Micro-power Synchronous Buck-Boost LED Driver

Features

- Synchronous Rectification: Up to 95% efficiency
- Single Inductor
- Quiescent Current: 500μA
- Programmable LED Drive Current: up to 1A
- Input Voltage Range from 2.7V to 5.5V
- No Schottky Diodes Required
- Package: SOP-8/PP

Applications

- LED standby light
- Constant current source
- LED flashlight

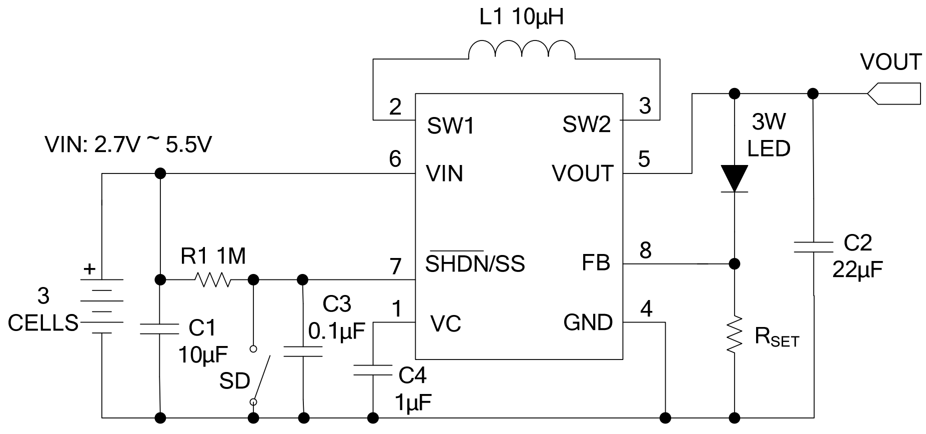
Description

The HM3441B is high efficiency, fixed frequency, Buck-Boost LED driver which operates from input voltages above, below or equal to the output voltage. The device is suitable for single lithium-ion, multi-cell alkaline or NiMH applications where the output voltage is within the scope of battery voltage.

The quiescent current is only 500μA, and this feature maximizing the battery life in portable applications.

Other features include thermal shutdown and current limit. The HM3441B is available in the SOP-8/PP package.

Typical Application Circuit



* The feedback reference voltage is typically 0.11V. $I_{LED}=V_{FB}/R_{SET}$.

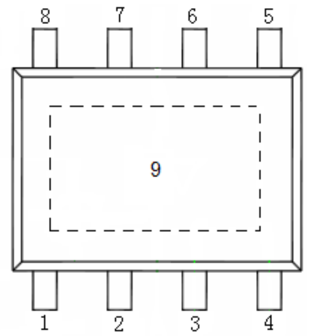
Absolute Maximum Ratings (Note 1)

- V_{IN} ……………………………………………………………-0.3V ～ 6V
- V_C, FB, SHDN/SS……………………………………………-0.3V ～ 6V
- V_{SW} ……………………………………………………………-0.3V ～ 6V
- V_{OUT}……………………………………………………………-0.3V ～ 6V
- Operating Temperature Range ……………………………………-40℃ ～ +85℃
- Storage Temperature Range ………………………………………-65℃ ～ +150℃
- Lead Temperature (Soldering 10 sec.)……………………………+265℃

Note 1: Stresses listed as the above "Absolute Maximum Ratings" may cause permanent damage to the device. Exposure to absolute maximum rating conditions for extended periods may remain possibility to affect device reliability.

