



### Description

The SE3506 is a step-up DC/DC converter specifically designed to drive white LEDs with a constant current. The device can drive two, three, four, or five LEDs in series from a Li-Ion cell. Series connection of the LEDs provides identical LED current resulting in uniform brightness and eliminating the need for ballast resistors. The SE3506 switches at 1MHz, allowing the use of any tiny external components. The output capacitor can be as small as 1 $\mu$ F, saving space and cost versus alternative solutions. A low 95mV feedback voltage minimizes power loss in the current setting resistor for better efficiency.

SE3506 is available in low profile SOT-23-5L package.

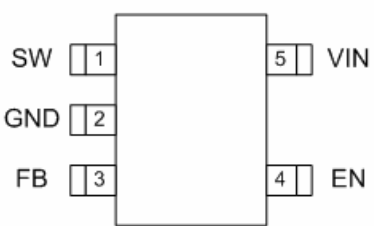
### Features

- Inherently Matched LED Current.
- High Efficiency: 85% Typical.
- Drives Up to Four LEDs from a 3.0V Supply.
- Drives Up to Six LEDs from a 3.6V Supply.
- Fast 1MHz Switching Frequency.
- Uses Tiny 1mm Tall Inductors.
- Requires Only 1 $\mu$ F Output Capacitor.
- Low Profile SOT-23-5L Packaging.

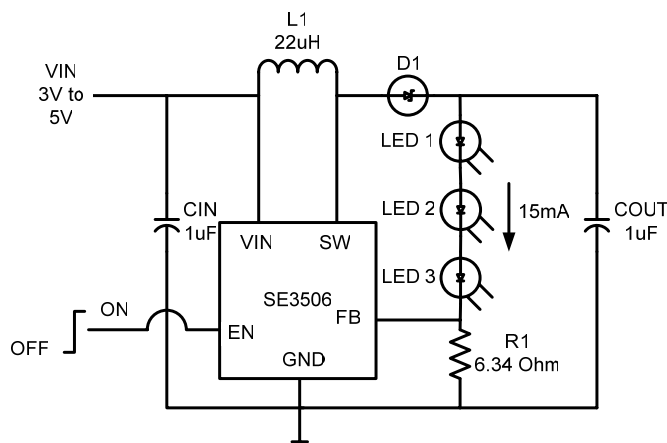
### Application

- Cellular Phones
- PDAs, Handheld Computers
- Digital Camera
- MP3 Players
- GPS Receivers

### Ordering/Marking Information

Package	Ordering Information	Marking Information	
SOT-23-5L  	SE3506-LF	506z*	Starting with 6, a bar on top of 5 is for production year 2005, and underlined 6 is for year 2006. The naming pattern continues with consecutive characters for later years. The last character is the week code. (A-Z: 1-26, a-z: 27-52) A dot on top right corner is for lead-free process.

### Application Diagram





**Absolute Maximum Rating <sup>(1)</sup>**

Parameter	Symbol	Value	Units
Input Voltage	V <sub>IN</sub>	+5.5	V
Switch Voltage	V <sub>SW</sub>	+30	V
Feedback Voltage	V <sub>FB</sub>	+5.5	V
Enable Voltage	V <sub>EN</sub>	+5.5	V
Thermal Resistance, Junction-to-Ambient	Θ <sub>JA</sub>	250 (SOT-23-5)	°C/W
Lead Temperature (Soldering, 10 sec.)		260	°C
Junction Temperature	T <sub>J</sub>	125	°C
Storage Temperature	T <sub>S</sub>	-65 to +150	°C

**Operating Rating <sup>(2)</sup>**

Parameter	Symbol	Value	Units
Supply Input Voltage	V <sub>IN</sub>	+2.7V to +5.5	V
Junction Temperature	T <sub>J</sub>	0 to +125	°C
Extended Commercial Operating Temperature		-40 to +85	°C

**Electrical Characteristics**

V<sub>IN</sub> = V<sub>EN</sub> = 3.6V; T<sub>J</sub> = 25°C; unless otherwise specified

