

## General Description

The EC4501 is a step-up DC/DC converter designed for driving up to 5 white LEDs in series from a single cell Lithium Ion battery with constant current. Because it directly regulates output current, the EC4501 is ideal for driving light emitting diodes(LEDs) whose light intensity is proportional to the current passing through them, not the voltage across their terminals. A single external resistor sets LED current between 2mA and 20mA, which can then be easily adjusted using either a DC voltage or a pulse width modulated (PWM) signal up to 100KHz. Its low 104mV feedback voltage reduces power loss and improves efficiency. The OV pin monitors the output voltage and turns off the converter if an over-voltage condition is present due to an open circuit condition. The EC4501 is available in SOT23-6 packages.

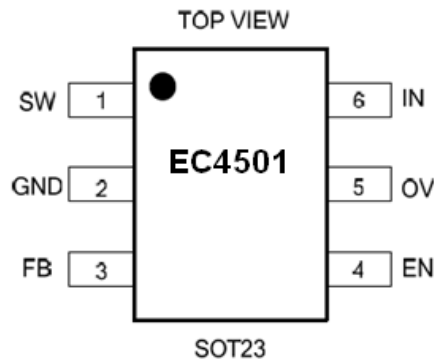
## Features

- Drives Up to 5 Series White LEDs from 3V
- Up to 87% Efficiency
- 1.25MHz Fixed Switching Frequency
- Low 104mV Feedback Voltage
- Open Load Shutdown
- PWM Dimming
- SOT23-6 Packages
- RoHS compliant

## Applications

- Cell Phones
- Handheld Computers and PDAs
- Digital Cameras
- Small LCD Displays

### Pin Assignments



### Pin Description

Pin Number	Pin Name	Description
1	SW	Power Switch Output. Connect the inductor and the blocking Schottky diode to SW.
2	GND	Ground
3	FB	Feedback input pin. The reference voltage at this pin is 104mV. Connect the cathode of the lowest LED to FB and a current sense resistor between FB and GND.
4	EN	Enable pin. A high input at EN enables the device and a low input disables the devices. When not used, connect EN to the input source for automatic startup.
5	OV	Over Voltage Input. OV measures the output voltage for open circuit protection. Connect OV to the output at the top of the LED string.
6	IN	Input Supply Pin. Must be locally bypassed.

