

## White LED Step-Up Regulator



The EL1848 is a constant current boost regulator specially designed for driving white LEDs. It can drive 3

LEDs in series or up to 9 LEDs in parallel/series configuration and achieves efficiency up to 91%.

The brightness of the LEDs is adjusted through a voltage level on the CNTL pin. When the level falls below 0.1V, the chip goes into shut-down mode and consumes less than 1μA of supply current for  $V_{IN}$  less than 5.5V.

The EL1848 is available in 8-pin TSOT and MSOP packages. The TSOT is just 1mm high, compared to 1.45mm for the standard SOT-23 package.

## Ordering Information

| PART NUMBER                  | PACKAGE                 | TAPE & REEL  | PKG. DWG. # |
|------------------------------|-------------------------|--------------|-------------|
| EL1848IWT-T7                 | 8-Pin TSOT              | 7" (3K pcs)  | MDP0049     |
| EL1848IWT-T7A                | 8-Pin TSOT              | 7" (250 pcs) | MDP0049     |
| EL1848IWTZ-T7<br>(See Note)  | 8-Pin TSOT<br>(Pb-free) | 7" (3K pcs)  | MDP0049     |
| EL1848IWTZ-T7A<br>(See Note) | 8-Pin TSOT<br>(Pb-free) | 7" (250 pcs) | MDP0049     |
| EL1848IY                     | 8-Pin MSOP              | -            | MDP0043     |
| EL1848IY-T7                  | 8-Pin MSOP              | 7"           | MDP0043     |
| EL1848IY-T13                 | 8-Pin MSOP              | 13"          | MDP0043     |

NOTE: Intersil Pb-free products employ special Pb-free material sets; molding compounds/die attach materials and 100% matte tin plate termination finish, which is compatible with both SnPb and Pb-free soldering operations. Intersil Pb-free products are MSL classified at Pb-free peak reflow temperatures that meet or exceed the Pb-free requirements of IPC/JEDEC J Std-020B.

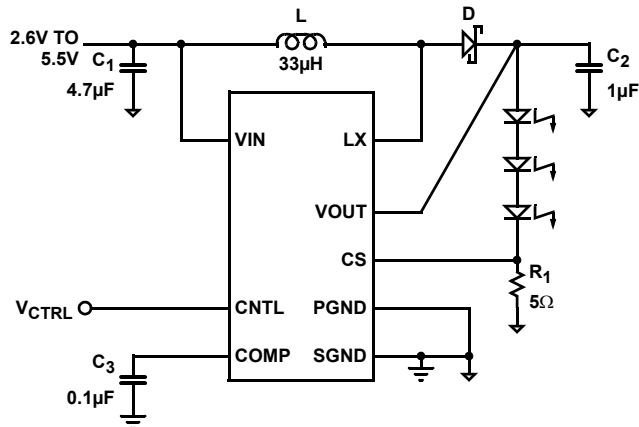
## Features

- 2.6V to 13.2V input voltage
- 14V maximum output voltage
- Drives up to 9 LEDs, 3 in a series
- 1MHz switching frequency
- Up to 91% efficiency
- 1μA maximum shut-down current
- Dimming control
- 8-pin TSOT and MSOP packages
- Pb-free Available

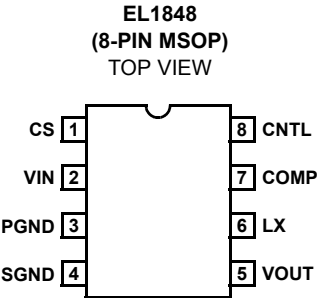
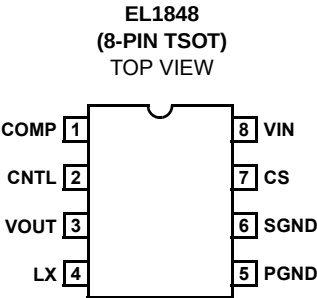
## Applications

- PDAs
- Cellular phones
- Digital cameras
- White LED backlighting

## Typical Connection



Pinouts



**Absolute Maximum Ratings** ( $T_A = 25^\circ\text{C}$ )

COMP, CNTL, CS to SGND . . . . . -0.3V to +6V  
 $V_{IN}$  to SGND . . . . . +14V  
 $V_{OUT}$  to SGND . . . . . +14V  
 LX to PGND . . . . . +16V

SGND to PGND . . . . . -0.3V to +0.3V  
 Storage Temperature . . . . .  $-65^\circ\text{C}$  to  $+150^\circ\text{C}$   
 Ambient Operating Temperature . . . . .  $-40^\circ\text{C}$  to  $+85^\circ\text{C}$   
 Power Dissipation . . . . . See Curves  
 Operating Junction Temperature . . . . .  $125^\circ\text{C}$

**CAUTION:** Stresses above those listed in "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress only rating and operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied. This part is ESD sensitive. Handle with care.