Pin Assignment and Description

TOP VIEW



SOP-8/PP

PIN	NAME	DESCRIPTION
1	VC	Error Amplifier Output
2	SW1	Switch 1
3	SW2	Switch 2
4	GND	Ground
5	VOUT	Output
6	VIN	Input
7	SHDN/SS	ON/OFF Control (High Enable)
8	FB	Feedback

* EXPOSED PAD (PIN 9) IS GND, MUST BE SOLDERED TO PCB

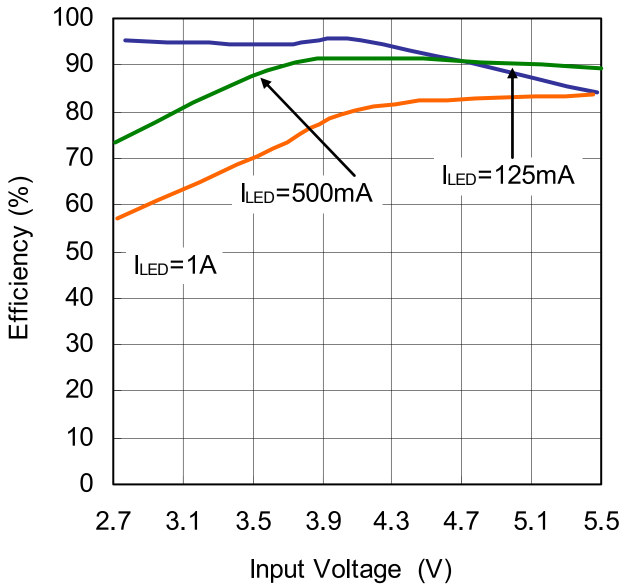
Electrical Characteristics

Operating Conditions: TA=25℃, V_{IN}= 3.6V, I_{LED} =300mA, unless otherwise specified.

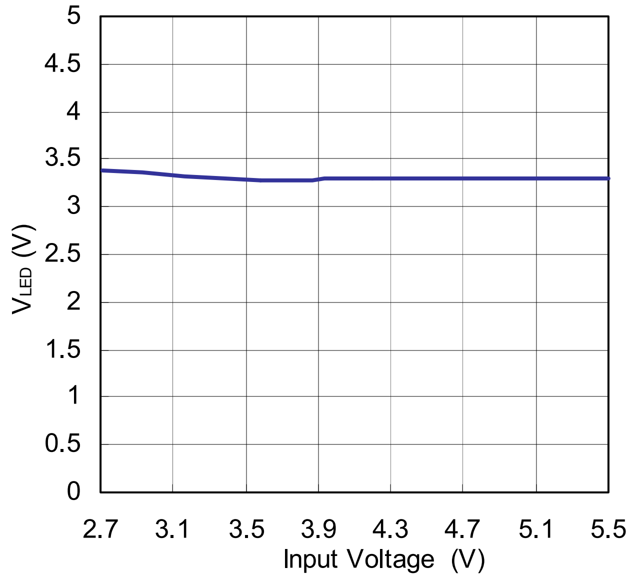
SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
V_{START}	Input Start-Up Voltage			2.1		V
V_{IN}	Input Operating Range		2.7		5.5	V
V_{FB}	Feedback Voltage	V_{IN}= 3V		0.11		V
I_{FB}	Feedback Input Current			1	50	nA
I_{OFF}	Quiescent Current, Shutdown	SHDN=0V, Not Including Switch Leakage		0.8		μA
I_Q	Quiescent Current, Active			500		μA
I_{LK-N}	NMOS Switch Leakage	Switches B and C		0.1	5	μA
I_{LK-P}	PMOS Switch Leakage	Switches A and D		0.1	10	μA
R_{NFET}	NMOS Switch On Resistance	Switches B and C		0.19		Ω
R_{PFET}	PMOS Switch On Resistance	Switches A and D		0.22		Ω
I_{LIM}	Input Current Limit			1.5		A
DC_{MAX}	Maximum Duty Cycle	Boost (% Switch C On)	55	75		%
		Buck (% Switch A On)	100			%
DC_{MIN}	Minimum Duty Cycle				0	%
V_{SHDN}	SHDN Threshold	When IC is Enabled	0.7	1	1.2	V
I_{SHDN}	SHDN Input Current	V_{SHDN}=5.5V		0.01	1	μA