## Ordering Information

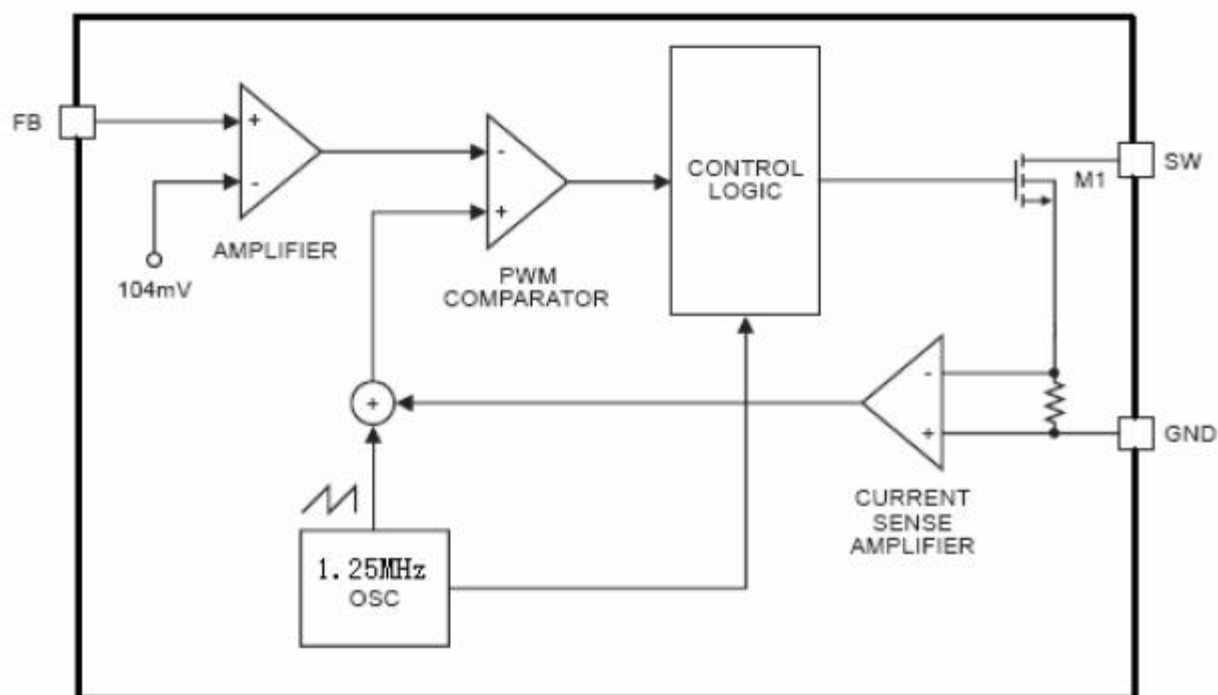
**EC4501NN** XX X

R=Tape & Reel

Package Type  
B3=SOT23-6L

Part Number	Package	Marking	Marking Information
EC4501NNB3R	SOT23-6	4501f	<ol style="list-style-type: none"> <li>Starting with underlined 5, a bar is for production year 2012. The next bar is mark on top of 0 is for year 2013. The next bar is mark on bottom of 0 is for year 2014. The next bar is mark on top of 1 is year for 2015. The naming pattern continues with consecutive characters for later years.</li> <li>f is the week of production. The big character of A~Z is for the week of 1~26, and small a~z is for the week of 27~52.</li> </ol>

## Functional Block Diagram



Function Block Diagram of EC4501

## Absolute Maximum Ratings

Symbol	Parameter	Rating	Unit
VIN	Input Voltage	-0.3~6	V
VSW	Voltage at SW Pin	-0.5~25	V
VIO	All Other I/O Pins	GND-0.3 to VDD+0.3	V
PDMAX	Power Dissipation (Note 2)	Internally Limited	W
PTR1	Thermal Resistance , SOT-23-6, $\Theta_{JA}$	220	$^{\circ}\text{C}/\text{W}$
Tstg	Storage Temperature	-55 to 150	$^{\circ}\text{C}$
Tsolder	Package Lead Soldering Temperature	260 $^{\circ}\text{C}$ , 10s	
	ESD Susceptibility (Note 3)	3	kV

## Recommended Operating Conditions

Symbol	Parameter	Range	Unit
VIN	VIN Supply Voltage	3 to 5.5	V
VSW	Output Voltage	VIN to 20	V
TOPT	Operating Temperature	-40 to +85	$^{\circ}\text{C}$