**IMPORTANT NOTE:** All parameters having Min/Max specifications are guaranteed. Typ values are for information purposes only. Unless otherwise noted, all tests are at the specified temperature and are pulsed tests, therefore:  $T_J = T_C = T_A$

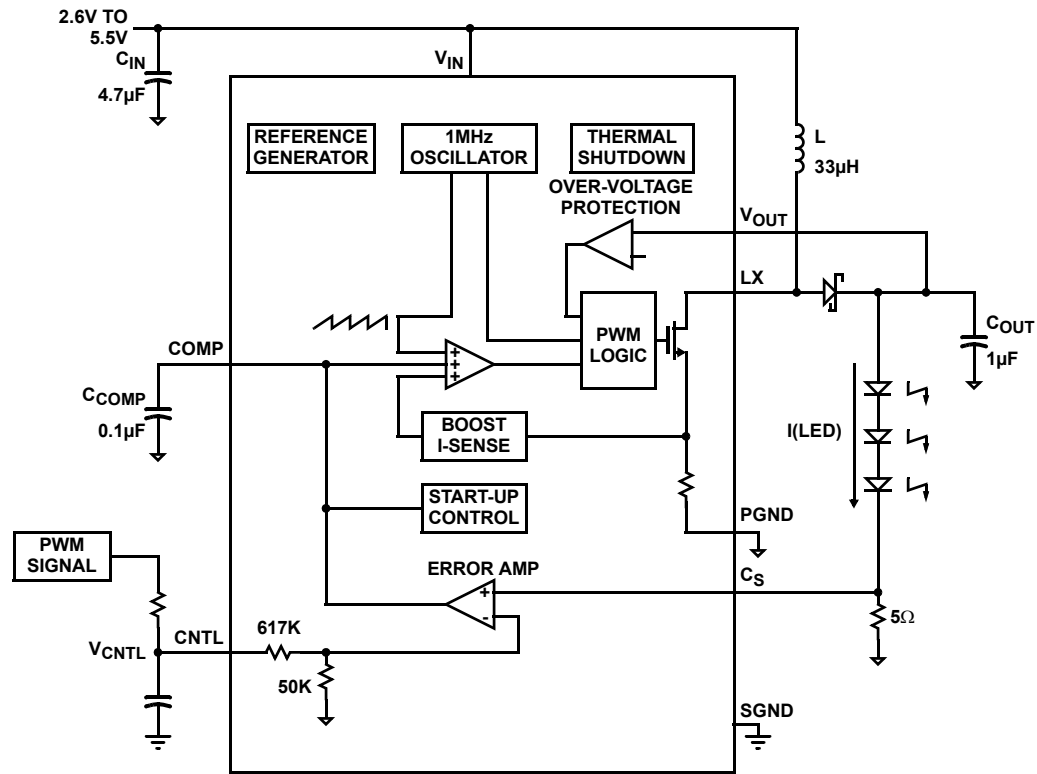
**Electrical Specifications**  $V_{IN} = 3\text{V}$ ,  $V_O = 12\text{V}$ ,  $C_1 = 4.7\mu\text{F}$ ,  $L = 33\mu\text{H}$ ,  $C_2 = 1\mu\text{F}$ ,  $C_3 = 0.1\mu\text{F}$ ,  $R_1 = 5\Omega$ ,  $T_A = 25^\circ\text{C}$ , unless otherwise specified.

| PARAMETER                    | DESCRIPTION                           | CONDITIONS                                     | MIN | TYP  | MAX  | UNIT          |
|------------------------------|---------------------------------------|------------------------------------------------|-----|------|------|---------------|
| $V_{IN}$                     | Input Voltage                         |                                                | 2.6 |      | 13.2 | V             |
| $I_{Q1}$                     | Total Input Current at Shut-down      | $V_{CNTL} = 0\text{V}$                         |     |      | 1    | $\mu\text{A}$ |
| $I_{Q1}$                     | Quiescent Supply Current at $V_O$ Pin | $V_{CNTL} = 1\text{V}$ , load disconnected     |     | 1    | 1.5  | mA            |
| $I_{COMP}$                   | COMP Pin Pull-up Current              | COMP connected to SGND                         |     | 11   | 20   | $\mu\text{A}$ |
| $V_{COMP}$                   | COMP Voltage Swing                    |                                                | 0.5 | 1.5  | 2.5  | V             |
| $I_{CNTL}$                   | CNTL Shut-down Current                | $CNTL = 0\text{V}$                             |     |      | 1    | $\mu\text{A}$ |
| $V_{CNTL1}$                  | Chip Enable Voltage                   |                                                | 240 |      |      | mV            |
| $V_{CNTL2}$                  | Chip Disable Voltage                  |                                                |     |      | 100  | mV            |
| $I_{OUT\_ACCURACY}$          | $V_{CNTL} = 1\text{V}$                | $V_{CNTL} = 1\text{V}$                         | 14  | 15   | 16   | mA            |
| $V_{OUT1}$                   | Over-voltage Threshold                | $V_{OUT}$ rising                               | 13  | 14   | 15   | V             |
| $V_{OUT2}$                   | Over-voltage Threshold                | $V_{OUT}$ falling, with resistive load         | 11  | 12   | 13   | V             |
| $I_{LX}$                     | MOSFET Current Limit                  |                                                | 400 |      |      | mA            |
| $R_{DS\_ON}$                 | MOSFET On-resistance                  |                                                |     | 0.7  |      | $\Omega$      |
| $I_{LEAK}$                   | MOSFET Leakage Current                | $V_{CNTL} = 0\text{V}$ , $V_{LX} = 12\text{V}$ |     |      | 1    | $\mu\text{A}$ |
| $F_S$                        | Switching Frequency                   |                                                | 800 | 1000 | 1200 | kHz           |
| $D_{MAX}$                    | Maximum Duty Ratio                    | $V_{CNTL} = 2\text{V}$ , $I_S = 0$             | 85  | 90   |      | %             |
| $I_{CS}$                     | CS Input Bias Current                 |                                                |     |      | 1    | $\mu\text{A}$ |
| $\Delta I_O / \Delta V_{IN}$ | Line Regulation                       | $V_{IN} = 2.6\text{V} - 5.5\text{V}$           |     | 0.03 |      | %/V           |

