

# IS31BL3506A

## 1.0MHZ BOOST CONVERTER WITH 35V INTERNAL MOSFET SWITCH

July 2012

### GENERAL DESCRIPTION

IS31BL3506A is a boost converter featuring an integrated MOSFET switch designed for driving series strings of LED or other device. Input operating voltage range is 2.7V~5.5V. The device regulates the LED load current is set using an external, low value sensing resistor. The device adjusts the PWM duty cycle of the switch to maintain the voltage at the FB pin at a value of 0.3V. The IS31BL3506A operates at a constant switching frequency of 1.0MHz to allow for small component size. IS31BL3506A features an over voltage shutdown pin which prevents the output voltage from exceeding 35V (typ.) in the case of an open circuit condition. The device is offered in a tiny TSOT-23-6 and DFN-8 (2mm×2mm) package and a temperature rating from -40°C ~ +85°C.

### FEATURES

- Supply voltage: 2.7V~5.5V
- Built-in soft start
- Drive series strings of
  - 9 LEDs (DFN-8)
  - 8 LEDs (TSOT-23-6)
- PWM or DC voltage dimming
- Frequency of PWM is 500Hz ~ 500kHz
- 1.0MHz high speed switching frequency
- 300mV feedback voltage
- Integrated high power MOSFET
- Over voltage protection
- -40°C ~ +85°C working temperature range
- TSOT-23-6 and DFN-8 (2mm×2mm) package

### APPLICATIONS

- Small LCD Backlights
- Notebook PC
- GPS

### TYPICAL APPLICATION CIRCUIT

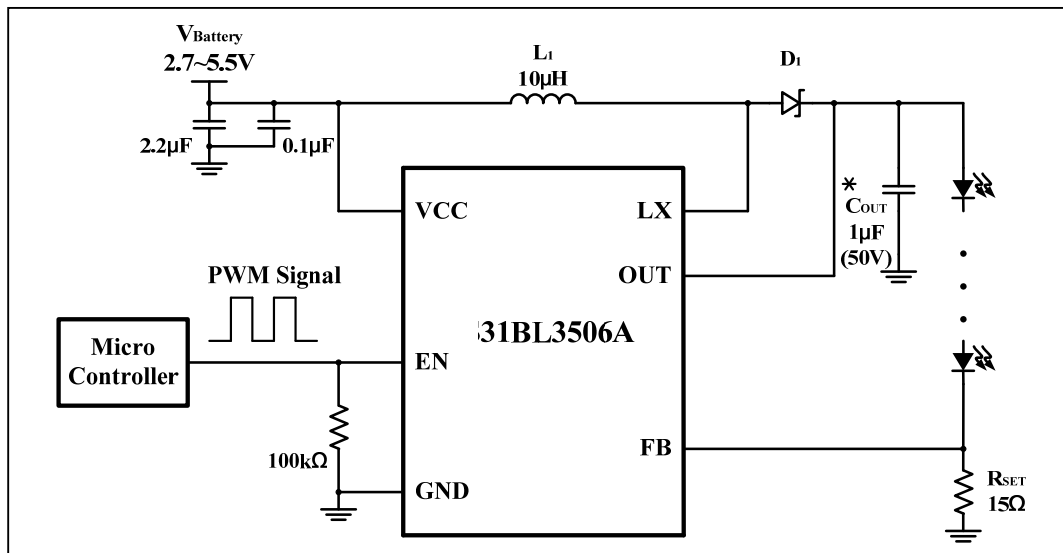


Figure 1 Constant current white LED driver using PWM at the EN pin to control intensity

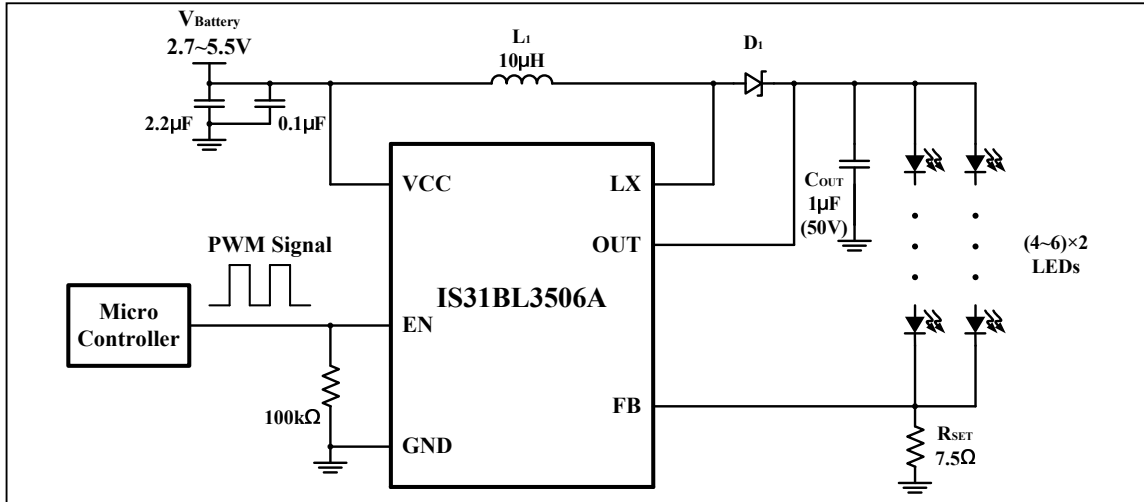
**Note 1:** C<sub>OUT</sub> must be rated for 50V. Smaller values of output capacitance will cause the LED current ripple to increase.

