

## White LED/OLED Step-Up Converter

### FEATURES

- Adjustable Output Voltage
- Drives OLEDs or White LEDs
- 30V High Voltage Switch
- 1MHz Switching Frequency
- Tiny Inductors and Capacitors
- Tiny SOT23-5 Package

### APPLICATIONS

- OLED Applications
- Cell Phones
- Digital Cameras
- PDAs, Laptops
- MP3 Players
- GPS

### GENERAL DESCRIPTION

The ACT6311 step-up DC/DC converter is optimized for driving OLEDs or white LEDs. It can provide an output voltage up to 24V. The device is capable of driving up to seven LEDs in series from a Lithium-Ion battery, with inherent current matching and uniform brightness.

The ACT6311 incorporates a 30V high voltage switch. The device operates at 1MHz and allows the use of few external components. The ACT6311 is available in the tiny SOT23-5 package.

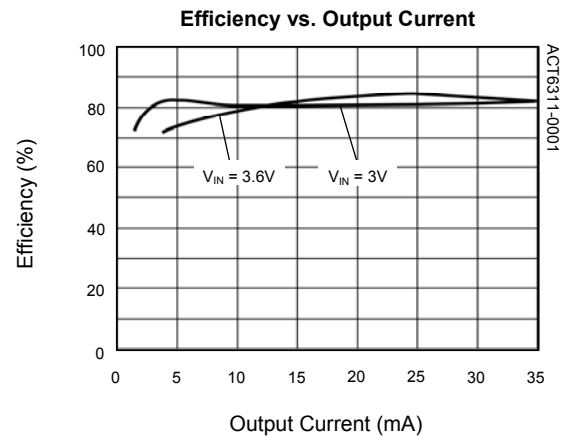
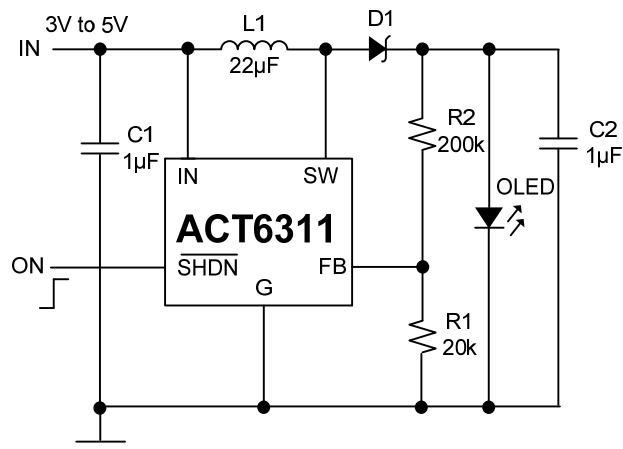


Figure 1. Typical Application Circuit

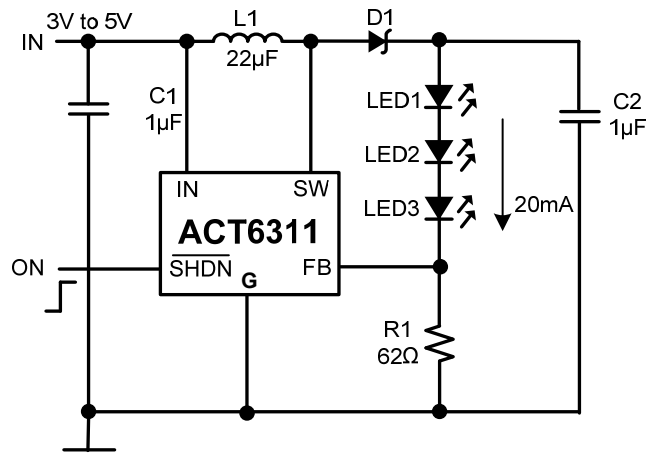
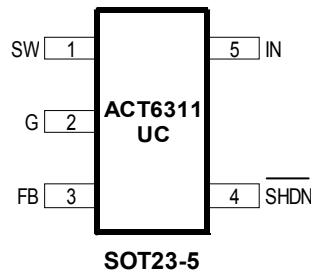


