

The EC4513 is a constant current boost regulator specially designed for driving white LEDs. It can drive 4 LEDs in series and achieves efficiency up to 90%. The brightness of the LEDs is adjusted through a voltage level on the CNTL pin. When the level falls below 0.2V, the chip goes into shut-down mode and consumes less than 1 μ A of supply current for VIN less than 5.5V. The EC4513 is available in the 8-pin MSOP packages.

Features

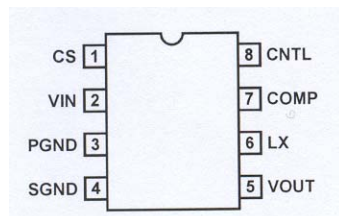
- 2.6V to 13.2V input voltage
- 18V maximum output voltage
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- 1MHz switching frequency
- Up to 90% efficiency
- 1 μ A maximum shut-down current
- Dimming control
- 8-pin MSOP packages

Applications

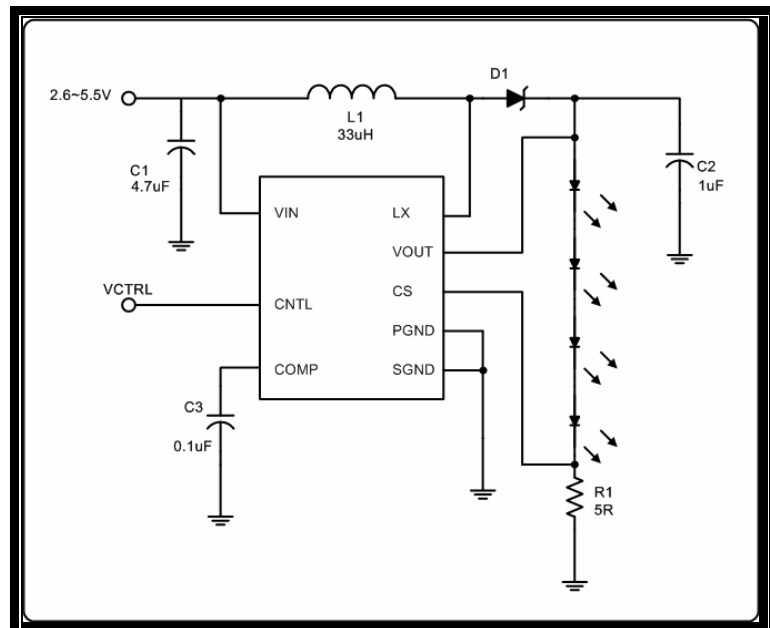
- PDAs
- Cellular phones
- Digital cameras
- White LED backlighting

Pinouts

MSOP 8-PIN
TOP VIEW



Application Circuit





White LED Step-Up Regulator

EC4513
Preliminary

Absolute Maximum Ratings (TA = 25°C)

COMP, CNTL, IS to SGND.	-0.3V to +6V	Storage Temperature	-65°C to +150°C
VOUT, VIN to SGND.	+19.5V	Lead Temperature	300°C
LX to PGND	+20V	Operating Temperature	-40°C to +85°C
SGND to PGND	-0.3V to +0.3V		

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.