**Note 2:** The resistor R<sub>EST</sub> should be placed as close as possible to the FB pin to prevent the EMI.

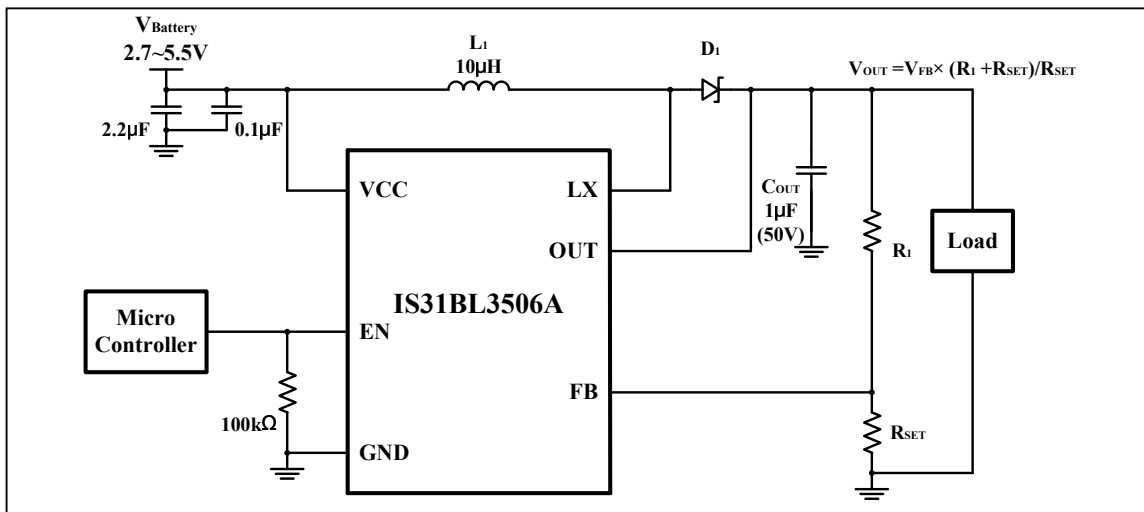
**Note 3:** Because of the different packages, V<sub>OVP</sub> is not the same (Page 6). 9 LEDs can be driven by DFN-8 package and 8 LEDs can be driven by TSOT-23-6 package most.

**Note 4:** The high level of PWM signal for EN pin should last at least 200ns when power on, or the IC won't start up.

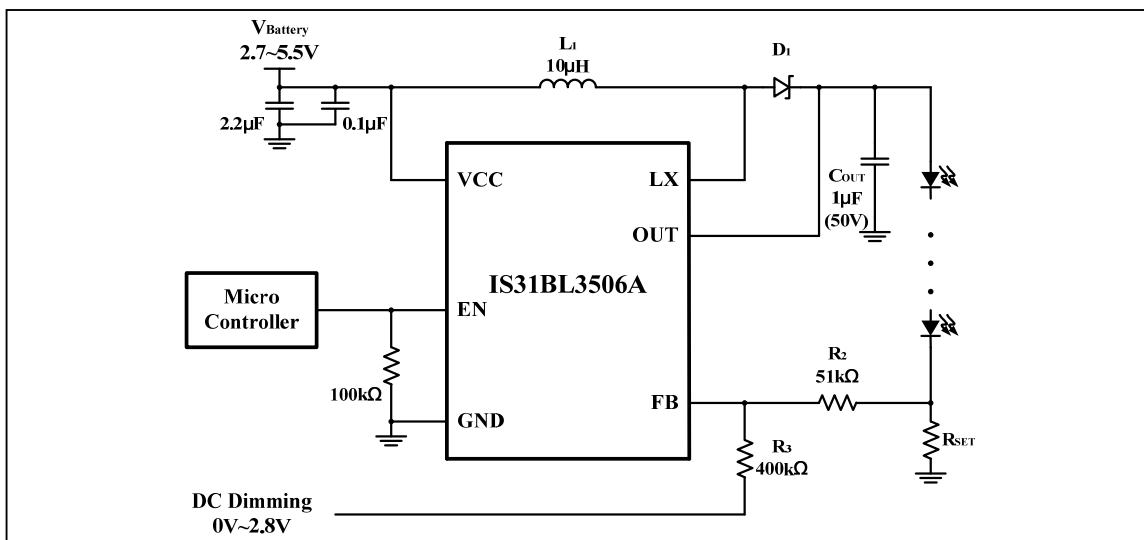
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**Figure 2** Constant current white LED driver using PWM at the EN pin to control intensity (4~6) x 2 LEDs