Figure 2: Application as White LED Drive

## ORDERING INFORMATION

| PART NUMBER | TEMPERATURE RANGE | PACKAGE | PINS | TOP MARK | PACKING     |
|-------------|-------------------|---------|------|----------|-------------|
| ACT6311UC-T | -40°C to 85°C     | SOT23-5 | 5    | YCXB     | TAPE & REEL |

## PIN CONFIGURATION



## PIN DESCRIPTION

| PIN NUMBER | PIN NAME                 | PIN DESCRIPTION   |
|------------|--------------------------|---|
| 1          | SW                       | Switch Output. Connect this pin to the inductor and the Schottky diode. To reduce EMI, minimize the PCB trace path between this pin and the input bypass capacitor. |
| 2          | G                        | Ground.   |
| 3          | FB                       | Feedback Input. This pin is referenced to 1.24V   |
| 4          | $\overline{\text{SHDN}}$ | Shutdown Control. Connect to a logic high to enable the device. Connect to a logic low to disable the device. Never leave the pin unconnected.                      |
| 5          | IN                       | Supply Input. Bypass to G with a capacitor 1µF capacitor or higher.   |

## ABSOLUTE MAXIMUM RATINGS

(Note: Exceeding these limits may damage the device. Exposure to absolute maximum rating conditions for long periods may affect device reliability.)

| PARAMETER   | VALUE                  | UNIT |
|---|------------------------|------|
| IN, SHDN Voltage  | -0.3 to 6              | V    |
| SW Voltage  | -0.3 to 30             | V    |
| FB Voltage  | -0.3 to $V_{IN} + 0.3$ | V    |
| Maximum Power Dissipation (derate 5mW/°C above $T_A = 50^\circ\text{C}$ ) | 0.4                    | W    |
| Junction to Ambient Thermal Resistance ( $\theta_{JA}$ )                  | 190                    | °C/W |
| Operating Junction Temperature  | -40 to 150             | °C   |
| Lead Temperature (Soldering, 10 sec)                                      | 300                    | °C   |

## ELECTRICAL CHARACTERISTICS

( $V_{IN} = V_{SHDN} = 3V$ ,  $T_A = 25^\circ\text{C}$ , unless otherwise specified.)

| PARAMETER                  | SYMBOL    | TEST CONDITIONS                                      | MIN  | TYP  | MAX  | UNIT |
|----------------------------|-----------|--|------|------|------|------|
| Input Voltage Range        |           |  | 2.5  |      | 5.5  | V    |
| Feedback Voltage           | $V_{FB}$  | $V_{IN} = 3V$  | 1.18 | 1.24 | 1.30 | V    |
| FB Input Current           |           |  |      | 50   |      | nA   |
| Supply Current             |           | $\overline{\text{SHDN}} = \text{IN}$                 |      | 0.7  | 1.5  | mA   |
| Supply Current in Shutdown |           | $\overline{\text{SHDN}} = \text{G}$                  |      | 0    | 1    | μA   |
| Switching Frequency        | $f_{SW}$  |  | 0.8  | 1    | 1.2  | MHz  |
| Maximum Duty Cycle         | $D_{MAX}$ |  | 80   | 85   |      | %    |
| Switch Current Limit       | $I_{LIM}$ | 75% Duty Cycle                                       |      | 320  |      | mA   |
| Switch On Voltage          |           | $I_{SW} = 200\text{mA}$                              |      | 350  |      | mV   |
| Switch Leakage Current     |           | $V_{SW} = 20V$ , $\overline{\text{SHDN}} = \text{G}$ |      |      | 10   | μA   |
| SHDN Logic High Threshold  |           |  | 1.6  |      |      | V    |
| SHDN Logic Low Threshold   |           |  |      |      | 0.4  | V    |
| SHDN Input Current         |           |  |      | 0    | 1    | μA   |

