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Application Report
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High Current LDO Linear Regulators (UCCx81-ADJ, UCx82-ADJ, UCCx83-ADJ, UCx85−ADJ)

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ABSTRACT

This application provides an overview of the UCCx81-ADJ, UCx82-ADJ, UCCx83-ADJ, and UCx85-ADJ devices.

High-Current Low Dropout (LDO) Linear Regulators Extended Output Voltage Adjustment Range (1.2 Down to 0.5 V)

The UCCx81-ADJ 1-A, UCx82-ADJ 3-A, UCCx83-ADJ 3-A, and the UCx85-ADJ 5-A LDO regulators were designed to provide output voltages only as low as their internal reference voltages (see data sheets SLUS215A, SLUS214B, SLUS317A, and SLUS212D, respectively, for the exact reference voltage value). Using the auxiliary circuitry highlighted below, each regulator's output voltage range can be extended down to 0.5 V.

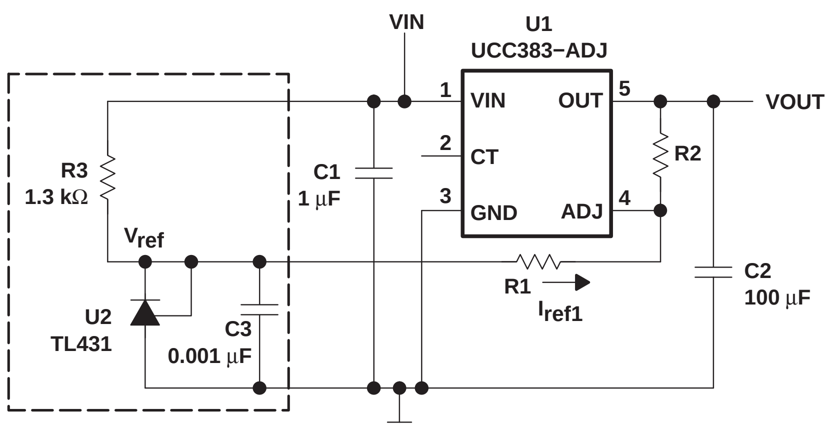

Figure 1. Extended Output Voltage Regulator Schematic

Three components are necessary to extend the output voltage range, an external voltage reference (U2), resistor (R3), and capacitor (C3), in addition to the input and output capacitors (C1 and C2) and feedback resistors (R1 and R2) normally required for the adjustable versions of these regulators. The size of feedback resistors R1 and R2 can be determined from the following equation:

$$I_{ref1} \geq \frac{V_{FB} - V_O}{R2} = \frac{V_{ref} - V_{FB}}{R1}$$

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where:

- I_{ref1} is the value of feedback current normally required for output voltages greater than the regulator's internal reference voltage
- V_{FB} is the regulator's internal reference voltage per the data sheet
- V_O is the output voltage
- V_{ref} is the value of the reference voltage (the TL431 used in this application nominally provides 2.495 V).

The table below shows the values of R1 and R2 for V_O = 0.7 V as computed from the internal reference voltage, reference current per the respective data sheets and V_I set to its minimum voltage of 2.8 V.

DEVICE	V_{FB} (V)	I_{ref1} (μA)	R1 (Ω)	R2 (Ω)
UCCx83−ADJ	1.25	25	49.9k	22k
UCCx81−ADJ	1.25	25	49.9k	22k
UCx82−ADJ	1.2	600	2.15k	835
UCx85−ADJ	1.2	600	2.15k	835

This auxiliary circuit requires that the regulator provide a minimum dc output current of the higher of I_{ref} or the specified minimum output current in the data sheet.

The use of the auxiliary circuitry above degrades the accuracy of the output of the regulator. In fact, assuming a resistor tolerance of ±0.1%, reference tolerance of ±2%, and UCCx83 regulator reference voltage accuracy of ±1.6% at T_A = 25°C, the error of the adjustable regulator at T_A= 25°C with V_O = 0.7 V can be as high as ±7.75%.

To improve accuracy, it is recommended to use the circuit below.

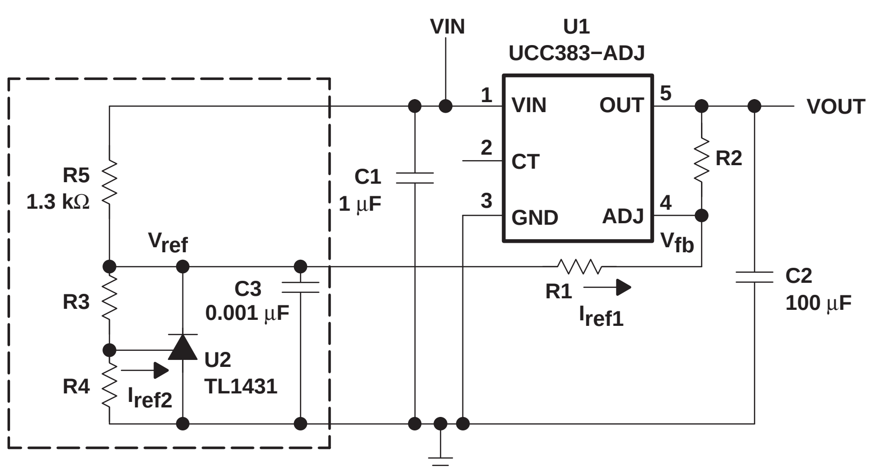

Figure 2. More Accurate Extended Output Voltage Regulator Schematic

The TL1431 reference has 0.4% accuracy. The equation for the output voltage from the circuit in Figure 2 is:

$$V_{OUT} = V_{FB} \times \left(\frac{R2}{R1} + 1\right) - \frac{R2}{R1} \times \left[V_{ref} \times \left(1 + \frac{R3}{R4}\right) + I_{ref2} \times R3\right]$$

Taking partial derivatives of the equation above with respect to each variable, it is readily apparent that making resistor R1 as large as possible results in the highest accuracy part. Resistor R1 is determined by I_{ref1}, so increasing V_{ref} is the only way to increase R1. Choosing V_I = 3.3 V allows V_{ref} = 3.2 V and R1 = 77,700 Ω, R2 = 22,100, R3 = 352,000 Ω (for an average I_{ref2} = 2.0 µA between V_I and ground) and R4 = 2,770 Ω. The accuracy is improved from 7.75% to 5.1%. Further increases in R1 improve the accuracy but the efficiency of the part suffers.

The UCCx81-ADJ 1-A regulator can be configured exactly as shown in Figures 1 and 2. The UCx82-ADJ 3-A and the UCx85-ADJ 5-A LDO regulators can be similarly configured; however, they require higher feedback currents and thus lower feedback resistors, so their output voltage tolerance is higher.

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