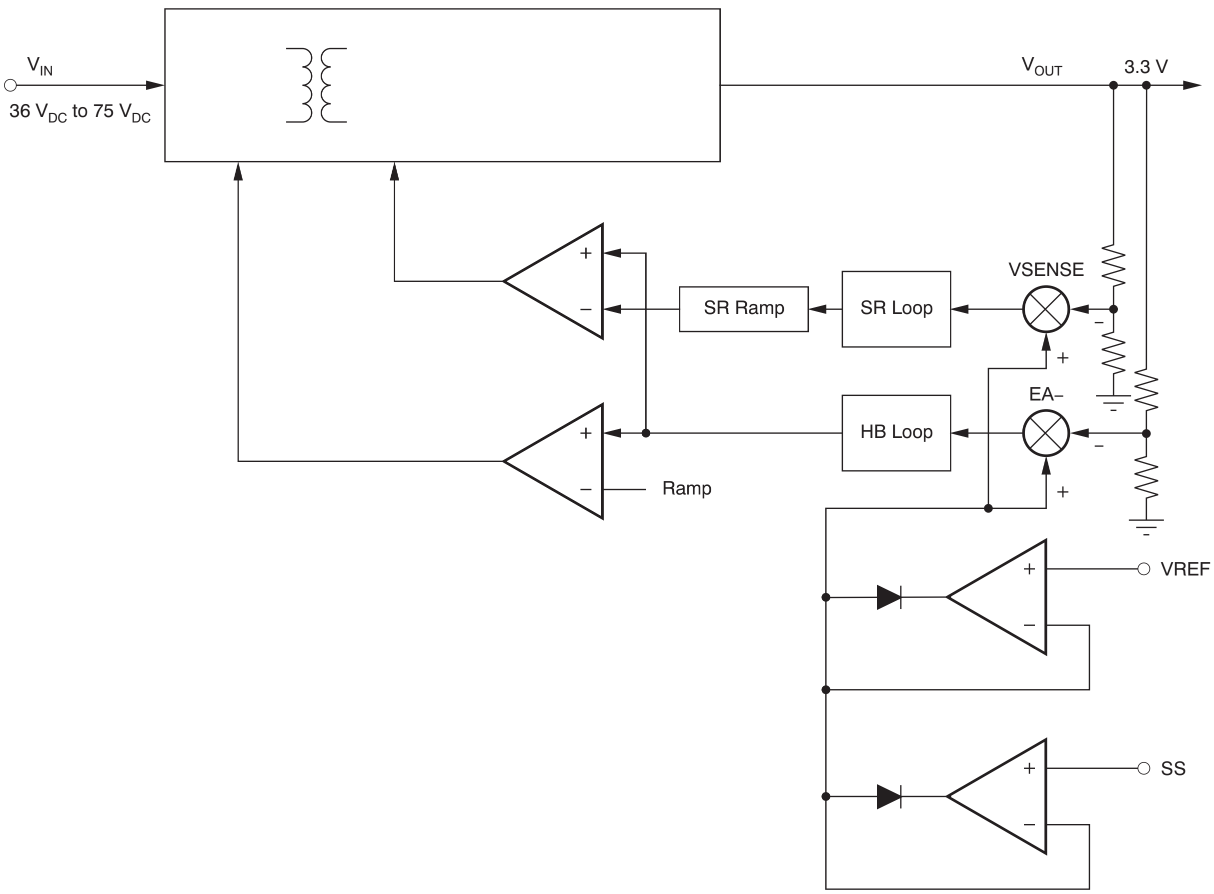

Figure 1. Two Feedback Loops of UCC28250

The loop with the sensed signal fed into VSENSE is called the *SR loop*. The loop with the sensed signal fed into EA– is called the *HB loop*. The SR loop is internally configured; that is, its internal parameters cannot be accessed externally except for the VSENSE pin feedback voltage divider; we also use VSENSE to represent this point, which is also known as the VSENSE feedback set-point. The HB loop is the standard feedback control loop that can be configured externally, such as when using the well-known Type III compensation technique in a voltage-mode control loop. To achieve a smooth turn-on with a pre-bias condition for V_{OUT}, the two loops can be designed following the suggested guidelines presented in Section 2.

2 Design Guidelines

These design guidelines are based on various performance tests using the UCC28250 to make a secondary side control with the requirement of a smooth V_{OUT} turn-on with a pre-bias condition.