**Pin Descriptions**

| PIN NUMBER | PIN NAME | DESCRIPTION                                                                                                                                    |
|------------|----------|------------------------------------------------------------------------------------------------------------------------------------------------|
| 1          | COMP     | Compensation pin. A compensation cap (4700pF to 1 $\mu\text{F}$ ) is normally connected between this pin and SGND.                             |
| 2          | CNTL     | Control pin for dimming and shut-down. A voltage between 250mV and 5.5V controls the brightness, and less than 100mV shuts down the converter. |
| 3          | VOUT     | Output voltage sense. Use for over voltage protection.                                                                                         |
| 4          | LX       | Inductor connection pin. The drain of internal MOSFET.                                                                                         |
| 5          | PGND     | Power Ground pin. The source of internal MOSFET.                                                                                               |
| 6          | SGND     | Signal Ground. Ground pin for internal control circuitry. Needs to connect to PGND at only one point.                                          |
| 7          | CS       | Current sense pin. Connect to sensing resistor to set the LED bias current.                                                                    |
| 8          | VIN      | Power supply for internal control circuitry.                                                                                                   |

## Block Diagram



## Typical Performance Curves

All performance curves and waveforms are taken with  $C_1 = 4.7\mu\text{F}$ ,  $C_2 = 1\mu\text{F}$ ,  $C_3 = 0.1\mu\text{F}$ ,  $L = 33\mu\text{H}$ ,  $V_{\text{IN}} = 3.3\text{V}$ ,  $V_{\text{CNTL}} = 1\text{V}$ ,  $R_1 = 5\Omega$ , 3 LEDs in a series; unless otherwise specified.

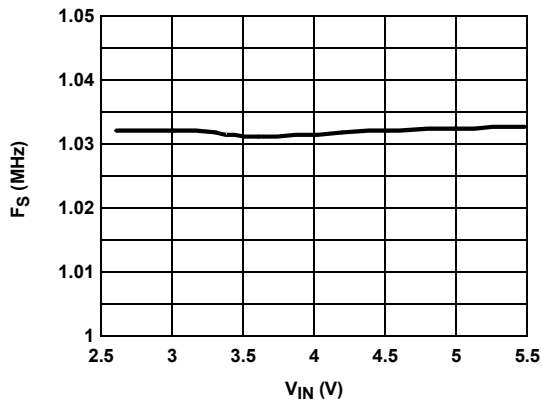


FIGURE 1. SWITCHING FREQUENCY vs  $V_{\text{IN}}$

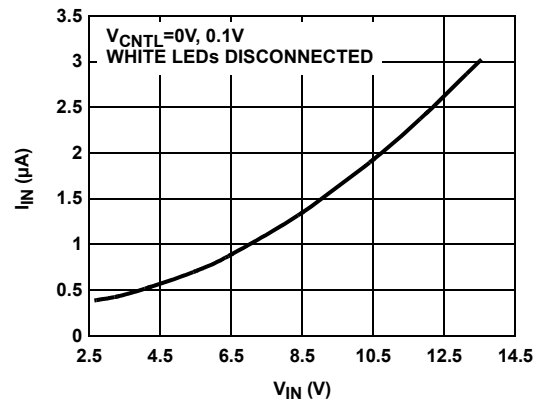


FIGURE 2. QUIESCENT CURRENT

### Typical Performance Curves (Continued)

All performance curves and waveforms are taken with  $C_1 = 4.7\mu\text{F}$ ,  $C_2 = 1\mu\text{F}$ ,  $C_3 = 0.1\mu\text{F}$ ,  $L = 33\mu\text{H}$ ,  $V_{\text{IN}} = 3.3\text{V}$ ,  $V_{\text{CNTL}} = 1\text{V}$ ,  $R_1 = 5\Omega$ , 3 LEDs in a series; unless otherwise specified.