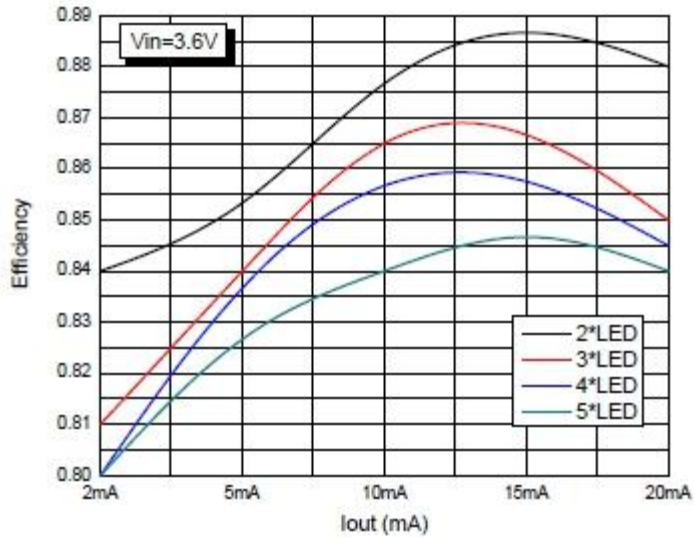


## Electrical Characteristics

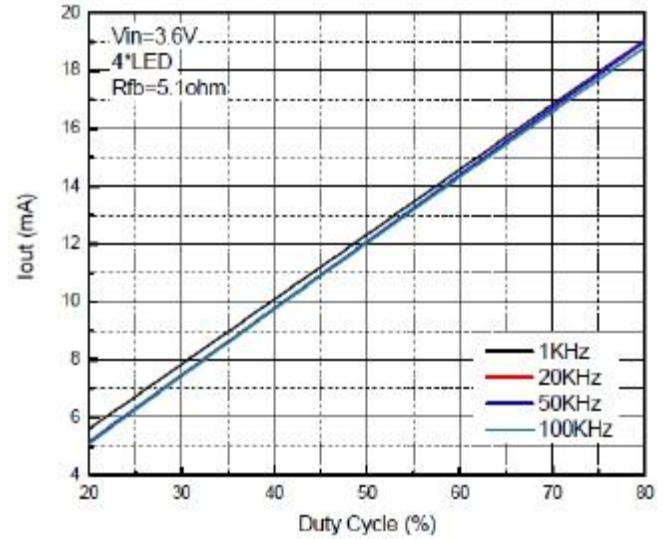
The following specifications apply for VIN= VEN =3.6V TA=25 °C, unless specified otherwise.

Symbol	Parameter	Test Conditions	EC4501			Unit
			Min.	Typ.	Max.	
VIN	Input Voltage		3.0		5.5	V
VFB	FB Pin Voltage	Driving 4xLED@20mA	94	104	114	mV
Isw	SW Pin leakage Current	VEN =0, VSW =20V			1	μA
Ioff	Operating Current ( Shutdown )			0.1	1	μA
Isby	Operating Current ( Quiescent )	VFB=0.5V		100	350	μA
Fsw	Switching Frequency		1.0	1.25	1.5	MHz
Dmax	Maximum Duty Cycle	VFB=0V	85	90		%
VEN_H	EN Minimum High Level		1.5			V
VEN_L	EN Maximum Low Level				0.4	V
RON	SW On Resistance			1.4		Ω
ILIMIT	SW Current Limit			400		mA
VOV	Open Circuit Shutdown Threshold	VOV Rising		20		V