1. The voltages on the VSENSE pin and on the EA– pin should meet the relationship defined by Equation 1:

$$V_{SENSE} = (1.05 \text{ to } 1.15) \times V_{EA-} \quad (1)$$

2. The output filter $L_O \times C_O$ double-pole frequency should be designed with the relationship of the switching frequency, f_{SW}, as shown in Equation 2:

$$f_{LC} \le \frac{f_{SW}}{40} \quad (2)$$

   with the output capacitor equivalent series resistance (ESR) zero frequency, f_{ESR_Z}:

   $f_{ESR\_Z} > 10 \times f_{LC}$

3. Bode plots of the HB loop-gain crossover frequency should be obtained with Equation 3:

$$f_C = (0.05 \text{ to } 0.1) \times f_{SW} \quad (3)$$

   with a phase margin not less than 45 degrees.

4. The loop-gain for the HB Loop should be designed close to 60 dB at 1 Hz.

3 Case Comparisons: Designs That Do and Do Not Follow the Design Guidelines

3.1 Case 1: UCC28250EVM-564 V_{OUT} Turn-on with Pre-Bias Condition

Case 1-1: Using the UCC28250EVM-564

Using the UCC28250EVM-564 with the specified design values:

- SR loop with VSENSE = 1.710 V and HB loop with EA– = 1.648 V

  This configuration makes VSENSE = 1.037 × V_{EA-}, or slightly lower than the recommendation from the guideline defined by Equation 1.
- Output filter double-pole frequency, f_{LC} = 4.73 kHz; switching frequency f_{SW} = 200 kHz

  These values make $f_{LC} \le f_{SW}/40$, which follows the recommendation of Equation 2.

NOTE: Any further increases in the output capacitance should continue to meet the stated guidelines, and good V_{OUT} turn-on performance can be maintained. However, when reducing the capacitance or inductance, you must ensure that the guidelines are followed.

- The HB loop-gain Bode plots are shown in Figure 2. The results show that f_C = 11.5 kHz with a phase margin of 59 degrees, which follows the guideline of Equation 3.

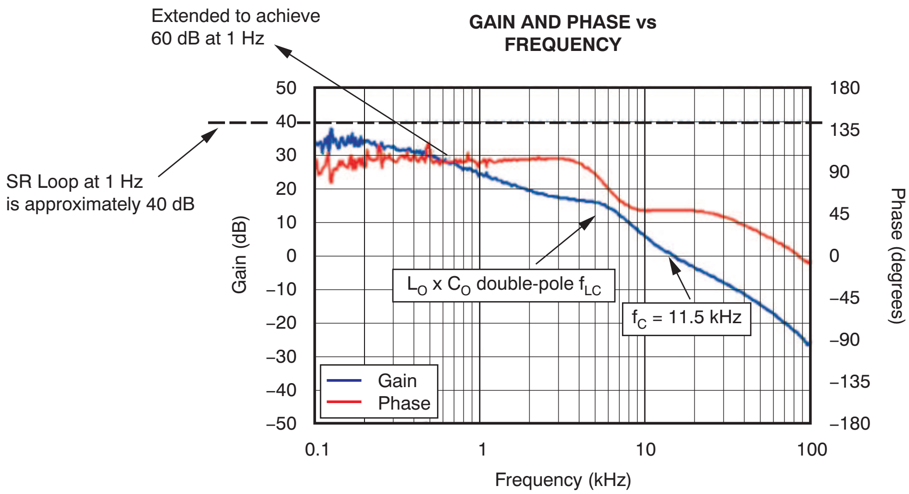

Figure 2. Case 1: HB Loop Compensation Bode Plots of HB Loop-Gain

- Based on the Bode plots, the extrapolated gain magnitude at 1 Hz is greater than 60 dB, in accordance with the fourth design guideline.
- Soft-start time is approximately 12 ms with a soft-start capacitance of 0.1 μF. Note that excessively long soft-start times can affect the actual device performance.

Case 1-2: Test Results

Figure 3 shows the output voltage (V_{OUT}) turn-on performance with regulation 3.3 V and pre-bias of 2.98 V. Based on Figure 3, the V_{OUT} turn-on is smooth and shows a monotonic rise; that is, there is no undershoot (ditch) or overshoot during the V_{OUT} turn-on from the pre-bias value to the final regulation value. Note that in Figure 3, *EN* represents the Enable signal.