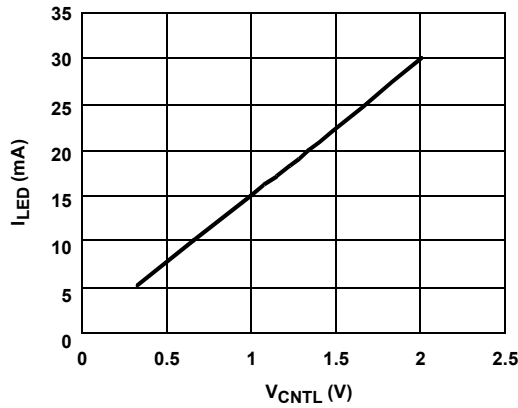


FIGURE 3.  $I_{\text{LED}}$  vs  $V_{\text{CNTL}}$

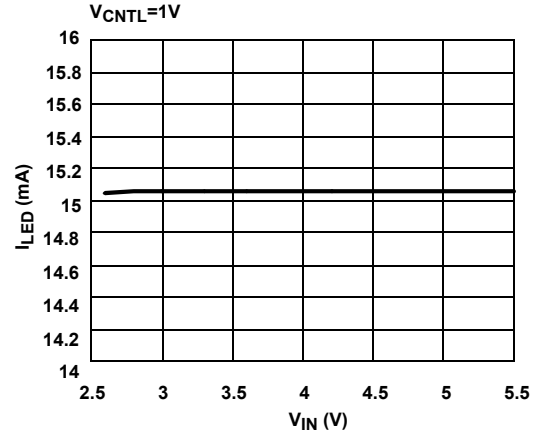


FIGURE 4.  $I_{\text{LED}}$  vs  $V_{\text{IN}}$

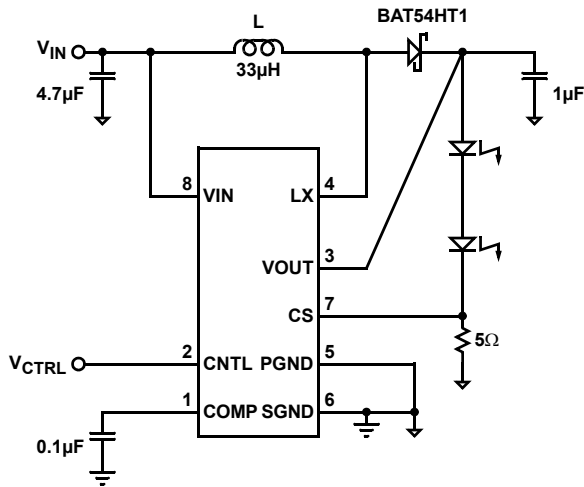


FIGURE 5A. 2 LEDs IN A SERIES

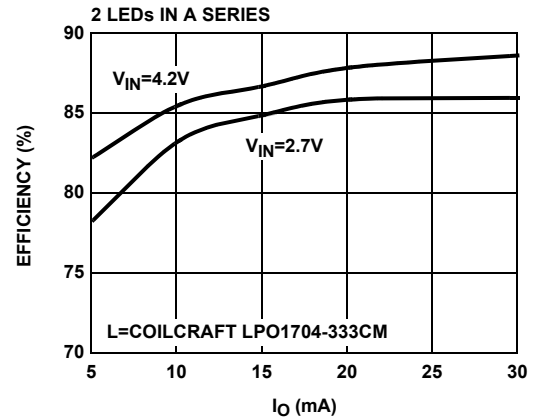


FIGURE 5B. EFFICIENCY vs  $I_{\text{O}}$

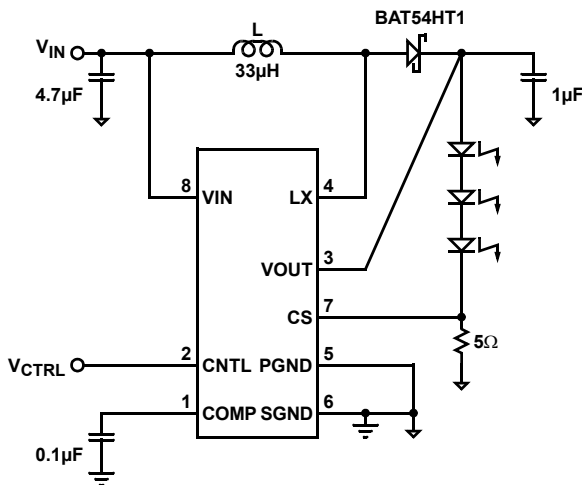


FIGURE 6A. 3 LEDs IN A SERIES

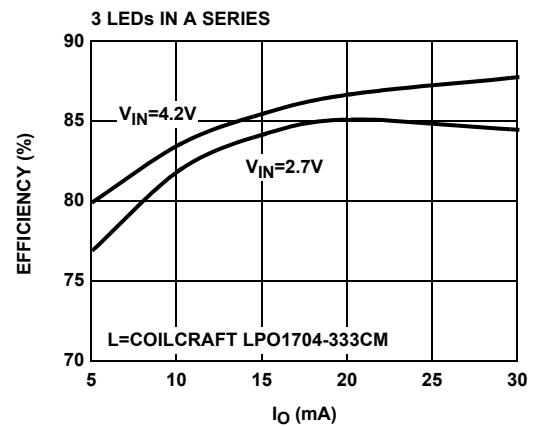


FIGURE 6B. EFFICIENCY vs  $I_{\text{O}}$



## Typical Performance Curves (Continued)

All performance curves and waveforms are taken with  $C_1 = 4.7\mu\text{F}$ ,  $C_2 = 1\mu\text{F}$ ,  $C_3 = 0.1\mu\text{F}$ ,  $L = 33\mu\text{H}$ ,  $V_{\text{IN}} = 3.3\text{V}$ ,  $V_{\text{CNTL}} = 1\text{V}$ ,  $R_1 = 5\Omega$ , 3 LEDs in a series; unless otherwise specified.