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V <sub>IN</sub>	Input Voltage Range		2.7	--	5.5	V
V <sub>FB</sub>	Feedback Voltage	I <sub>SW</sub> = 100mA, Duty Cycle = 66%	--	95	--	mV
I <sub>FB</sub>	FB Pin Bias Current		--	45	100	nA
I <sub>CC</sub>	Supply Current		--	100	--	μA
		V <sub>EN</sub> = 0V	--	0.1	1	μA
	Switching Frequency		--	1.0	--	MHz
	Maximum Duty Cycle		--	85	--	%
I <sub>LIMIT</sub>	Switch Current Limit	V <sub>IN</sub> =4.1V, V <sub>OUT</sub> =10V	--	450	--	mA
	Switch Leakage Current	V <sub>SW</sub> = 5V		0.01	5	μA
V <sub>TH(EN)</sub>	Enable Input Threshold Voltage	Voltage Raising, Output Turns On, Logic High	1.6	--	--	V
		Voltage Falling, Output Turns Off, Logic Low	--	--	0.4	
I <sub>EN</sub>	Enable Pin Bias Current		--	300	--	nA

**Note 1:** Exceeding the absolute maximum rating may damage the device.

**Note 2:** The device is not guaranteed to function outside its operating rating. The SE3506 is guaranteed to meet specifications from 0°C to 70°C. Specifications over the -40°C to 85°C operating temperature range are assured by design, characterization and correlation with statistical process controls.



## Application Hints

### Inductor Selection

A 10μH inductor is recommended for most SE3506 applications. Although small size and high efficiency are major concerns, the inductor should have low core losses at 1MHz and low DCR (copper wire resistance). It should also be noted that the Maximum current rating of the inductor should not be exceeded in applications. Typically 100mA to 200mA rating is sufficient for most applications.

### Capacitor Selection

The small size of ceramic capacitors makes them ideal for SE3506 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 1μF output capacitor are sufficient for most SE3506 applications.

### Diode Selection

Schottky diodes, with their low forward voltage drop and fast reverse recovery, are the ideal choices for SE3506 applications. The forward voltage drop of a Schottky diode represents the conduction losses in the diode, while the diode capacitance ( $C_T$  or  $C_D$ ) 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 1MHz switching frequency of the SE3506. A Schottky diode rated at 100mA to 200mA is sufficient for most SE3506 applications.

### LED Current Control

The LED current is controlled by the feedback resistor (R1). The feedback reference is internally set at 95mV. The LED current is then determined by the equation:  $95\text{mV}/R1$ . In order to have accurate LED current, precision resistors are preferred (1% is recommended). The formula and table for R1 selection are shown below.

$$R1 = 95\text{mV}/I_{LED}$$

### R1 Resistor Value Selection

$I_{LED}$ (mA)	R1 (Ω)
5	19.1
10	9.53
12	7.87
15	6.34
20	4.75

### Open-Circuit Protection

In the cases of output open circuit, such as when the LEDs are disconnected from the circuit or the LEDs fail, the feedback voltage will drop to zero. The SE3506 will then switch at a high duty cycle resulting in a high output voltage, which may cause the SW pin voltage to exceed its maximum 30V rating. A Zener diode can be used at the output to limit the voltage on the SW pin. The Zener voltage should be larger than the maximum forward voltage of the LED string. For example, a Four-LED string can be protected by a Zener diode with a breakdown voltage greater than 16V and less than 30V. The current rating of the zener should be larger than 10mA.

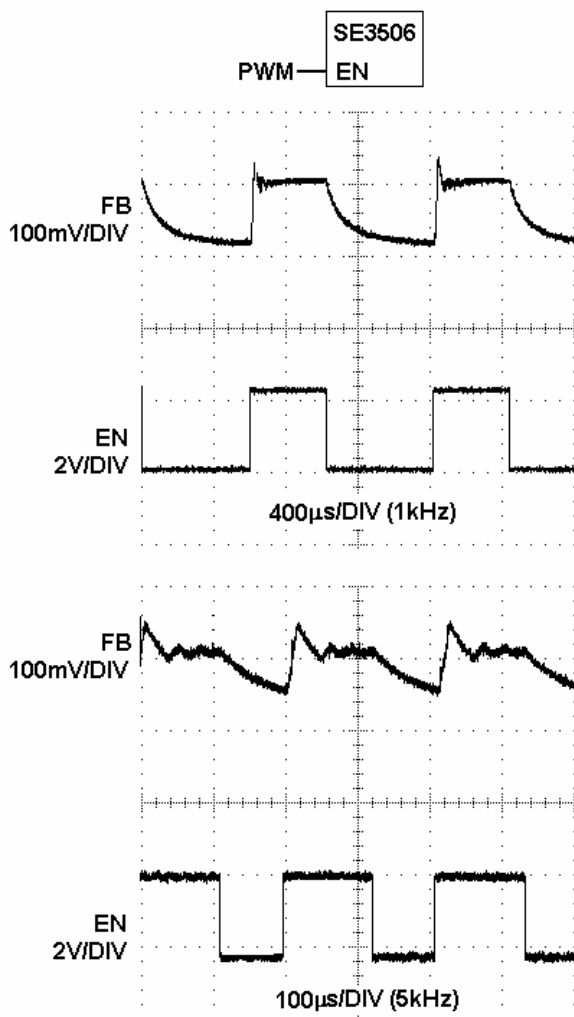


### Dimming Control

There are two different types of dimming control circuits:

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

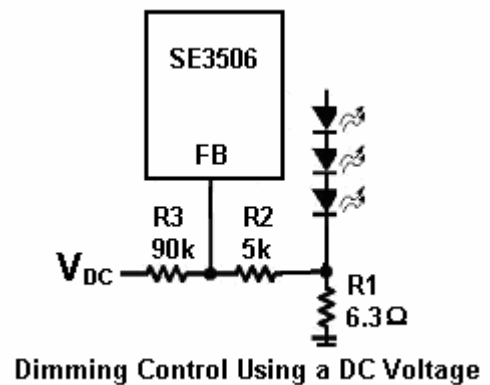
With the PWM signal applied to the EN pin, the SE3506 is turned on or off by the PWM signal. The LEDs operate at either zero or full current. The average LED current increases proportionally with the duty cycle of the PWM signal. A 0% duty cycle will turn off the SE3506 and corresponds to zero LED current. A 100% duty cycle corresponds to full current. The typical frequency range of the PWM signal is 1kHz to 5kHz. The magnitude of the PWM signal should be higher than the minimum EN voltage high. The switching waveforms of the EN pin PWM control are shown below.



PWM Dimming Control Using the EN Pin

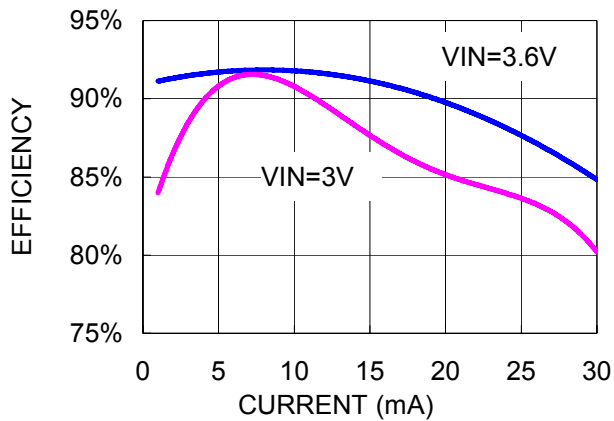
#### 2. Using a DC Voltage

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 below. 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. For  $V_{DC}$  range from 0V to 2V, the selection of resistors gives dimming control of LED current from 0mA to 15mA.