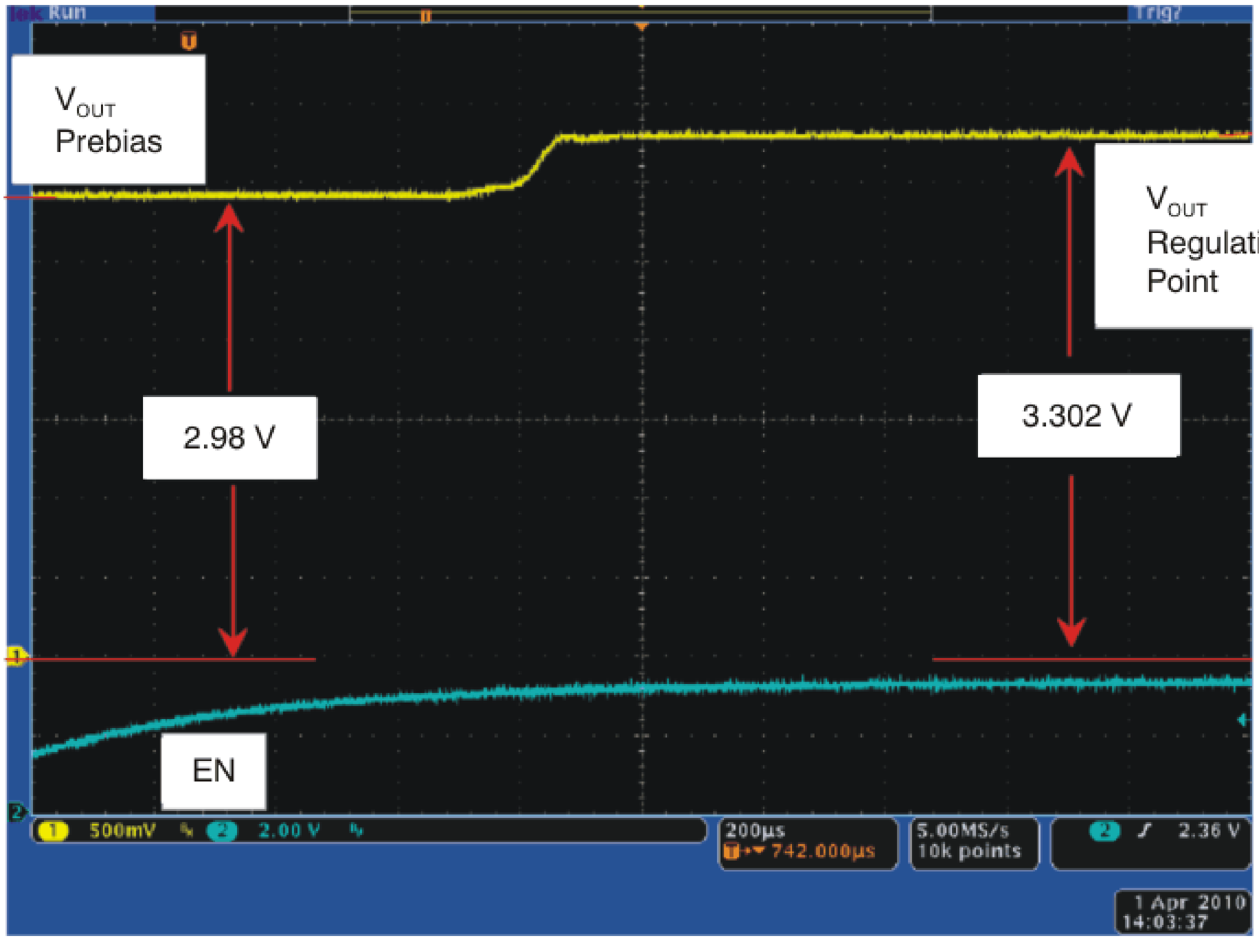

Figure 3. Case 1 V_{OUT} Turn-on with Pre-Bias Condition

3.2 Case 2: Output Filter $L_O \times C_O$ Does Not Follow the Guidelines

- L_O = 0.5 µH, C_O = 100µF, and f_{SW} = 150 kHz.
  This configuration generates a value of f_{LC} = 22.5 kHz, which does not follow the guideline defined in Equation 2.
- The HB loop-gain crossover frequency setup at f_C = 25 kHz.
  This value does not follow the guideline shown in Equation 3.
- These two violations result in a V_{OUT} turn-on with chattering observed, as shown in Figure 4.