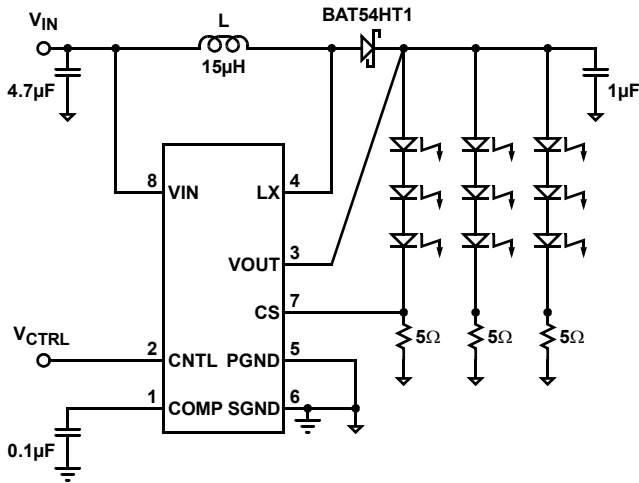


FIGURE 10A. 3 LEGS OF 3 LEDs IN A SERIES

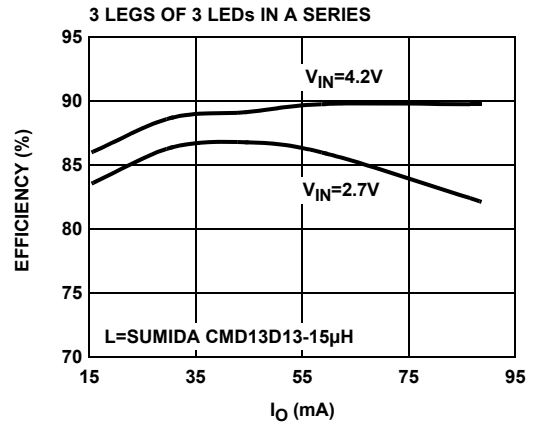


FIGURE 10B. EFFICIENCY vs  $I_O$

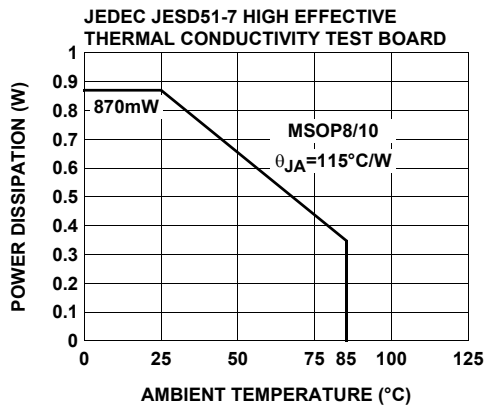


FIGURE 11. PACKAGE POWER DISSIPATION vs AMBIENT TEMPERATURE

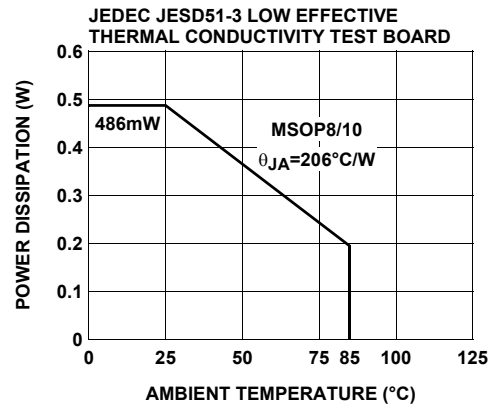


FIGURE 12. PACKAGE POWER DISSIPATION vs AMBIENT TEMPERATURE

## Waveforms

All performance curves and waveforms are taken with  $C_1 = 4.7\mu\text{F}$ ,  $C_2 = 1\mu\text{F}$ ,  $C_3 = 0.1\mu\text{F}$ ,  $L = 33\mu\text{F}$ ,  $V_{\text{IN}} = 3.3\text{V}$ ,  $V_{\text{CNTL}} = 1\text{V}$ ,  $R_1 = 5\Omega$ , 4 LEDs in a series; unless otherwise specified.