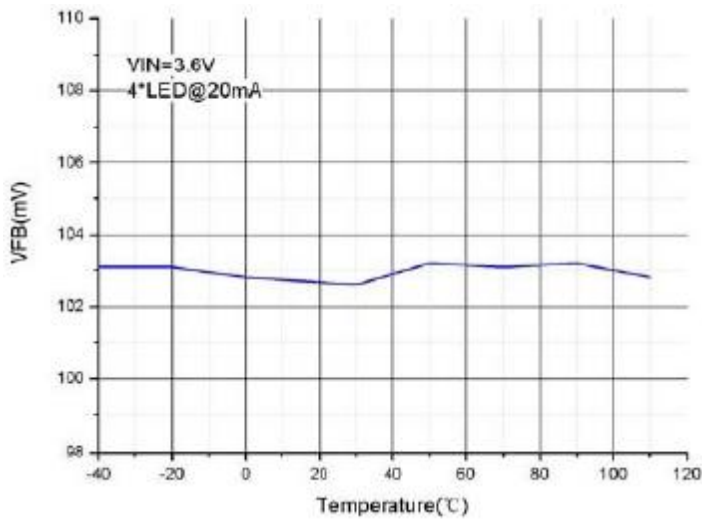
### Typical Performance Characteristics



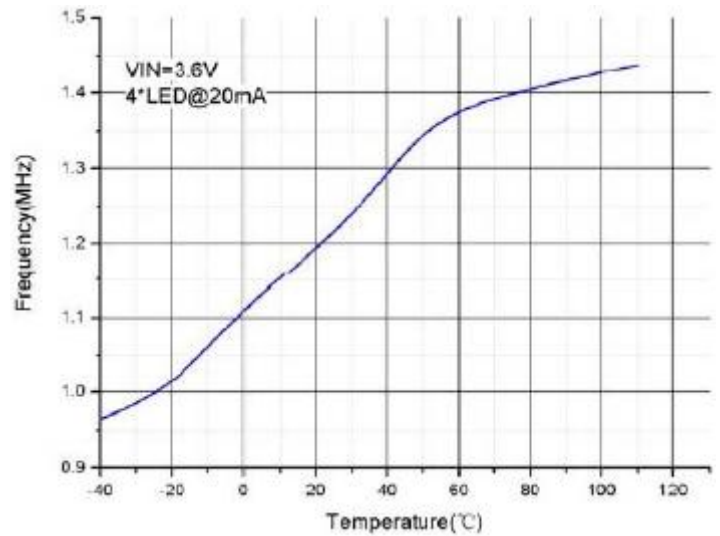
Efficiency vs Number of LEDs



Dimming Control using PWM signal to EN pin

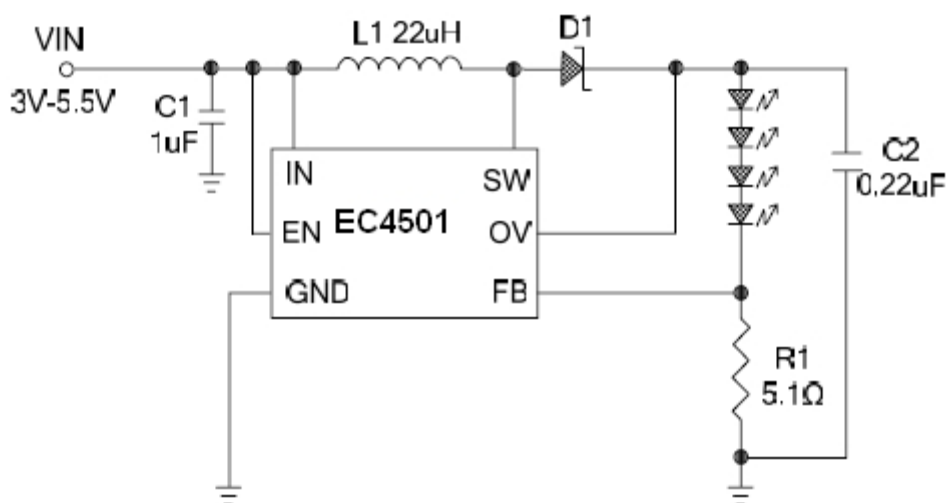


VFB VS Temperature



Frequency VS Temperature

### Typical Application Circuit



### OPERATION DESCRIPTION

The EC4501 uses a constant frequency, peak current mode boost regulator architecture to regulate the series string of white LEDs. The operation of the EC4501 can be understood by referring to the simplified block diagram shown above. At the start of each oscillator cycle, the control logic turns on the power switch M1. The signal at the non-inverting input of the PWM comparator is proportional to the switch current, summed together with a portion of the oscillator ramp. When this signal reaches the level set by the output of error amplifier, the PWM comparator resets the latch in the control logic and turns off the power switch. In this manner, error amplifier sets the correct peak current level to keep the LED current in regulation. If the feedback voltage starts to drop, the output of the error amplifier increases. This results in more current to flow through M1, hence increasing the power delivered to the output.

## Function Description

### Driving Capability

V <sub>in</sub>	I <sub>LED</sub> =15mA	I <sub>LED</sub> =20mA
3V	5 x LED	4 x LED
3.6V	5 x LED	5 x LED
5V	5 x LED	5 x LED

### Inductor Selections

PARTNUMBER	DCR (Ω)	CURRENT RATING	MANUFACTURER
LQH3C220	0.71	250	MURATA
CDRH3D16-220	0.53	350	SUMIDA
LB2012B220M	1.7	75	TAIYO YUDEN
LEM2520-220	5.5	125	TAIYO YUDEN
EJPC220KF	4.0	160	PANASONIC

### Capacitor Selection

The small size of ceramic capacitors makes them ideal for EC4501 applications. X5R and X7R types are recommended because they retain their capacitance over wider voltage and temperature ranges than other types such as Y5V or Z5U. A 1μF input capacitor and a 0.22 μF output capacitor are sufficient for most EC4501 applications.