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: TJ = TC = TA

Electrical Specifications

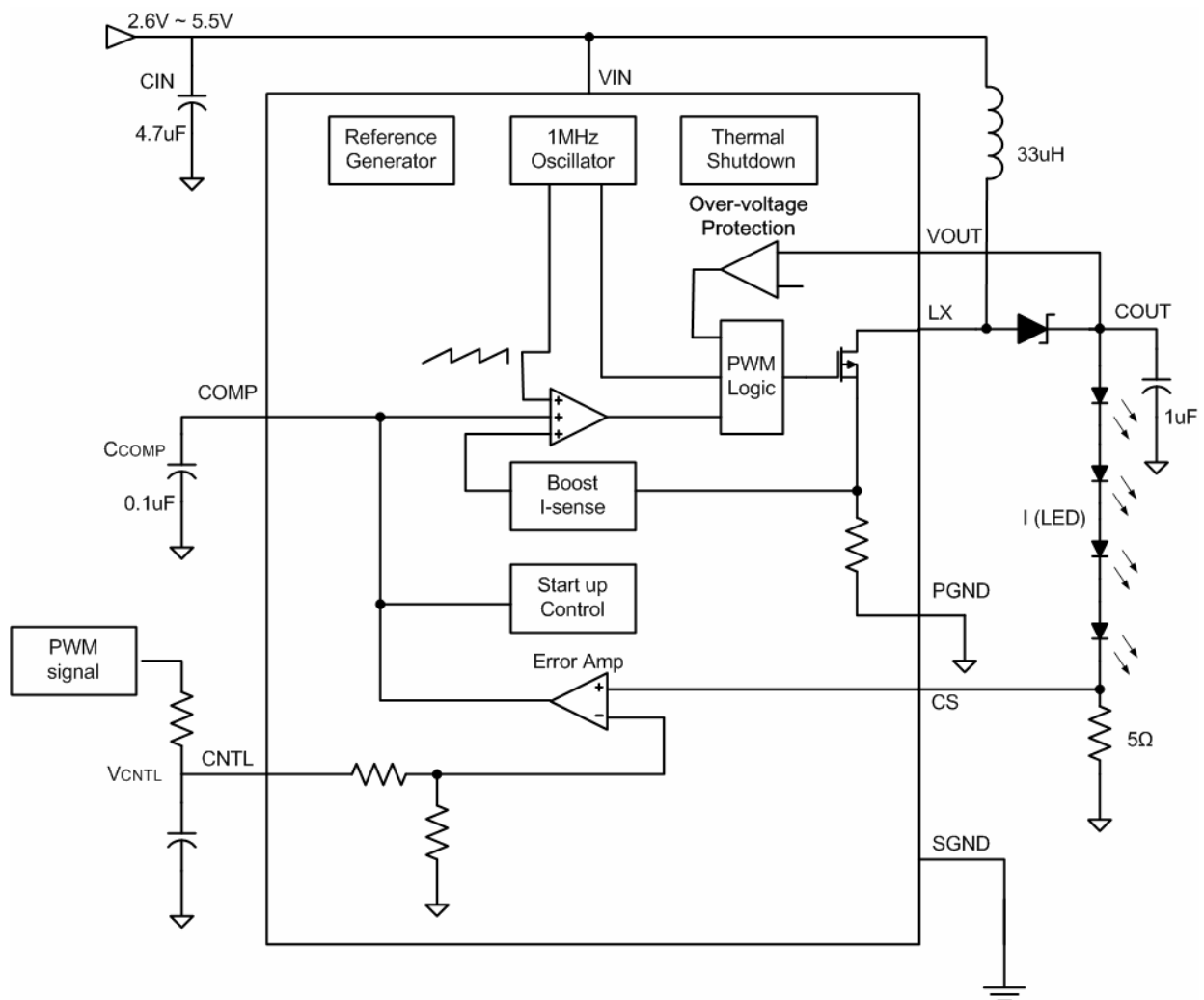
VIN = 3V, VO = 12V, C1 = 4.7µF, C2 = 1µF, C3 = 0.1µF, R1 = 5Ω, TA = 25°C, unless otherwise specified.