**Figure 3** Constant output voltage for general purpose use



**Figure 4** Constant output current with DC dimming input

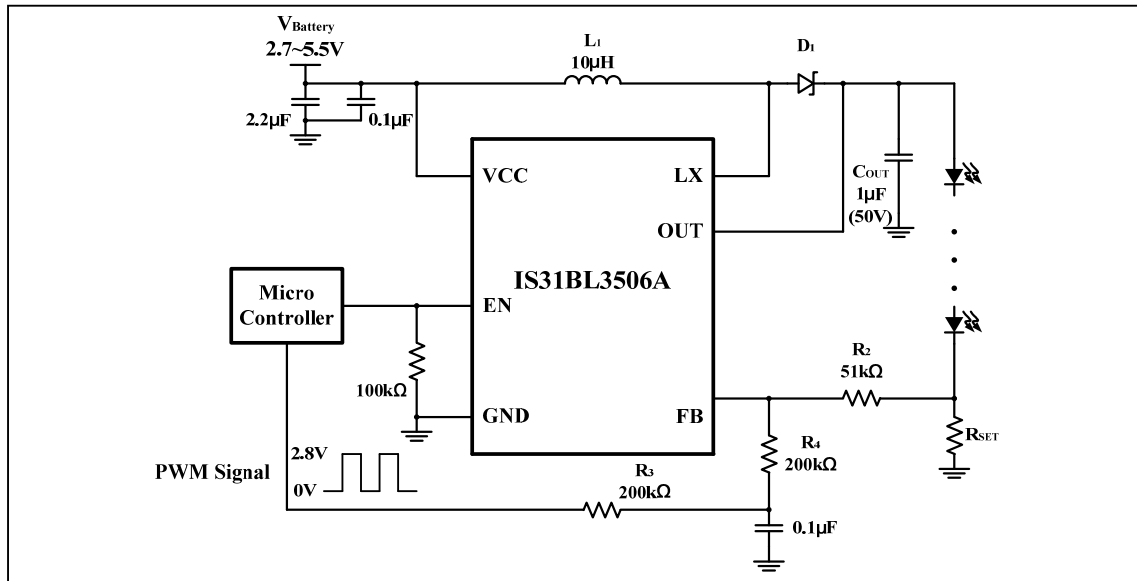
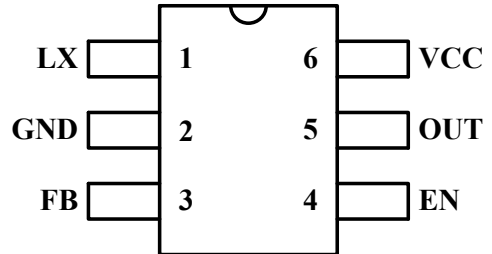
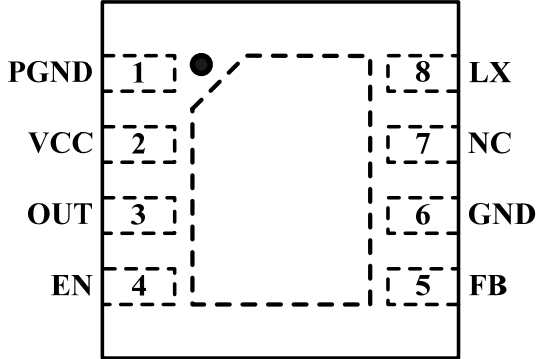


Figure 5 Constant output current with PWM dimming control

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## PIN CONFIGURATION

| Package   | Pin Configurations (Top View)                                                      |
|-----------|------------------------------------------------------------------------------------|
| TSOT-23-6 |  |
| DFN-8     |  |

## PIN DESCRIPTION

| No.       |       | Pin         | Description                                           |
|-----------|-------|-------------|-------------------------------------------------------|
| TSOT-23-6 | DFN-8 |             |                                                       |
| 1         | 8     | LX          | Switch input, connect to the inductor.                |
| 2         | 6     | GND         | Ground.                                               |
| 3         | 5     | FB          | Feedback input pin.                                   |
| 4         | 4     | EN          | Device enable pin, active high.                       |
| 5         | 3     | OUT         | Output voltage sense pin for over voltage protection. |
| 6         | 2     | VCC         | Supply voltage input pin.                             |
| -         | 7     | NC          | No connection.                                        |
| -         | 1     | PGND        | Power ground. Connect independently.                  |
| -         |       | Thermal Pad | Connect to GND.                                       |

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- b.) the user assume all such risks; and
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## ORDERING INFORMATION

Industrial Range: -40°C to +85°C

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| Order Part No.       | Package              | QTY/Reel |
|----------------------|----------------------|----------|
| IS31BL3506A-TTLS2-TR | TSOT-23-6, Lead-free | 3000     |
| IS31BL3506A-DLS2-TR  | DFN-8, Lead-free     |          |

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## ABSOLUTE MAXIMUM RATINGS

|                                          |                |
|------------------------------------------|----------------|
| Supply voltage, $V_{CC}$                 | -0.3V ~ +6.0V  |
| LX pin voltage                           | -0.3V ~ +40V   |
| Voltage at any input pin                 | -0.3V ~ +6.0V  |
| Maximum junction temperature, $T_{JMAX}$ | 150°C          |
| Storage temperature range, $T_{STG}$     | -65°C ~ +150°C |
| Operating temperature range, $T_A$       | -40°C ~ +85°C  |
| ESD HBM                                  | 2kV            |