### Diodes Selection

Schottky diodes, with their low forward voltage drop and fast reverse recovery, are the ideal choices for EC4501 applications. The forward voltage drop of a Schottky diode represents the conduction losses in the diode, while the diode capacitance (C<sub>T</sub> or C<sub>D</sub>) represents the switching losses. For diode selection, both forward voltage drop and diode capacitance need to be considered. Schottky diodes with higher current ratings usually have lower forward voltage drop and larger diode capacitance, which can cause significant switching losses at the 1.25MHz switching

frequency of the EC4501. A Schottky diode rated at 100mA to 200mA is sufficient for most EC4501 applications. Some recommended Schottky diodes are listed in the following table:

PART NUMBER	FORWARD CURRENT (mA)	VOLTAGE DROP (V)	DIODE CAPACITANCE	MANUFACTURER
CMDSH-3	100	0.58@100mA	7.0@10V	Central
CMDSH2-3	200	0.49@200mA	15@10v	Central
BAT54	200	0.53@100mA	10@25v	Zetex

### LED Current Control

The LED current is controlled by the feedback resistor. The feedback reference is 104mV. The LED current is 104mV/R<sub>fb</sub>. In order to have accurate LED current, precision resistors are preferred (1% is recommended). The formula and table for R<sub>FB</sub> selection are shown below

$$R_{FB} = 104mV / I_{LED}$$

I <sub>LED</sub> (mA)	R <sub>FB</sub> Value (Ω)
5	20.8
10	10.4
15	6.93
20	5.1

### Open Circuit Protection

Open circuit protection will shut off the EC4501 if the output voltage goes too high when the OV pin is tied to the output. In some cases an LED may fail, which will result in the feedback voltage always being zero. The EC4501 will then switch at its maximum duty cycle boosting the output voltage higher and higher. By connecting the OV pin to the top of the LED string the EC4501 checks this condition and if the output ever exceeds 20V, the EC4501 will shut down. The part will not switch again until the power is recycled.



## Function Description

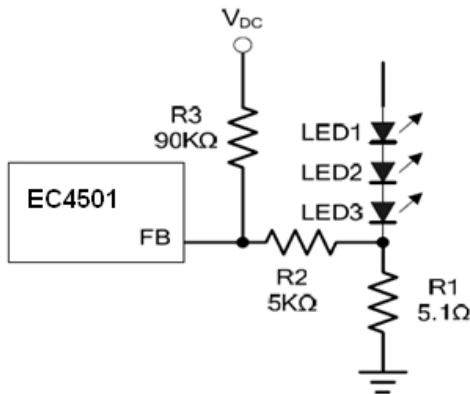
### Dimming Control

There are three different types of dimming control circuits:

#### 1. Using a DC Voltage

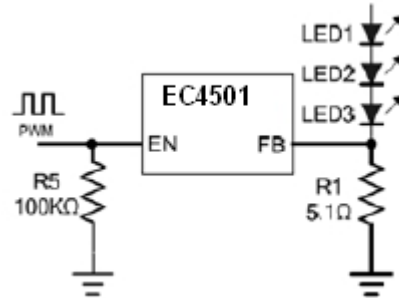
For some applications, the preferred method of brightness control is a variable DC voltage to adjust the LED current.

The dimming control using a DC voltage is shown in Figure 3. As the DC voltage increases, the voltage drop on R2 increases and the voltage drop on R1 decreases. Thus, the LED current decreases. The selection of R2 and R3 will make the current from the variable DC source much smaller than the LED current and much larger than the FB pin bias current.