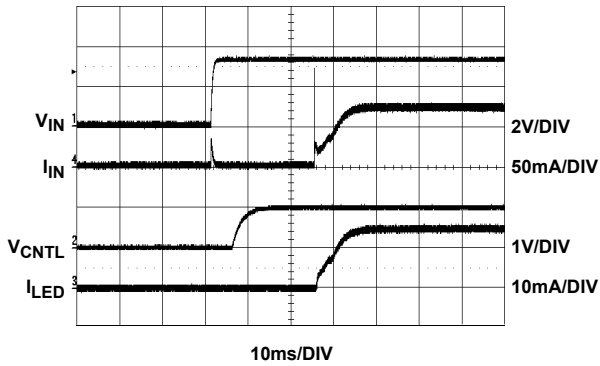


FIGURE 13. START-UP

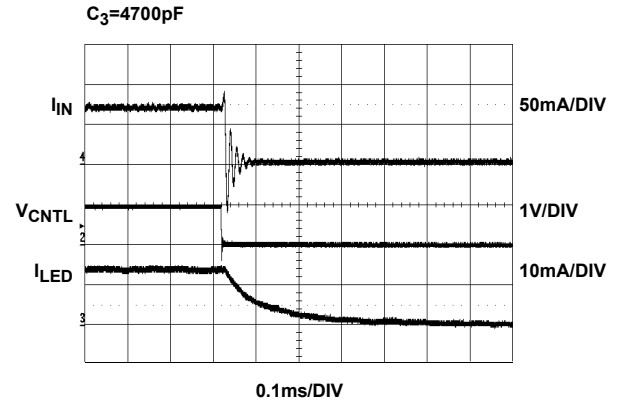


FIGURE 14. SHUT-DOWN

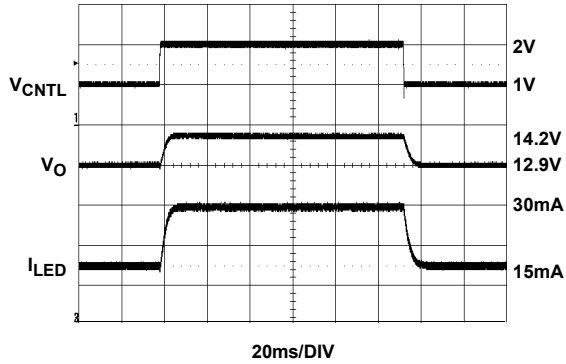


FIGURE 15. TRANSIENT RESPONSE

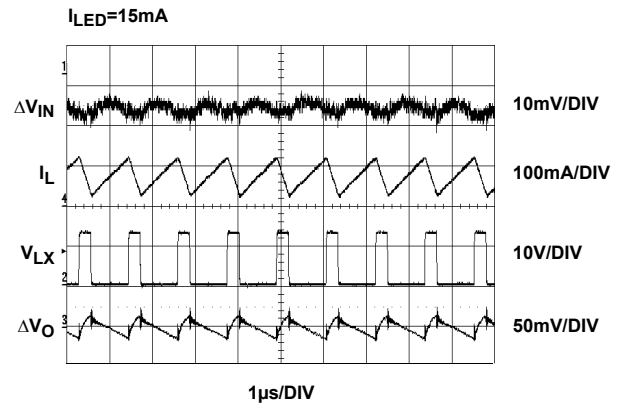


FIGURE 16. CONTINUOUS CONDUCTION MODE

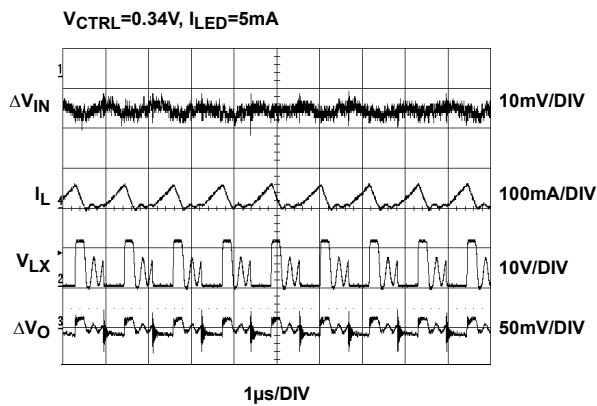


FIGURE 17. DISCONTINUOUS CONDUCTION MODE

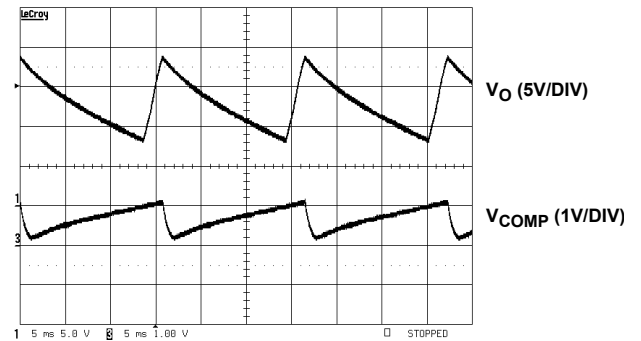


FIGURE 18. OVER VOLTAGE PROTECTION (LED DISCONNECTED)

## Detailed Description

The EL1848 is a constant current boost regulator specially designed for driving white LEDs. It can drive up to 3 LEDs in series or 9 LEDs in parallel/series configuration and achieves efficiency up to 91%.

The brightness of the LEDs is adjusted through a voltage level on the CNTL pin. When the level falls below 0.1V, the chip goes into shut-down mode and consumes less than 1µA of current for  $V_{IN}$  less than 5.5V.

## Steady-State Operation

EL1848 is operated in constant frequency PWM. The switching is around 1MHz. Depending on the input voltage, the inductance, the type of LEDs driven, and the LED's current, the converter operates at either continuous conduction mode or discontinuous conduction mode (see waveforms). Both are normal.

## Brightness Control

LED's current is controlled by the voltage level on CNTL pin ( $V_{CNTL}$ ). This voltage can be either a DC or a PWM signal with frequency less than 200Hz (for  $C_3=4700pF$ ). When a higher frequency PWM is used, an RC filter is recommended before the CNTL pin (see Figure 17).

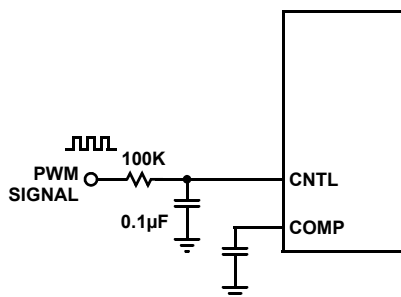


FIGURE 19. PWM BRIGHTNESS CONTROL

The relationship between the LED current and CNTL voltage level is as follows:

$$I_{LED} = \frac{V_{CNTL}}{13.33 \times R_1}$$

When  $R_1$  is 5Ω, 1V of  $V_{CNTL}$  conveniently sets  $I_{LED}$  to 15mA. The range of  $V_{CNTL}$  is 250mV to 5.5V.

## Shut-Down

When  $V_{CNTL}$  is less than 100mV, the converter is in shut-down mode. The max current consumed by the chip is less than 1µA for  $V_{IN}$  less than 5.5V.

## Over-Voltage Protection

When an LED string is disconnected from the output,  $V_O$  will continue to rise because of no current feedback. When  $V_O$  reaches 14V (nominal), the chip will shut down. The output voltage will drop. When  $V_O$  drops below 11V (nominal), the chip will boost output voltage again until it reaches 14V. This

hiccough continues until LED is applied or converter is shut down.

When designing the converter, caution should be taken to ensure the highest operating LED voltage does not exceed 13V, the minimum shut-down voltage. There is no external component required for this function.

## Component Selection

The input and output capacitors are not very important for the converter to operate normally. The input capacitance is normally 0.22µF - 4.7µF and output capacitance 0.22µF - 1µF. Higher capacitance is allowed to reduce the voltage/current ripple, but at added cost. Use X5R or X7R type (for its good temperature characteristics) of ceramic capacitors with correct voltage rating and maximum height.

When choosing an inductor, make sure the inductor can handle the average and peak currents giving by following formulas (80% efficiency assumed):

$$I_{LAVG} = \frac{I_O \times V_O}{0.8 \times V_{IN}}$$

$$I_{LPK} = I_{LAVG} + \frac{1}{2} \times \Delta I_L$$

$$\Delta I_L = \frac{V_{IN} \times (V_O - V_{IN})}{L \times V_O \times F_S}$$

where:

- $\Delta I_L$  is the peak-to-peak inductor current ripple in Ampere
- L inductance in µH
- $F_S$  switching frequency, typical 1MHz

A wide range of inductance (6.8µH - 68µH) can be used for the converter to function correctly. For the same series of inductors, the lower inductance has lower DC resistance (DCR), which has less conducting loss. But the ripple current is bigger, which generates more RMS current loss. Figure 9 shows the efficiency of the demo board under different inductance for a specific series of inductor. For optimal efficiency in an application, it is a good exercise to check several adjacent inductance values of your preferred series of inductors.