### Note:

Stresses beyond those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other condition beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

## ELECTRICAL CHARACTERISTICS

Test conditions:  $T_A = -40^{\circ}\text{C} \sim +85^{\circ}\text{C}$ ,  $V_{CC} = 3.6\text{V}$ , unless otherwise noted. Typical values at  $T_A = 25^{\circ}\text{C}$ .

| Symbol          | Parameter                                  | Condition             | Min | Typ | Max | Unit               |
|-----------------|--------------------------------------------|-----------------------|-----|-----|-----|--------------------|
| $V_{CC}$        | Supply Voltage                             |                       | 2.7 |     | 5.5 | V                  |
| $I_{CC}$        | Quiescent current                          | Switching             |     | 1.2 |     | mA                 |
| $I_{SD}$        | Shutdown Current                           | $V_{EN} = 0\text{V}$  |     | 1.5 |     | $\mu\text{A}$      |
| $V_{EN\_ON}$    | EN Input logic High                        | $V_{EN}$ rising       | 1.4 |     |     | V                  |
| $V_{EN\_OFF}$   | EN Input logic Low                         | $V_{EN}$ falling      |     |     | 0.4 | V                  |
| $F_{OSC}$       | Operating Frequency                        |                       |     | 1   |     | MHz                |
| $D_{MAX}$       | Maximum Duty Cycle                         |                       |     | 90  |     | %                  |
| $R_{DS\_ON}$    | LX Switch On resistance                    |                       |     | 0.8 |     | $\Omega$           |
| $I_{SW\_LK}$    | LS Switch Leakage current                  | $V_{SW} = 35\text{V}$ |     |     | 1   | $\mu\text{A}$      |
| $I_{SW\_LIMIT}$ | Switch over current limit                  | Duty = 90%            | 1.8 | 2.2 | 2.6 | A                  |
| $V_{OVP}$       | OUT over voltage protection                | TSOT-23-6             |     | 35  |     | V                  |
|                 |                                            | DFN-8                 |     | 38  |     |                    |
| $V_{FB}$        | Feedback Voltage                           |                       |     | 0.3 |     | V                  |
| $T_{ST}$        | Over temperature protection                | (Note 1)              |     | 160 |     | $^{\circ}\text{C}$ |
| $t_{PWM\_H}$    | EN pin PWM high level time (when power on) | (Note 1)              | 200 |     |     | ns                 |

Note 1: Guaranteed by design.