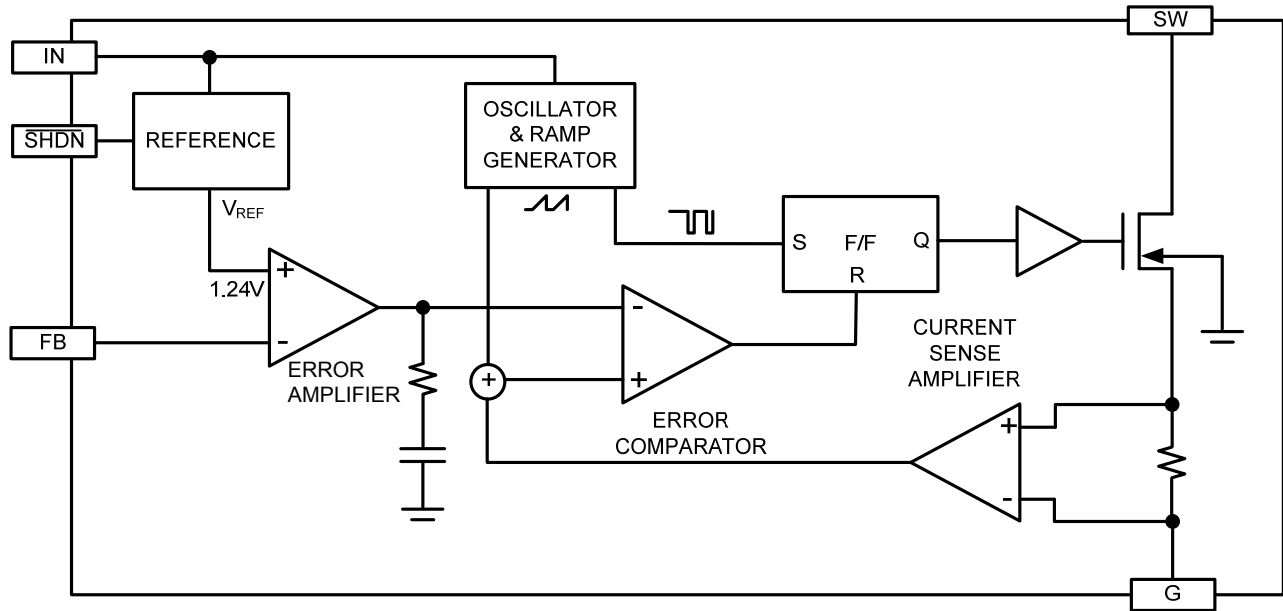


Figure 3. Functional Block Diagram

## FUNCTIONAL DESCRIPTION

The ACT6311 is a high efficiency step-up DC/DC converter that employs a current-mode, fixed frequency pulse-width modulation (PWM) architecture with excellent line and load regulation. Figure 3 shows the functional block diagram of the IC. The flip-flop is set at the start of each oscillator cycle, and turns on the power switch. During this on time, the switch current level is sensed and added to a ramp signal, and the resulting sum is compared

with the output of the error amplifier. If the error comparator output is high, the flip-flop is reset and the power switch turns off. Thus, the peak inductor current level is controlled by the error amplifier output, which is integrated from the difference between FB input and the 1.24V reference point.

The ACT6311 operates at a constant switching frequency for output current higher than 4mA. If the output current decreases further, the IC will enter frequency modulation mode, resulting in some low frequency ripple.

## APPLICATION INFORMATION

### Inductor Selection

**Table 1:**
**Recommended Inductors**

| PART NUMBER  | CURRENT RATING (MA) | DCR (Ω) | SUPPLIER    |
|--------------|---------------------|---------|-------------|
| CDRH3D16-220 | 350                 | 0.5     | Sumida      |
| ELJPC220KF   | 160                 | 4.0     | Panasonic   |
| LQH3C220     | 250                 | 0.7     | Murata      |
| LEM2520-220  | 125                 | 5.5     | Taiyo Yuden |

A 22μH inductor is typically used for the ACT6311. The inductor should have low DC resistance (DCR) and losses at 1MHz. See Table 1 for examples of small size inductors.

### Capacitor Selection

The ACT6311 only requires a 1μF input capacitor and a 1μF output capacitor for most applications. Ceramic capacitors are ideal for these applications. For best performance, use X5R and X7R type ceramic capacitors, which possess less degradation in capacitance over voltage and temperature ranges.

