UNITRODE

Design Note

UCC3954 Single Cell Lithium-Ion to +3.3V Converter Evaluation Board, Schematic, and List of Materials

By David Olson

The UCC3954 evaluation kit allows the designer to evaluate the performance of the UCC3954 Single Cell Lithium-Ion to +3.3V converter. The UCC3954, along with a few external components, develops a regulated +3.3V from a single lithium-ion battery whose terminal voltage can vary between 2.5V and 4.2V. The UCC3954 employs a simple flyback (buck-boost) technique to convert the battery voltage to +3.3V. This is accomplished by referencing the battery's positive terminal to system ground. The schematic for the evaluation kit is shown in Figure 1.

UCC3954 Features

- Converts +3.3V @ 700mA Load Current
- Load Disconnect in Shutdown
- High Efficiency Flyback Operation
- Internal 0.15Ω MOSFET Switch
- Low Battery LED Driver
- Internal 2.5A Peak Current Limit
- Internal 200kHz Oscillator

Absolute Maximum Ratings

Input Supply Voltage (BAT+ to BAT-). 4.5V
OUT:
  Maximum Forced Voltage
  (ref. to BAT+) 5.5V
SWITCH:
  Maximum Forced Voltage
  (ref. to BAT+) 10.2V
  Maximum Forced Current . . . internally limited
SD
  Maximum Forced Voltage
  (ref. to BAT+) 5.5V
  Maximum Forced Current 10mA
COMP
  Maximum Forced Current. . . . . self limiting
  Maximum Forced Voltage
  (ref. to BAT+) 4.5V

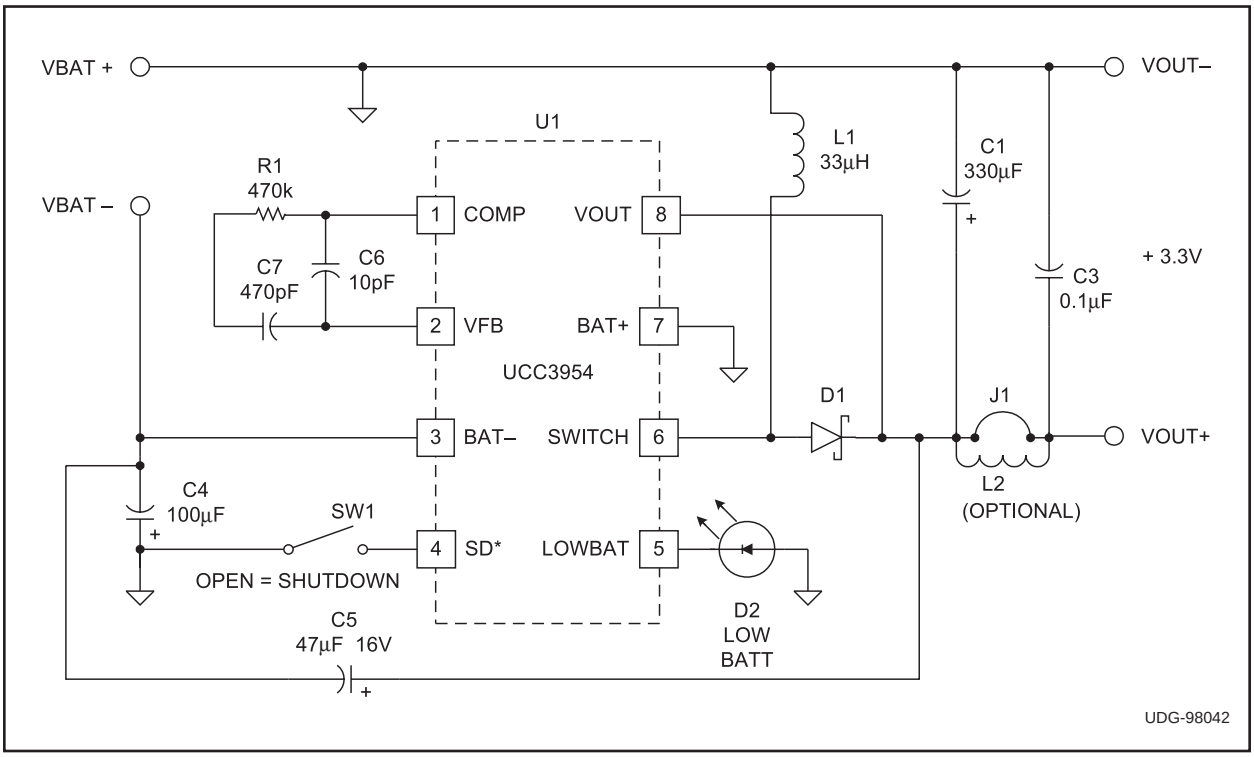

Figure 1. UCC3954 Evaluation Board Schematic

Function of SW1

SW1 provides the shutdown for the UCC3954 evaluation board. Pulling SD to BAT+ (On position) will enable the IC. An internal 100k pulldown to BAT– disables the IC when SD is left open (Off position). ***Note****: the switch positions for SW1 are reversed.*

Function of J1

J1 allows the user to evaluate additional output filtering for applications requiring even lower ripple and noise. J1 must be inserted if no additional filtering is added.