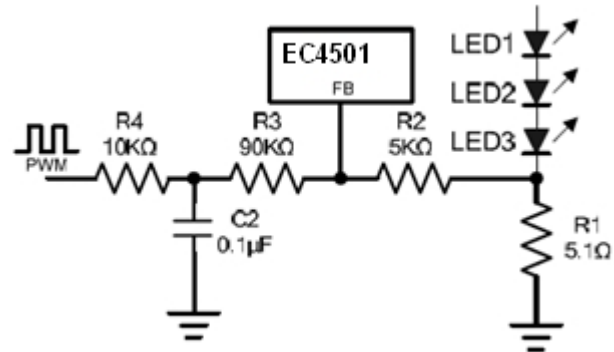
#### 2. Using a PWM Signal to EN Pin

With the PWM signal applied to the EN pin, the EC4501 is turned on or off by the PWM signal. The LEDs operate at either zero or full current. The average LED current increases proportionally with the duty cycle of the PWM signal. A 0% duty cycle corresponds to zero LED current. A 100% duty cycle corresponds to full current. The frequency range of the PWM signal should be up to 100KHz



#### 3. Using a Filtered PWM Signal

The filtered PWM signal can be considered as an adjustable DC voltage. It can be used to replace the variable DC voltage source in dimming control.

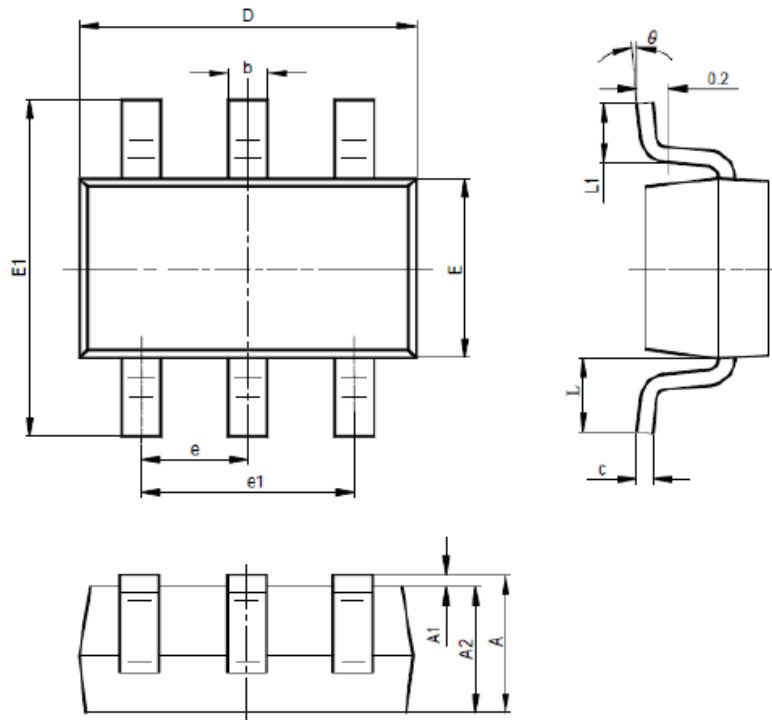


### Board Layout Consideration

As with all switching regulators, careful attention must be paid to the PCB board layout and component placement. To maximize efficiency, switch rise and fall times are made as short as possible. To prevent electromagnetic interference (EMI) problems, proper layout of the high frequency switching path is essential. The voltage signal of the SW pin has sharp rise and fall edges. Minimize the length and area of all traces connected to the SW pin and always use a ground plane under the switching regulator to minimize interplane coupling. In addition, the ground connection for the feedback resistor R1 should be tied directly to the GND pin and not shared with any other component, ensuring a clean, noise-free connection.

## Package Information

### SOT23-6 Package Outline Dimensions



SYMBOL	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	1.050	1.250	0.041	0.049
A1	0.000	0.100	0.000	0.004
A2	1.050	1.150	0.041	0.045
b	0.300	0.400	0.012	0.016
c	0.100	0.200	0.004	0.008
D	2.820	3.020	0.111	0.119
E	1.500	1.700	0.059	0.067
E1	2.650	2.950	0.104	0.116
e	0.950TYP		0.037TYP	
e1	1.800	2.000	0.071	0.079
L	0.700REF		0.028REF	
L1	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°