### Diode Selection

The ACT6311 requires a fast recovery Schottky diode as the rectifier. Select a low forward voltage drop Schottky diode with a forward current (IF) rating of 100mA to 200mA and a sufficient peak repetitive reverse voltage (VRRM). Some suitable Schottky diodes are listed in Table 2.

**Table 2:**
**Recommended Schottky Diodes**

| PART NUMBER | IF(MA) | VRRM (V) | SUPPLIER |
|-------------|--------|----------|----------|
| CMDSH-3     | 100    | 30       | Central  |
| CMDSH2-3    | 200    | 30       | Central  |
| BAT54       | 200    | 30       | Zetex    |

### OLED Application

Figure 1 shows the feedback network necessary to set the output voltage. Select the proper ratio of the two feedback resistors R1 and R2 based on the desired output voltage. Typically choose R1 = 20kΩ

and determine R2 from the output voltage:

$$R2 = R1 \left( \frac{V_{OUT}}{1.24V} - 1 \right) \quad (1)$$

### White LED Application

The LED current is determined by the value of the feedback resistor R1. Because the FB input of the IC is regulated to 1.24V, the LED current is determined by  $I_{LED} = 1.24V/R1$ . The value of R1 for different LED currents is shown in Table 3.

**Table 3:**
**R1 Resistor Value Selection**

| $I_{LED}$ (MA) | R1 (Ω) |
|----------------|--------|
| 5              | 246    |
| 10             | 124    |
| 12             | 103.3  |
| 15             | 82.7   |
| 20             | 62     |

To improve efficiency, resistors R2 and R3 can be connected as shown in Figure 4 to lower the effective feedback voltage.

The following are dimming control methods for the ACT6311 series white LED application.

#### 1) PWM Signal Driving $\overline{SHDN}$

When a PWM signal is connected to the  $\overline{SHDN}$  pin, the ACT6311 is turned on and off alternately under the control of the PWM signal. The current through the LEDs is either zero or full scale. By changing the duty cycle of the PWM signal (typically 1kHz to 10kHz), a controlled average current is obtained.

#### 2) DC Voltage Control

Figure 5 shows an application in which a DC voltage is used to adjust the LED current. The LED current increases when  $V_{DC}$  is lower than  $V_{FB}$  and decreases when  $V_{DC}$  is higher than  $V_{FB}$ . In Figure 5, the LED current range of 15mA to 0mA is controlled by  $V_{DC} = 0V$  to 2V.

#### 3) Filtered PWM Control

Figure 6 shows an application using a filtered PWM signal to control dimming.

#### 4) Logic Control

A logic signal can be used to adjust the LED current in a discrete step, as shown in Figure 7.