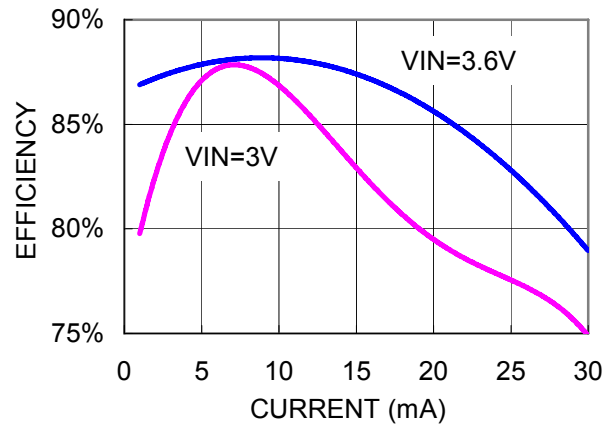




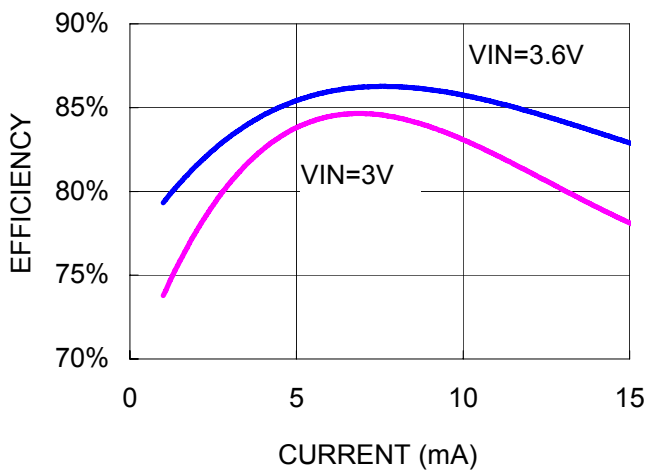
Two LED Efficiency



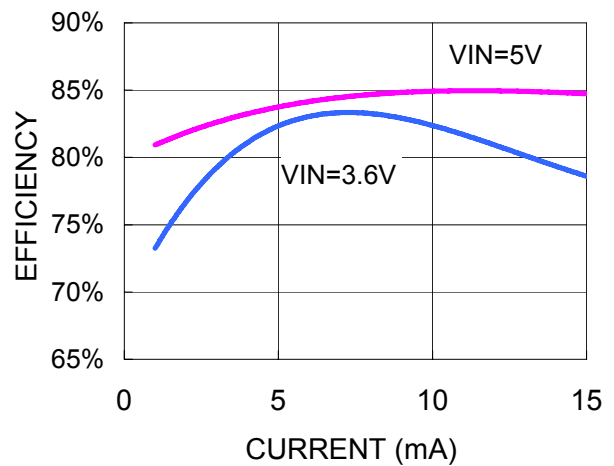
Three LED Efficiency



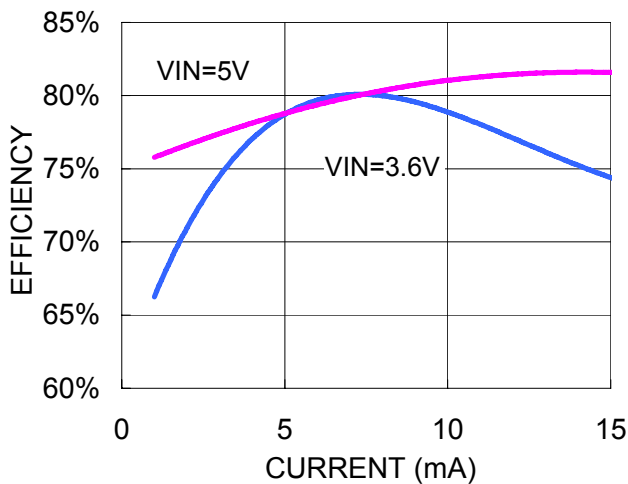
Four LED Efficiency



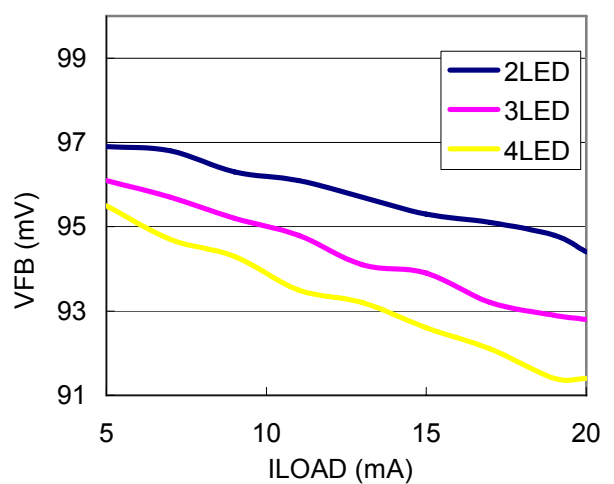
Five LED Efficiency



Six LED Efficiency

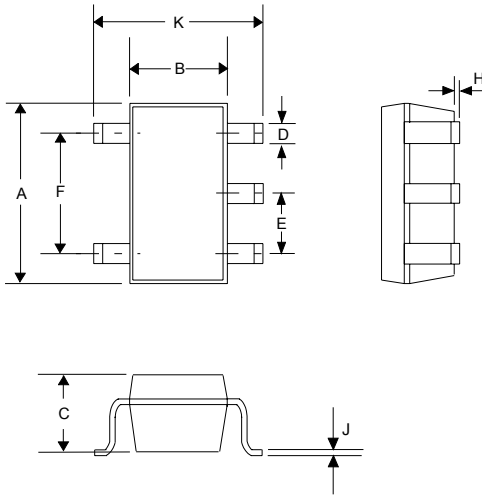


VFB VS. ILOAD





**OUTLINE DRAWING SOT-23-5L**



DIM <sup>N</sup>	DIMENSIONS			
	INCHES		MM	
	MIN	MAX	MIN	MAX
A	0.110	0.120	2.80	3.05
B	0.059	0.070	1.50	1.75
C	0.036	0.051	0.90	1.30
D	0.014	0.020	0.35	0.50
E	-	0.037	-	0.95
F	-	0.075	-	1.90
H	-	0.006	-	0.15
J	0.0035	0.008	0.090	0.20
K	0.102	0.118	2.60	3.00

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