Function Of LED

The LED provides a low battery warning. The LED is illuminated by the LOWBAT output pulling low when the input battery voltage drops below the low battery warning threshold, 2.7V typical. Note: The LOWBAT output is referenced to BAT–.

Optional Components

The UCC3954 evaluation kit provides additional footprints for optional L-C output filtering. The inductor footprint (L2) is sized to accept Coilcraft D01608C size inductors. The 0.1µF Capacitor (C3) can be replaced with a small (case B) tantalum capacitor.

Choosing an Inductor (L1)

The input inductor value will determine if the converter is operating in the continuous or discontinuous conduction mode for a given input voltage and load current. The efficiency will be higher in the continuous mode (larger inductor value), due to the lower peak currents. However, a larger inductor value will be physically larger for the same current rating, and reduces loop bandwidth, making it more difficult to compensate. The evaluation kit is equipped with a 33µH inductor.

Output Capacitor Selection (C1)

To minimize output voltage ripple, a good high frequency capacitor must be used. Low ESR tantalums or *Sanyo Oscon's* are recommended. The evaluation kit is equipped with a low ESR 330µf surface mount tantalum capacitor.

Loop Compensation

The loop may be compensated utilizing the simple dominant pole method, by placing a capacitor between VFB and COMP. The dominant pole method provides good stability over a wide range of loads at the expense of loop bandwidth and dynamic regulation.

When large dynamic load transients are expected, the simple dominant pole compensation method may not provide adequate dynamic load regulation. In this case, lead-lag compensation is recommended, as shown in the evaluation circuit of Figure 1. The addition of R1 and C7 in the error amp feedback loop provides significantly wider loop bandwidth, resulting in improved transient response. The optimum values of these compensation components will depend on a number of factors; including input voltage, load current, inductor value and output capacitance, as well as the ESR of the inductor and output capacitor. The compensation values shown in Figure 1 will provide good loop stability and good transient response over the full range of input voltage and output load. They were chosen assuming a nominal inductor value of 33µH.

Reducing Output Ripple for Noise Sensitive Applications

In some applications it may be necessary to have very low output voltage ripple. There are a number of ways to achieve this goal. Since the ripple is dominated by the ESR of the output filter capacitor, one way to reduce the ripple is to put multiple low ESR capacitors in parallel. However, this brute force method can be expensive and take up excessive board real estate.

A more effective method of ripple reduction is shown in Figure 1. By adding a small tantalum capacitor (C5) between the 3.3V output and the negative battery input (BAT–), both input and output voltage ripple are reduced. This technique is a kind of ripple current cancellation scheme, since the ripple voltage on these two nodes is 180° out of phase. Using this method, output ripple can be reduced by up to 50%. As with the other filter capacitors, it is imperative that stray inductance and resistance in series with the capacitor be minimized for maximum effectiveness. Note that this capacitor sees the sum of the input and output voltages; therefore an absolute minimum voltage rating of 10V is required. (See the Optional Components section for additional information on L-C output filtering.)

For more complete information, pin descriptions and specifications for the UCC3954 Single Cell Lithium-Ion to +3.3V Converter, please refer to the UCC3954 datasheet or contact your Unitrode Field Applications Engineer at (603) 424-2410.

Table I.
UCC3954 Evaluation Board List of Materials

Reference Designator	Description	Manufacturer	Part Number
C1	330µF, 6.3V, Low ESR Tantalum Capacitor	Sprague	593D337X06R3E2W
C2	Unused		
C3	0.1µF, X7R Ceramic Capacitor		
C4	100µF, 10V, low ESR Tantalum Capacitor	Sprague	593D107X0010D2W
C5	47µF, 16V, low ESR Tantalum Capacitor	Sprague	594D476X0016C2T
C6	10pF NPO Ceramic Capacitor		
C7	470pF NPO Ceramic Capacitor		
D1	1A, 30V Schottky Diode		
D2	LED		
J1	Jumper (location for optional 1µH choke to reduce noise)		
L1	33µH Choke	Coilcraft	DO3316P-333
R1	470k, 1/10W, 5%, MF Resistor		
U1	Single Cell Lithium-Ion to +3.3V Converter	Unitrode	UCC3954
SW1	Slide Switch		

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