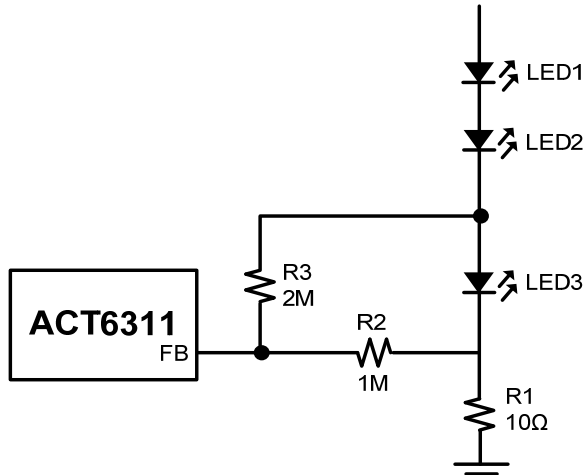


Figure 4. Current Setting for White LED Application

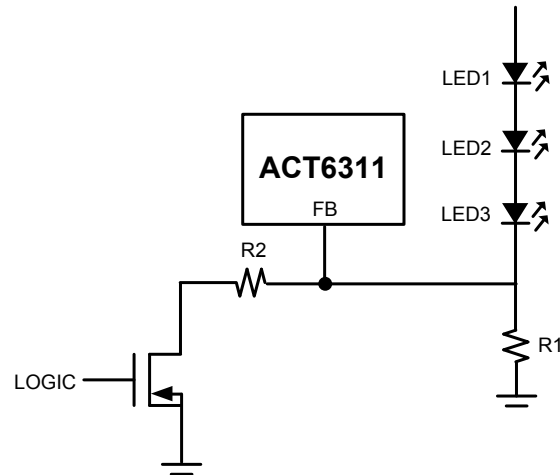


Figure 7. Logic Controlled Dimming

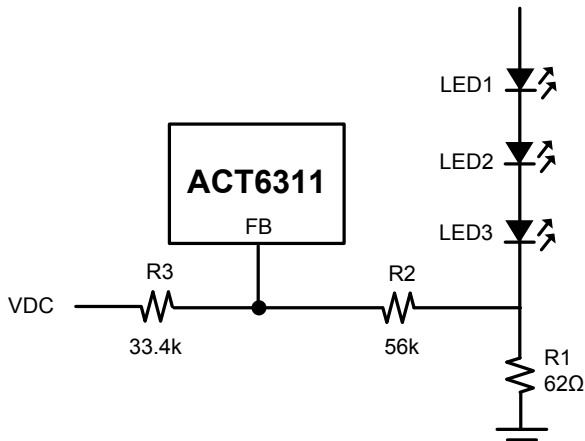


Figure 5. DC Voltage Controlled Dimming

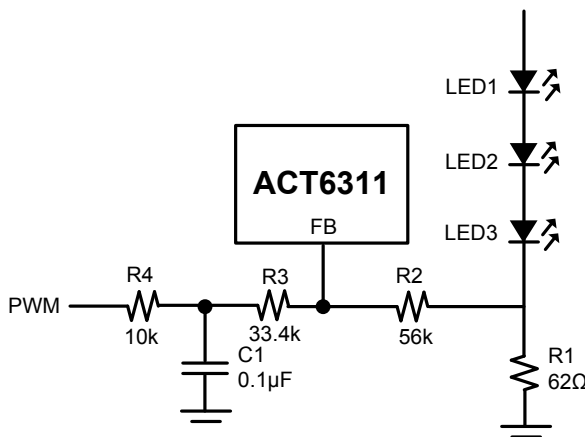


Figure 6. Filtered PWM Controlled Dimming

### Start-up and Inrush Current

In order to facilitate quick startup, a soft-start circuit is not incorporated into the ACT6311. When the IC is first turned on with no external soft-start circuit, the peak inrush current is about 400mA. Figure 8 shows an implementation for soft-start. When soft-start and dimming controls are used simultaneously, a low frequency PWM signal (less than 10kHz) or the methods in Figures 5, 6 and 7 should be used.

### Open-Circuit Protection (White LEDs)

If one of the LEDs is disconnected, the FB voltage drops to zero and the IC switches at maximum duty cycle. This results in a high voltage that may exceed the SW voltage rating. To limit this voltage, use a Zener diode as shown in Figure 9. The Zener voltage must be large than the total forward voltage of the LEDs and the current rating should be higher than 0.1mA.

### Board Layout

To reduce EMI, minimize the area and path length of all traces connected to SW. Use a ground plane under the switching regulator and connect R1 directly to the G pin of the IC.