PARAMETER	DESCRIPTION	CONDITIONS	MIN	TYP	MAX	UNIT
VIN	Input Voltage		2.6		13.2	V
IQ1	Shut-down Supply Current	V _{CNTL} = 0V, Vin=3V			1	µA
ICOMP	COMP Pin Pull-up Current	COMP connected to SGND		10		µA
VCOMP	COMP Voltage Swing		0.5	2.5	3.5	V
ICNTL	CNTL shut-down Current	CNTL = 0V			1	µA
V _{CNTL1}	Chip Enable Voltage		270			mV
	Chip Disable Voltage				200	mV
I _{OUT_ACCURACY}	V _{CNTL} = 1V	V _{CNTL} = 1V	14	15	16	mA
V _{OUT1}	Over-voltage Threshold	V _{OUT} rising		17		V
V _{OUT2}	Over-voltage Threshold	V _{OUT} falling		15		V
ILX	MOSFET Current Limit		500			mA
R _{DS_ON}	MOSFET On-resistance			0.7		Ω
I _{LEAK}	MOSFET leakage Current	V _{CNTL} = 0V , V _{LX} = 12V			1	µA
F _s	Switching Frequency		800	1000	1200	KHz
D _{MAX}	Maximum Duty Ratio	V _{CNTL} = 2V , IS = 0	85			%
ICS	CS Input Bias Current				1	µA
ΔI _o /ΔV _{IN}	Line Regulation	VIN = 2.6V - 5.5V		0.05		%/V

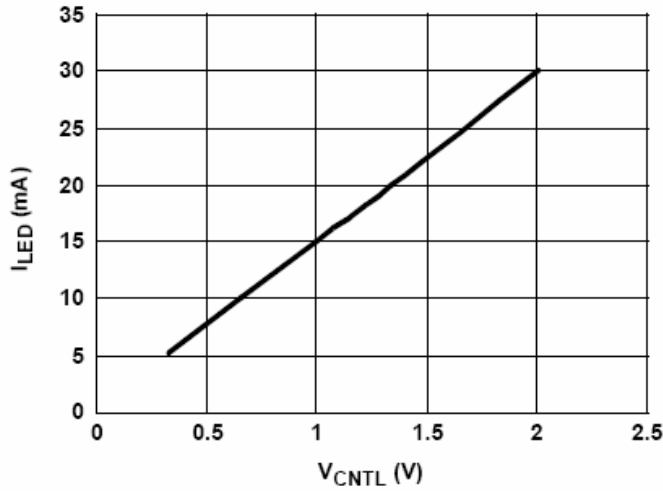
PIN Description

PIN NUMBER	PIN NAME	DESCRIPTION
1	COMP	Compensation pin. A compensation cap (2200pF to 0.1uF) is normally between this pin and SGND
2	CNTL	Control pin for dimming and shut-down. A voltage between 270mV and 5.5V controls the brightness, and less then 200mV 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