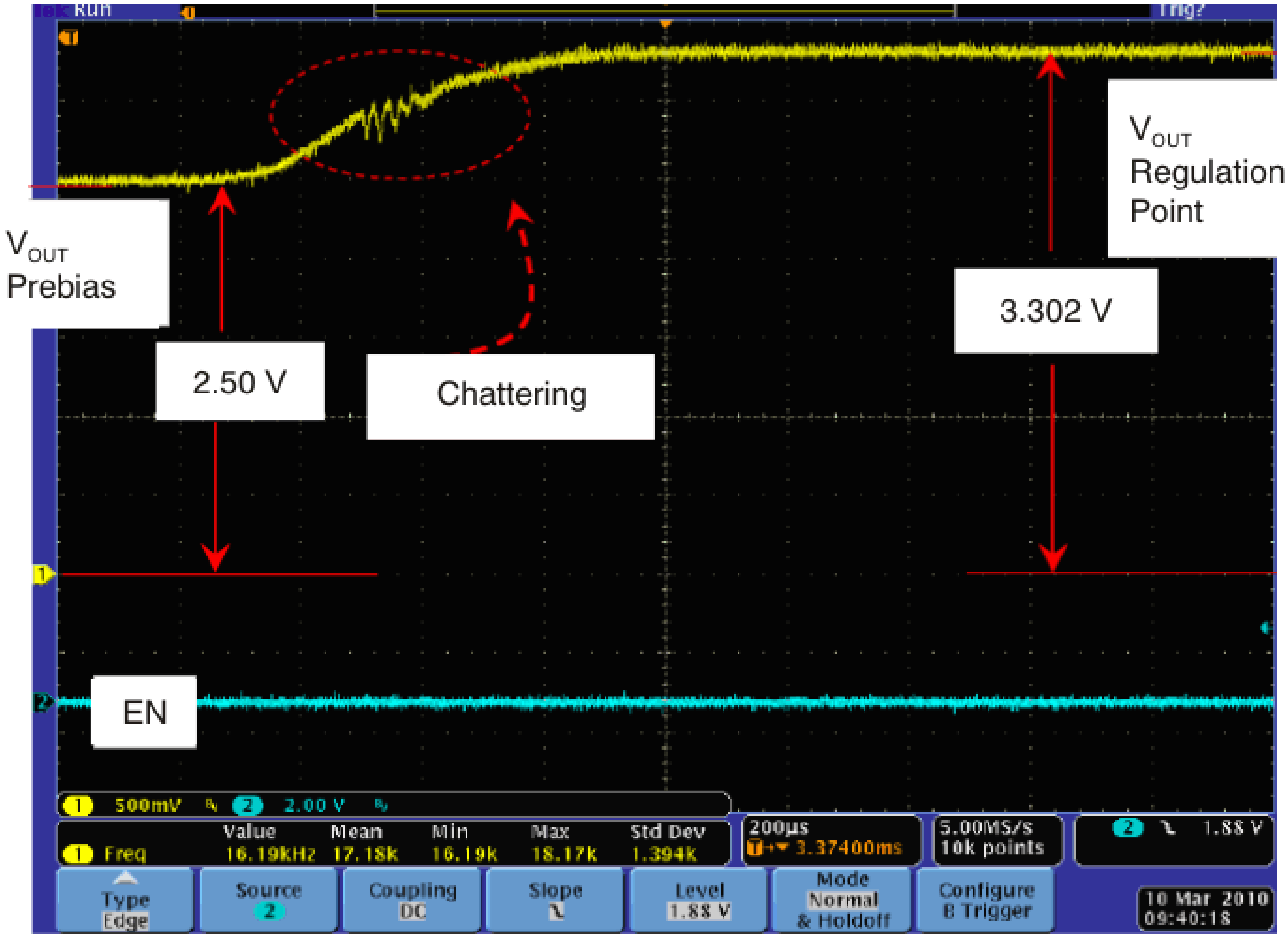

Figure 4. Case 2-1: Chattering Observed During V_{OUT} Turn-On

- The chattering may become a severe ditch (that is, an undershoot) when higher degrees of violations are present, as shown in Figure 5.