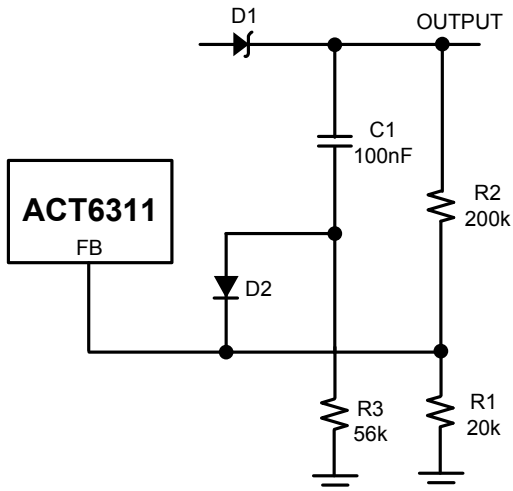


Figure 8: Soft-Start Circuit

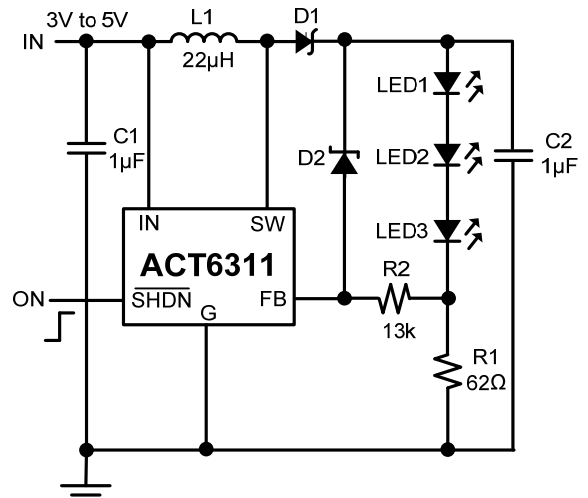
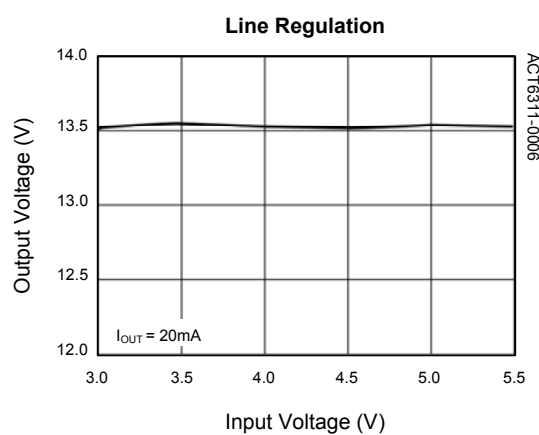
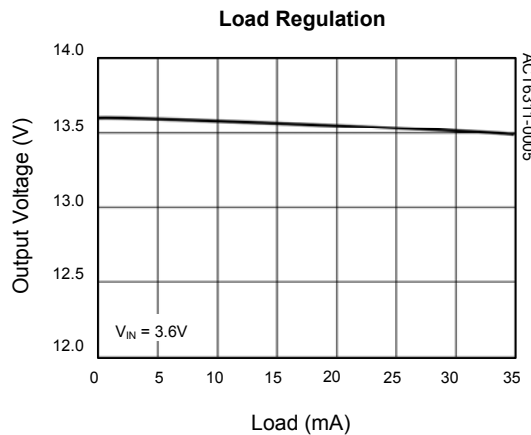
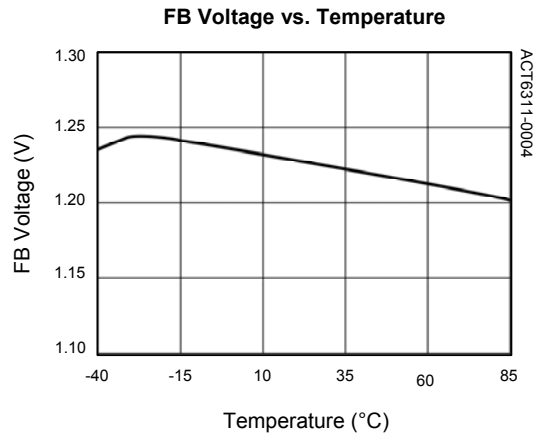
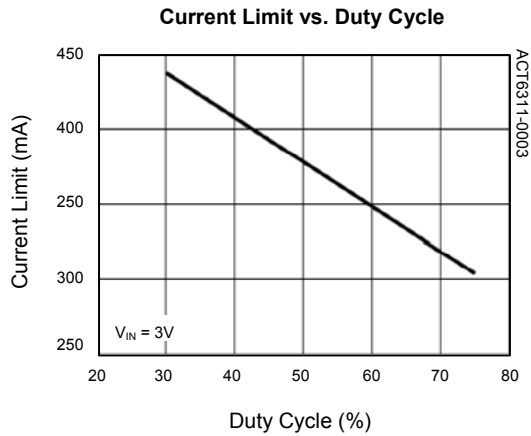
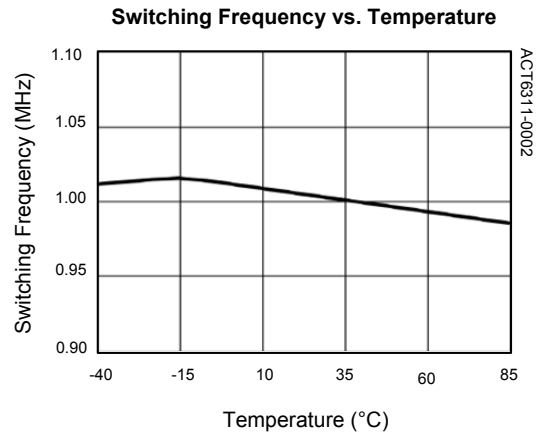
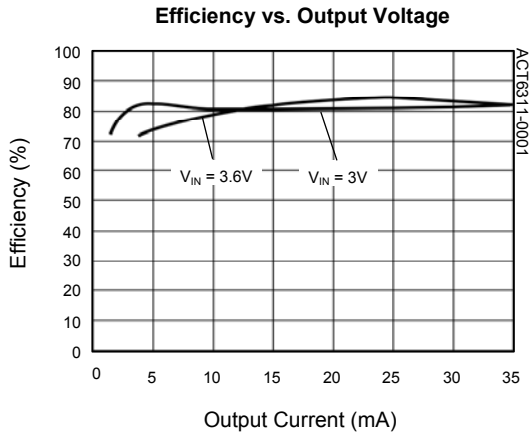