For the same inductance, higher overall efficiency can be obtained by using lower DCR inductor.

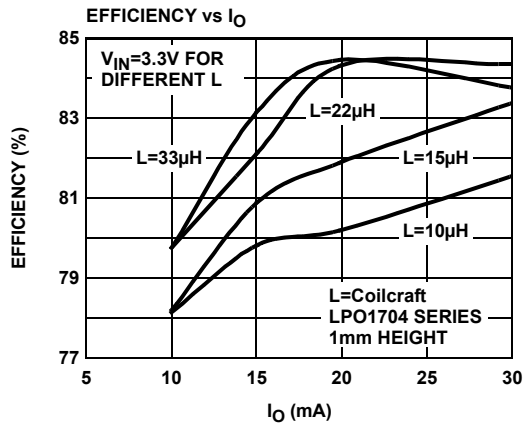


FIGURE 20. EFFICIENCY OF DIFFERENT INDUCTANCE (4 LEDs IN A SERIES)

The diode should be Schottky type with minimum reverse voltage of 20V. The diode's peak current is the same as inductor's peak current, the average current is  $I_O$ , and RMS current is:

$$I_{DRMS} = \sqrt{I_{LAVG} \times I_O}$$

Ensure the diode's ratings exceed these current requirements.

### White LED Connections

One leg of LEDs connected in series will ensure the uniformity of the brightness. 14V maximum voltage enables 3 LEDs can be placed in series.

However, placing LEDs into series/parallel connection can give higher efficiency as shown in the efficiency curves. One of the ways to ensure the brightness uniformity is to pre-screen the LEDs.

### PCB Layout Considerations

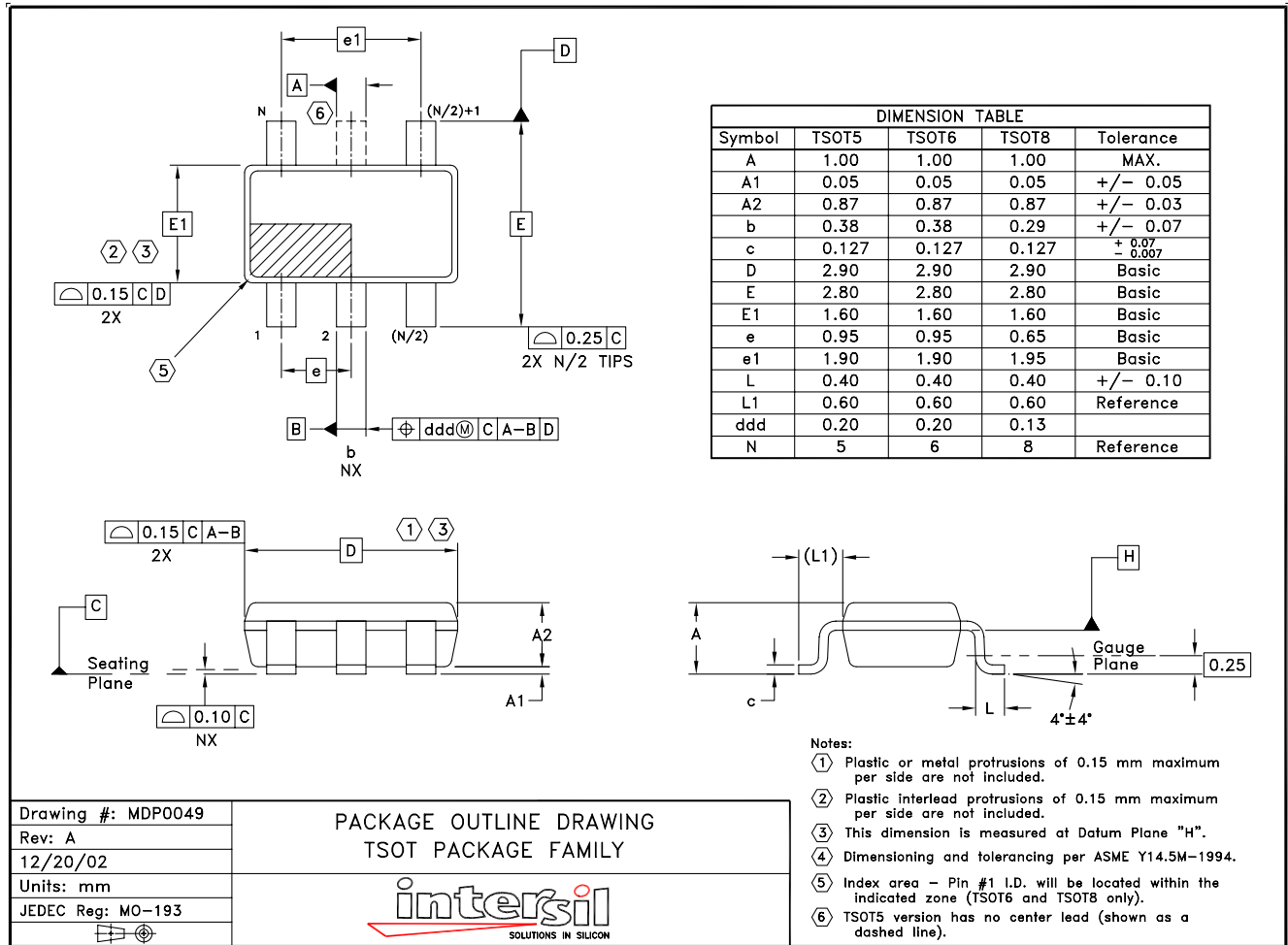
The layout is very important for the converter to function properly. Power Ground ( $\downarrow$ ) and Signal Ground ( $\perp$ ) should be separated to ensure the high pulse current in the power ground does not interference with the sensitive signals connected to Signal Ground. Both grounds should only be connected at one point right at the chip. The heavy current paths ( $V_{IN}$ -L- $L_X$  pin-PGND, and  $V_{IN}$ -L-D-C<sub>2</sub>-PGND) should be as short as possible.