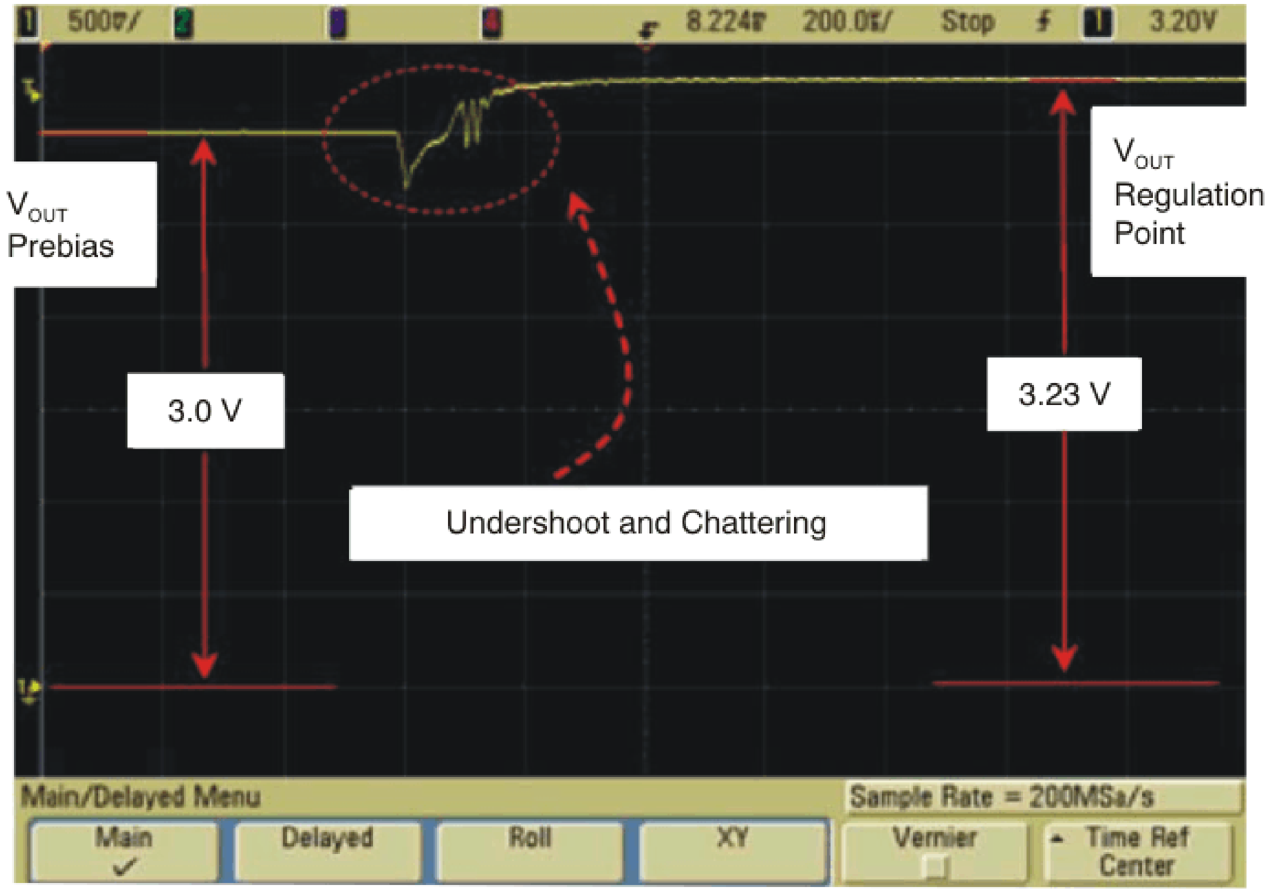

Figure 5. Case 2-2: Observed Undershoot and Chattering During V_{OUT} Turn-on with Pre-Bias Condition

4 Conclusion

In this note, four design guidelines are presented in order to design the UCC28250 as a secondary side control for output voltage turn-on with a pre-bias condition. These guidelines are obtained from various tests and clearly demonstrate the effectiveness of designing with the UCC28250 PWM controller. These suggestions are recommended in order to achieve smooth and monotonic output turn-on with a pre-bias condition.

5 References

The following documents are available for download from the TI website at www.ti.com.

- UCC28250 product data sheet. Literature number SLUSA29.
- UCC28250EVM-501 evaluation module user guide. Literature number SLUU429.
- UCC28250EVM-564 evaluation module user guide. Literature number SLUU441.