## TYPICAL PERFORMANCE CHARACTERISTIC

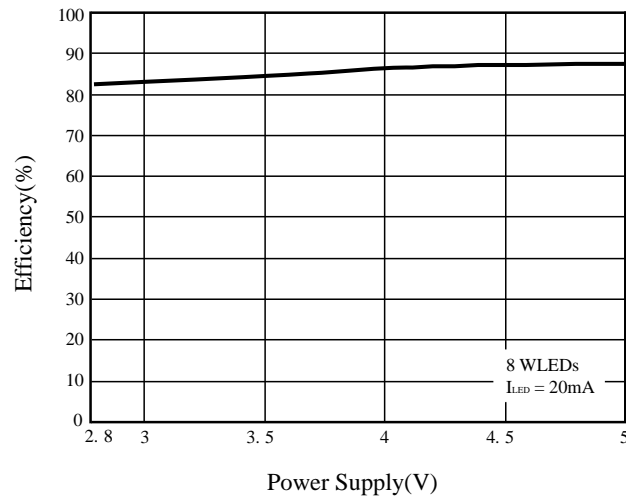


Figure 6 Efficiency vs. V<sub>CC</sub>

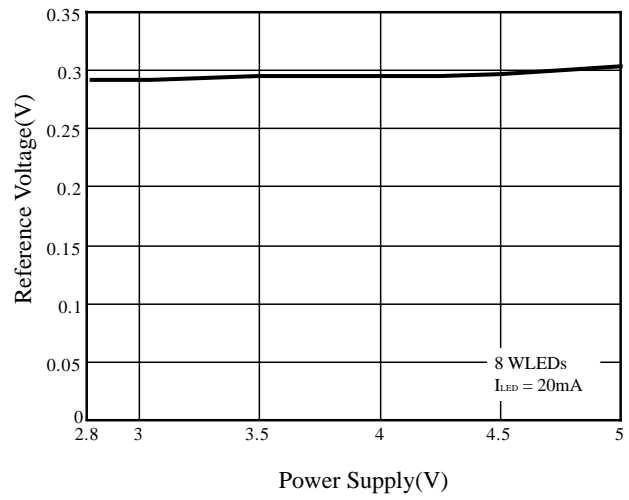


Figure 7 V<sub>FB</sub> vs. V<sub>CC</sub>

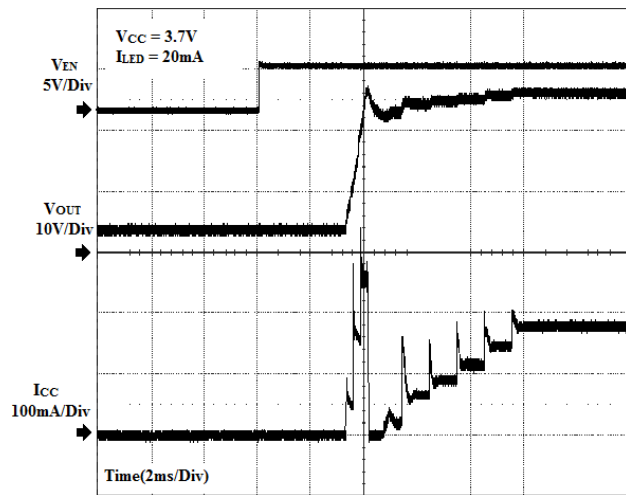


Figure 8 Power On from EN

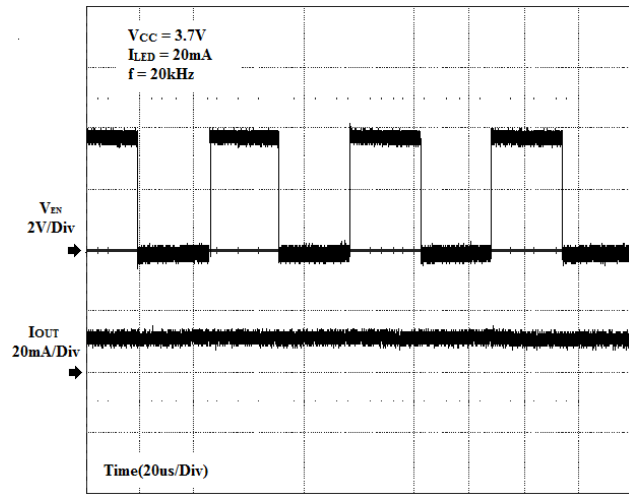


Figure 9 PWM Dimming from EN

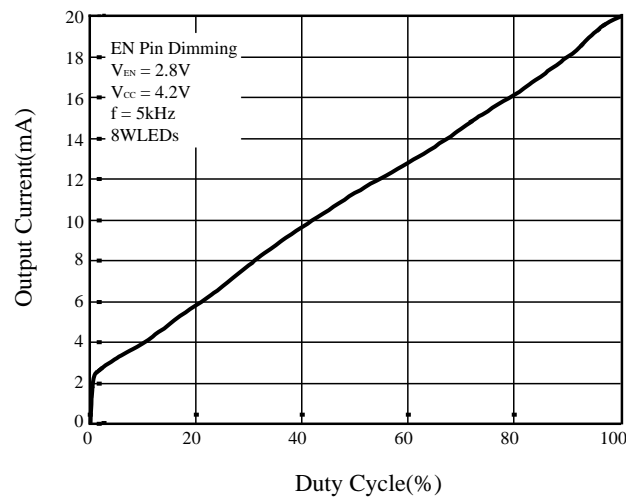


Figure 10 Enable Pin Dimming

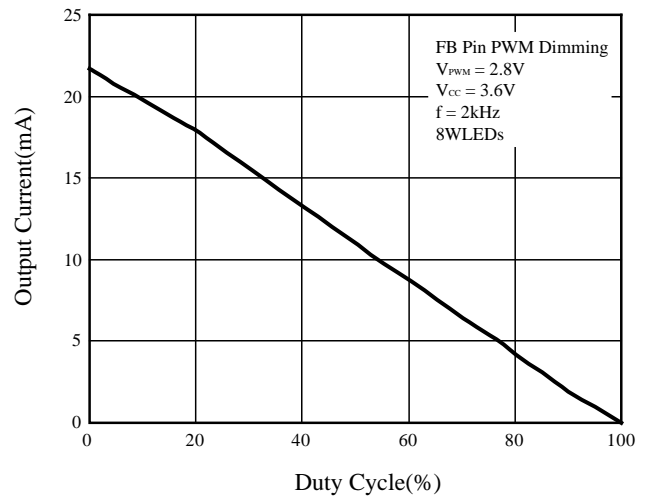


Figure 11 FB pin PWM Dimming

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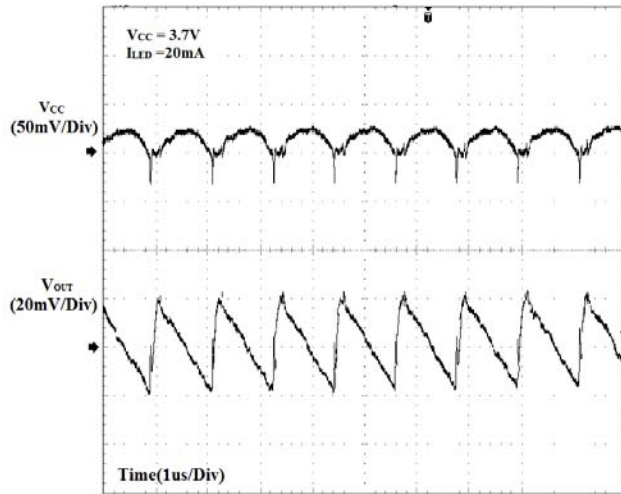
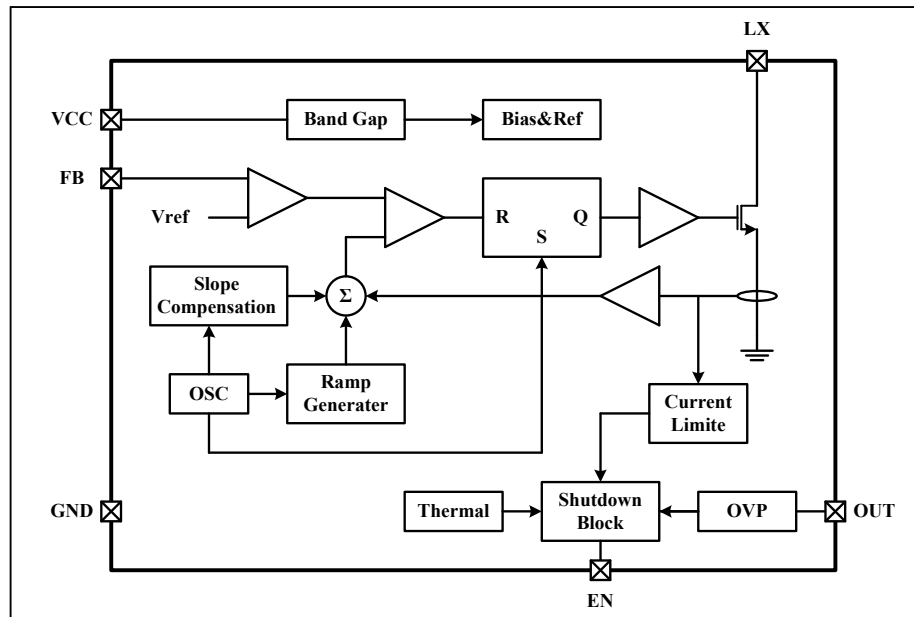


Figure 12 Ripple Voltage



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## FUNCTIONAL BLOCK DIAGRAM



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## APPLICATION INFORMATION

### INPUT AND OUTPUT CAPACITOR

A 2.2μF input capacitor is used to reduce input ripple and noise, where the input ripple amplitude is inversely proportional to the value of the input capacitance. The input and output capacitors should be placed as close to the device as possible, so as to reduce the effect of voltage ripple. The value of the output capacitor is dependent upon the output ripple. A 1μF or 0.22μF ceramic capacitor with a 50V rating is sufficient for the majority of applications.

### INDUCTOR VALUE

The choice of the inductor value will affect the performance of the device. Large value inductors will reduce the current ripple in the inductor, thus reducing output voltage ripple. However large value inductors of the same current rating, typically also have larger DC resistance, thus reducing the system efficiency. For the majority of applications 4.7μH or 10μH is sufficient.