Figure 9: Open-Circuit Protection

## TYPICAL PERFORMANCE CHARACTERISTICS

(Circuit of Figure 1, unless otherwise specified.)

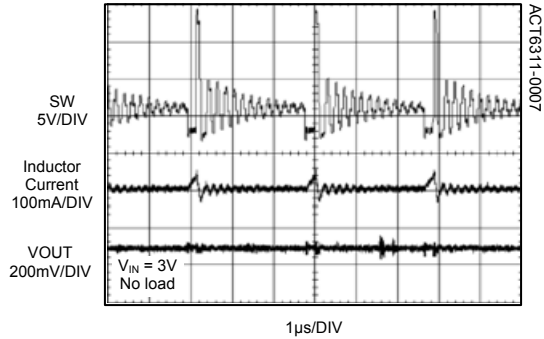




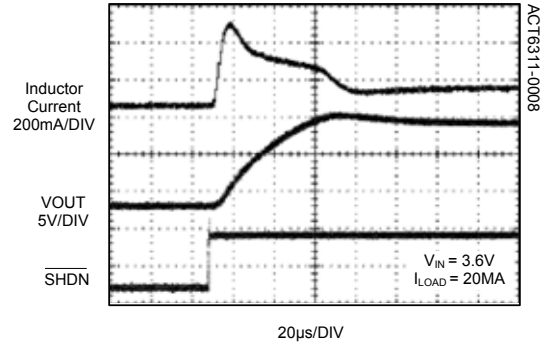
## TYPICAL PERFORMANCE CHARACTERISTICS CONT'D

(Circuit of Figure 1, unless otherwise specified.)

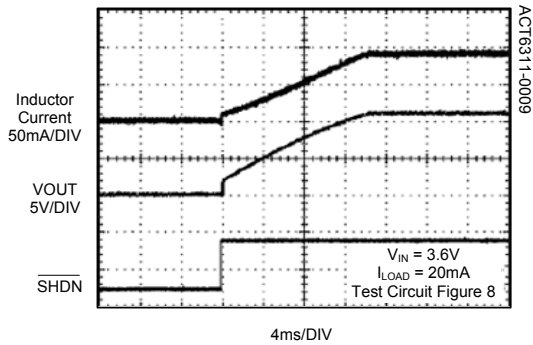
**Switching Waveform in Discontinuous Mode**