The trace connected to the CS pin is most important. The current sense resistor  $R_1$  should be very close to the pin. When the trace is long, use a small filter capacitor close to the CS pin.

The heat of the IC is mainly dissipated through the PGND pin. Maximizing the copper area around the plane is preferable. In addition, a solid ground plane is always helpful for the EMI performance.

The demo board is a good example of layout based on the principle. Please refer to the EL1848 Application Brief for the layout.

## TSOT Package Outline Drawing



Drawing #: MDP0049

Rev: A

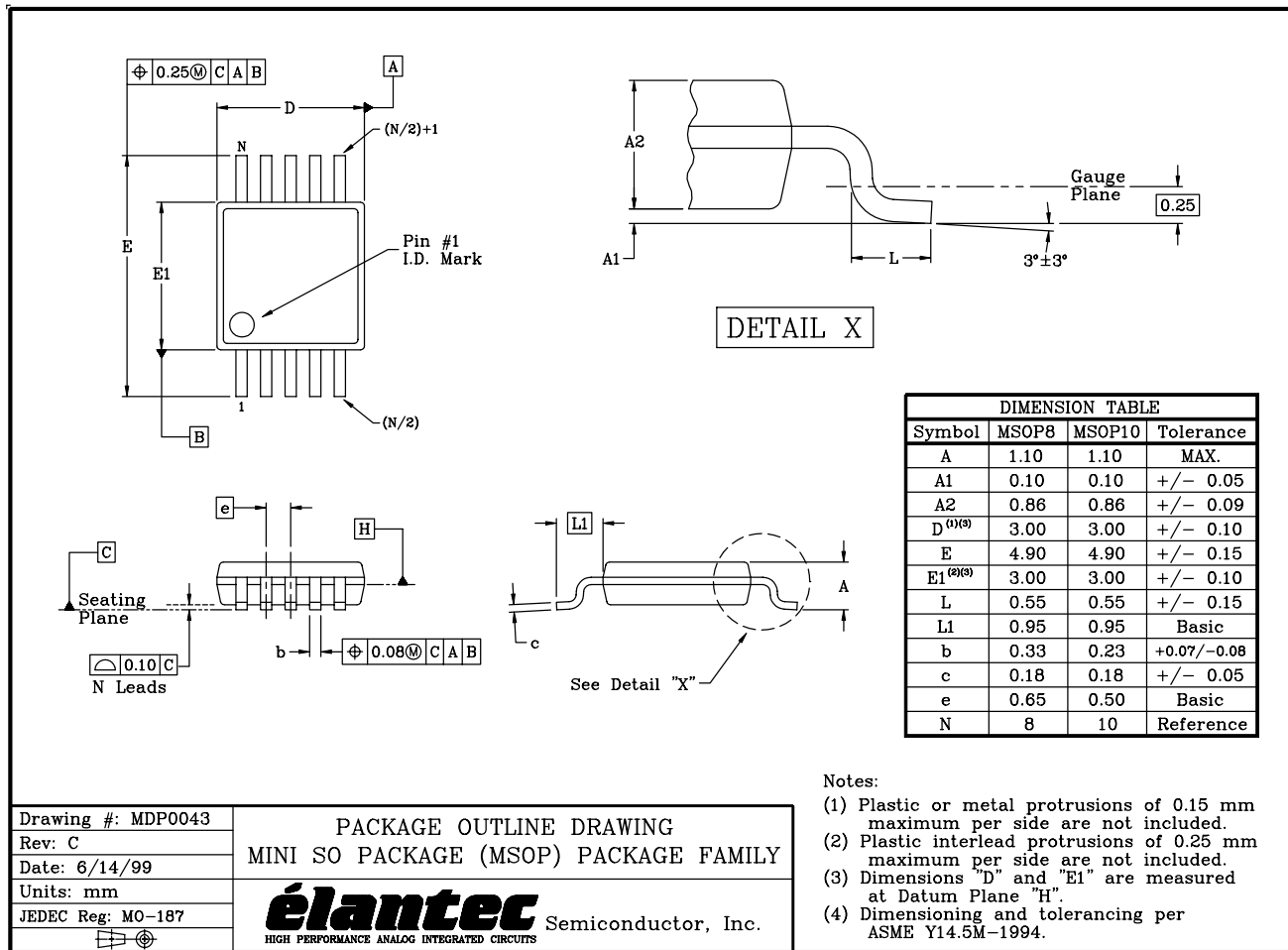
12/20/02

Units: mm

JEDEC Reg: MO-193


 PACKAGE OUTLINE DRAWING  
 TSOT PACKAGE FAMILY


## MSOP Package Outline Drawing



NOTE: The package drawing shown here may not be the latest version. To check the latest revision, please refer to the Intersil website at <<http://www.intersil.com/design/packages/index.asp>>

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 Intersil Corporation's quality certifications can be viewed at [www.intersil.com/design/quality](http://www.intersil.com/design/quality)

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