### LED CURRENT SETPOINT

When the IS31BL3506A is used for LED driving applications (Figure 1), the LED current flows through the external feedback resistor  $R_{SET}$  to regulate the LED current. The internal feedback regulation point is 0.3V. The maximum LED current may be calculated by the following equation, (1).

$$I_{MAX} = V_{FB} / R_{SET} \quad (1)$$

For accurate LED current, resistors should be 1% or better tolerance.

### LED INTENSITY CONTROL

#### EN PIN DIMMING

The EN pin of the IS31BL3506A can accept a PWM signal to implement LED dimming (Figure 1). LED current may be computed using the following equation, (2).

$$I_{LED} = I_{MAX} \cdot D_{PWM} \quad (2)$$

$I_{MAX}$  is computed using equation (1). Recommended PWM frequency is in the range of 500Hz ~ 500kHz. So as to guarantee a reasonably good dimming effect, the minimum duty cycle should be about 1%.

Driving the EN pin with a PWM signal can effectively adjust the LED intensity. The PWM signal voltage levels must meet the EN pin input voltage levels,  $V_{EN\_ON}$  and  $V_{EN\_OFF}$ .

IS31BL3506A can also use a DC voltage or PWM signal to directly control the LED current, and thus provide fine adjustment for the LED intensity.

### FB PIN DC VOLTAGE DIMMING

The schematic of Figure 4 show an example of using a DC input voltage at the FB pin to implement LED dimming. When the DC input voltage increases, the current through  $R_2$  and  $R_3$  increases producing an offset voltage across  $R_2$ , thereby causing the LED current to be reduced. The LED current may be computed using the following equation, (3).  $V_{FB}$  is 0.3V (typ).

$$I_{LED} = \frac{V_{FB} - \frac{R_2 \times (V_{DC} - V_{FB})}{R_3}}{R_{SET}} \quad (3)$$

When the DC voltage range is 0V~1.8V, a good value for  $R_2$  is 75kΩ, and for  $R_3$  is 360kΩ.