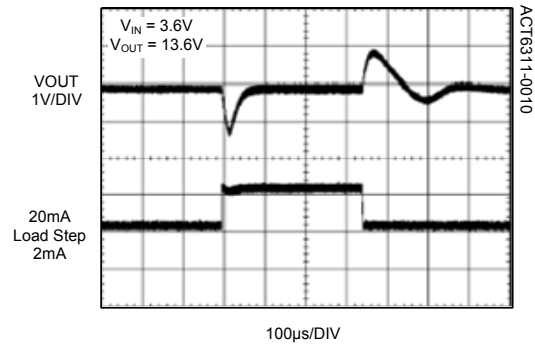
**Startup without Soft Start Circuit**



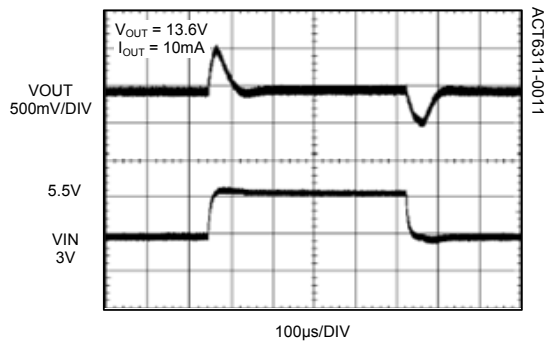
**Startup with Soft Start Circuit**



**Load Step Response**

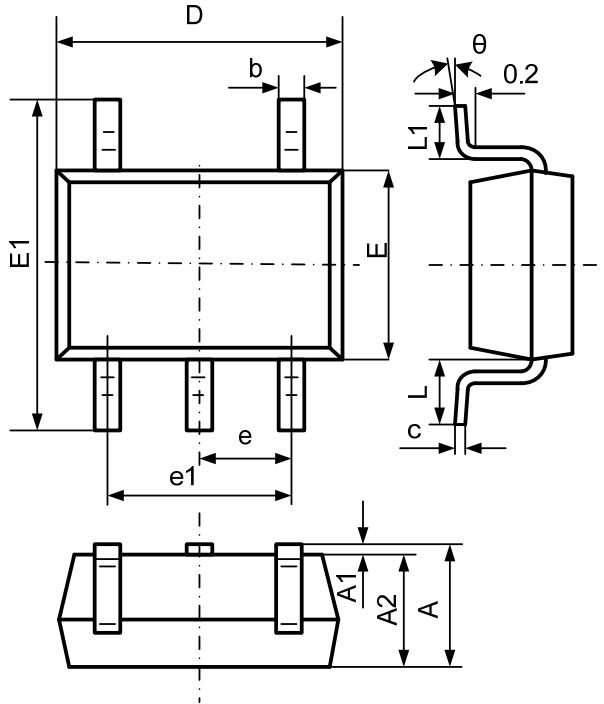


**Line Step Response**



## PACKAGE OUTLINE


### SOT23-5 PACKAGE OUTLINE AND DIMENSIONS



| SYMBOL   | DIMENSION IN MILLIMETERS |       | DIMENSION IN INCHES |       |
|----------|--------------------------|-------|---------------------|-------|
|          | MIN                      | MAX   | MIN                 | MAX   |
| A        | -                        | 1.450 | -                   | 0.057 |
| A1       | 0.000                    | 0.150 | 0.000               | 0.006 |
| A2       | 0.900                    | 1.300 | 0.035               | 0.051 |
| b        | 0.300                    | 0.500 | 0.012               | 0.020 |
| c        | 0.080                    | 0.220 | 0.003               | 0.009 |
| D        | 2.900 BSC                |       | 0.114 BSC           |       |
| E        | 1.600 BSC                |       | 0.063 BSC           |       |
| E1       | 2.800 BSC                |       | 0.110 BSC           |       |
| e        | 0.950 BSC                |       | 0.037 BSC           |       |
| e1       | 1.900 BSC                |       | 0.075 BSC           |       |
| L        | 0.60REF                  |       | 0.024REF            |       |
| L1       | 0.300                    | 0.600 | 0.012               | 0.024 |
| $\theta$ | 0°                       | 8°    | 0°                  | 8°    |

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