I_{LED} vs. V_{CTRL}

Application Circuit

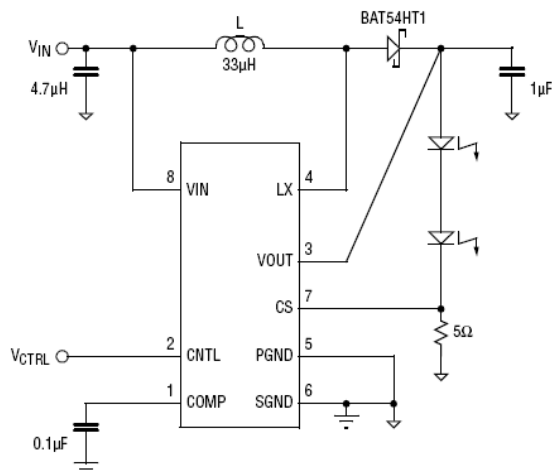


FIGURE 1A : 2 LEDs in a series

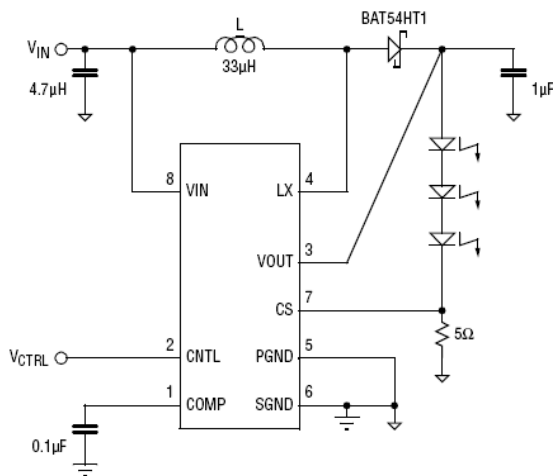


FIGURE 2A : 3 LEDs in a series

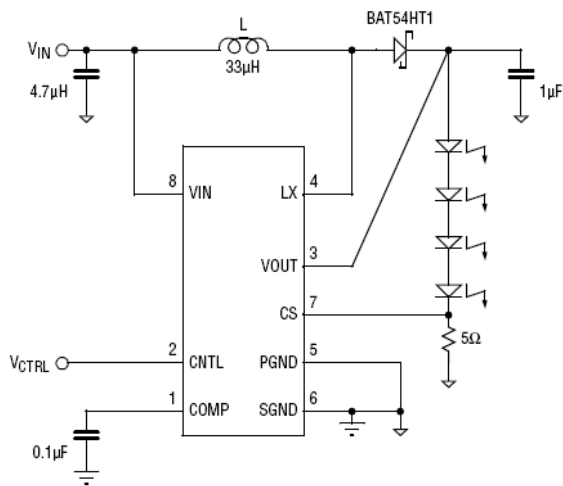


FIGURE 3A : 4 LEDs in a series

Detailed Description

The EC4513 is a constant current boost regulator specially designed for white LEDs. It can drive up to 4 LEDs in series and achieves efficiency up to 90%.

The brightness of the LEDs is adjusted through a voltage level on CNTL pin. When the level falls below 0.2V, the chip goes into shut-down mode and consumes less than 1µA of current for VIN less than 5.5V.

Steady-State Operation

EC4513 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 (VCNTL). This voltage can be either a DC or a PWM signal with frequency less than 200Hz (for C3=2200pF). When a higher frequency PWM is used, an RC filter is recommended before the CNTL pin (see Figure 11).

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

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

When R1 is 5k, 1V of VCNTL conveniently sets ILED to 15mA. The range of VCNTL is 250mV to 5.5V.

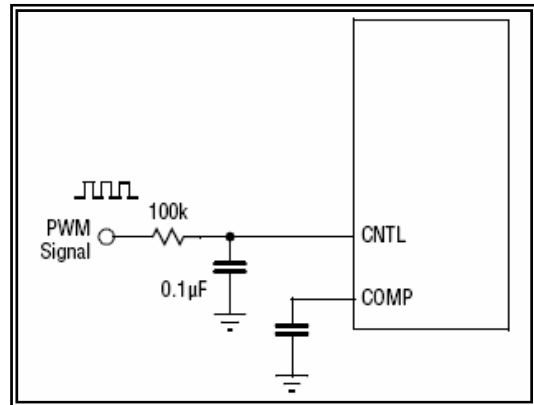


FIGURE 11 : PWM Brightness Control

Shut-Down

When VCNTL is less than 200mV, the converter is in shutdown mode. The max current consumed by the chip is less than 1µA for VIN less than 5.5V.

Over-Voltage Protection

When an LED string is disconnected from the output, VO will continue to rise because of no current feedback. When VO reaches 18.5V (nominal), the chip will shut down. The output voltage will drop. When VO drops below 18V (nominal), the chip will boost output voltage again until it reaches 18.5V. This hiccup 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 18V, 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 2.2µF - 4.7µF and output capacitance 0.47µF - 1µF. Higher capacitance is allowed to reduce the oltage/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):

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

where:

- ΔI_L is the peak-to-peak inductor current ripple in Ampere
- L inductance in μH

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

A wide range of inductance (6.8 μH - 68 μH) can be used for the converter to function correctly.

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

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 12 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.

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. 18V maximum voltage enables 4 LEDs can be placed in series. When placing 4 LEDs in series, make sure the worst total forward voltage does not exceed 18V. 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 prescreen the LEDs.

PCB Layout Considerations

The layout is very important for the converter to function properly. Power Ground () and Signal Ground () 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 (VIN-L-LX pin-PGND, and VIN-L-D-C2-PGND) should be as short as possible.

The trace connected to pin (CS) is most important. The current sense resistor R1 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 EC4513 Application Brief for the layout.