### FB PIN PWM DIMMING

A PWM signal connected to the FB pin can also be used to directly control the LED current (Figure 5). A low pass filter converts the PWM duty cycle to a DC level, which is in turn summed together with the feedback voltage of RSET to effectively reduce the LED current proportionally. Due to the filtering of the PWM signal, the frequency of the PWM signal can have an affect on the output voltage ripple. For a PWM signal input signal of 2.8V, the recommended frequency is greater than 2kHz. Using a fixed frequency PWM signal and adjusting the PWM duty cycle effectively adjusts the LED intensity. LED current may be computed using the following equation, (4).  $V_{FB}$  is 0.3V (typ).

$$I_{LED} = \frac{V_{FB} - \frac{R_2 \times (V_{PWM} \times Duty - V_{FB})}{R_4 + R_3}}{R_{SET}} \quad (4)$$

For a PWM signal range of 0V~1.8V, a suitable value for  $R_2$  is 75kΩ,  $R_3$  is 150kΩ,  $R_4$  is 200kΩ. To ensure good dimming effect, the minimum duty cycle is about 10%.

### SETTING THE OUTPUT VOLTAGE

The IS31BL3506A can be configured to provide a constant output voltage (Figure 3). The output voltage level can be computed using the following equation, (5). The device internal  $V_{FB}$  is 0.3V (typ).

$$V_{OUT} = V_{FB} \times (R_1 + R_{SET}) / R_{SET} \quad (5)$$

### OVERVOLTAGE THRESHOLD

Device open circuit protection is realized using the overvoltage protection function (OVP). If the output voltage surpasses the overvoltage threshold, the overvoltage protection circuit is activated and the device will stop working.

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## CLASSIFICATION REFLOW PROFILES

| Profile Feature                                                                                                                                                               | Pb-Free Assembly                 |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|
| <b>Preheat &amp; Soak</b><br>Temperature min (T <sub>smin</sub> )<br>Temperature max (T <sub>smax</sub> )<br>Time (T <sub>smin</sub> to T <sub>smax</sub> ) (t <sub>s</sub> ) | 150°C<br>200°C<br>60-120 seconds |
| Average ramp-up rate (T <sub>smax</sub> to T <sub>p</sub> )                                                                                                                   | 3°C/second max.                  |
| Liquidous temperature (T <sub>L</sub> )<br>Time at liquidous (t <sub>L</sub> )                                                                                                | 217°C<br>60-150 seconds          |
| Peak package body temperature (T <sub>p</sub> )*                                                                                                                              | Max 260°C                        |
| Time (t <sub>p</sub> )** within 5°C of the specified classification temperature (T <sub>c</sub> )                                                                             | Max 30 seconds                   |
| Average ramp-down rate (T <sub>p</sub> to T <sub>smax</sub> )                                                                                                                 | 6°C/second max.                  |
| Time 25°C to peak temperature                                                                                                                                                 | 8 minutes max.                   |

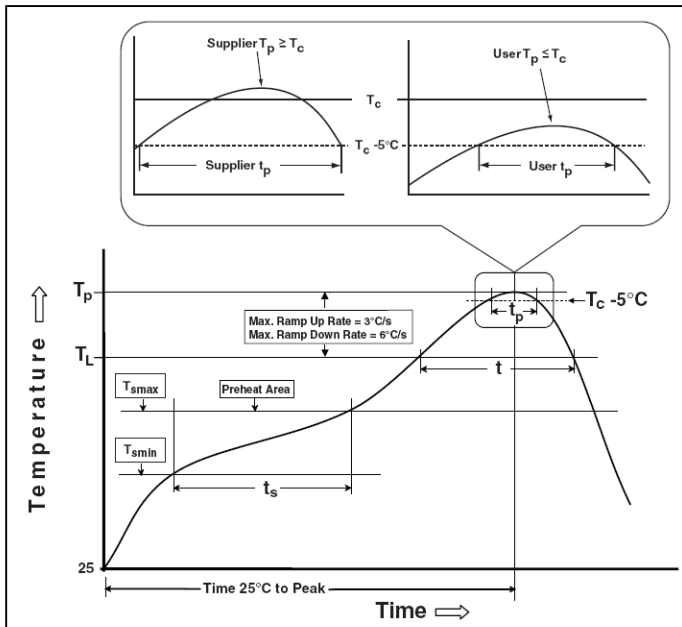
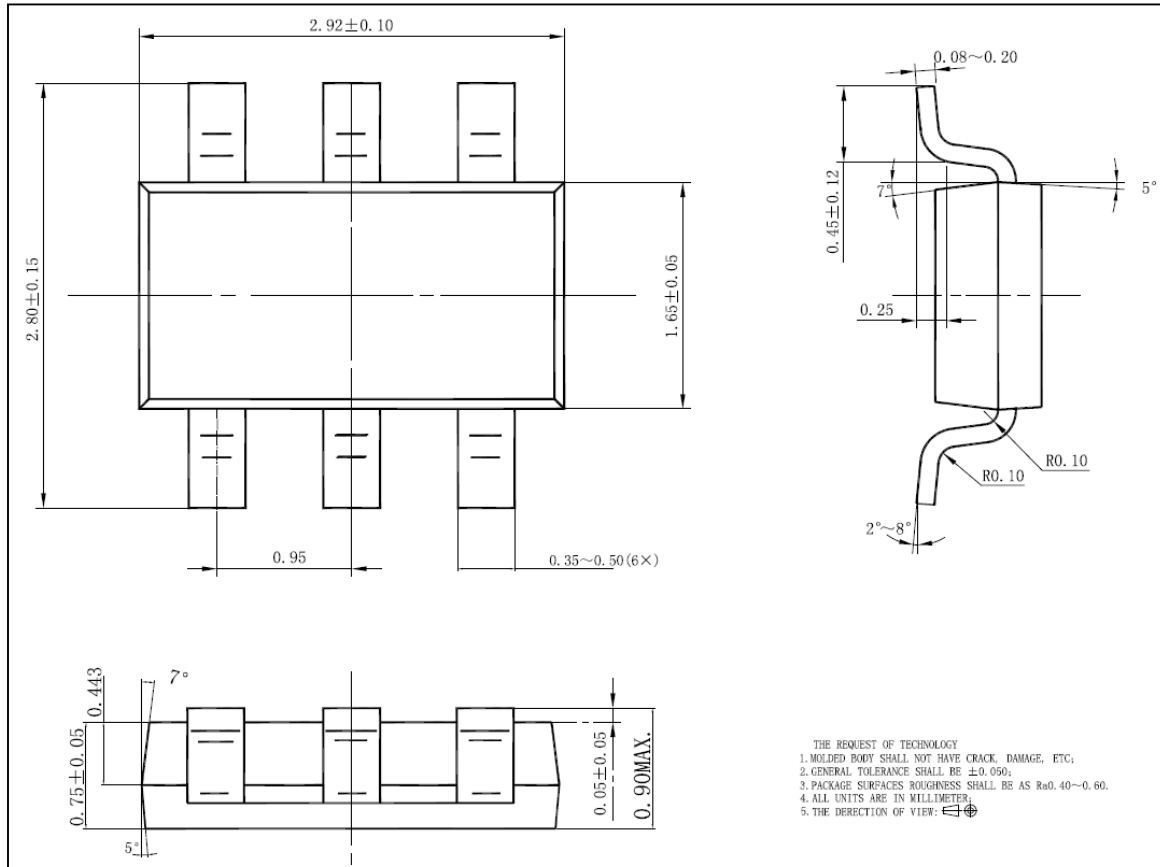


Figure 13 Classification Profile

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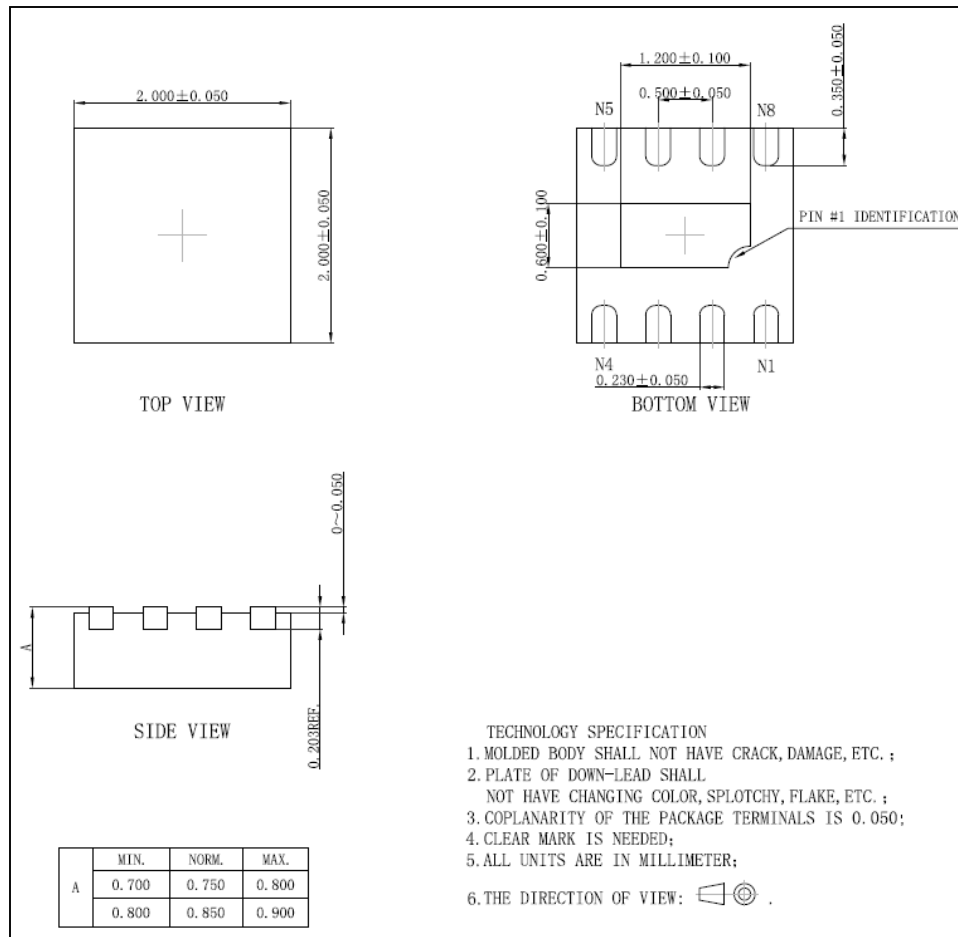
## PACKAGE OUTLINE DRAWING

### TSOT-23-6



# IS31BL3506A

## DFN-8



**Note:** All dimensions in millimeters unless otherwise stated.