Typical Performance Characteristics

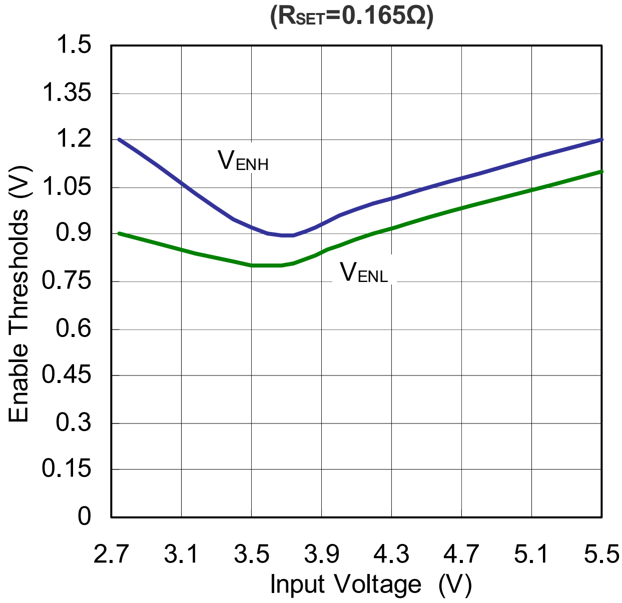
LED Power Efficiency vs. Input Voltage



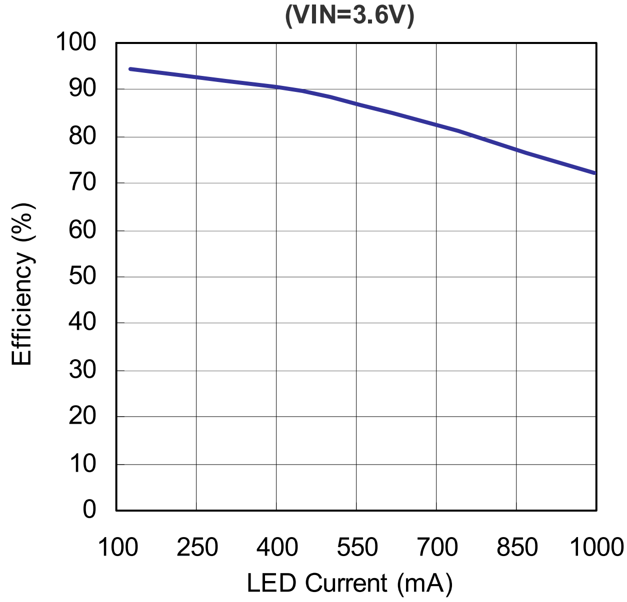
VLED vs. Input Voltage
(RSET=0.165Ω)



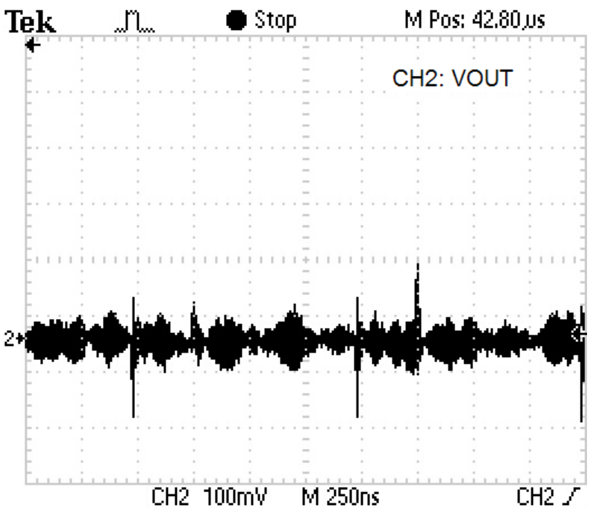
Enable Thresholds vs. Input Voltage
(RSET=0.165Ω)



LED Power Efficiency vs. LED Current
(VIN=3.6V)



Output Ripple (VIN=3V)



Pin Functions

VC (Pin 1): Error Amplifier Output.

SW1 (Pin 2): Switch Pin where the Internal Switches A and B are Connected. Connect inductor from SW1 to SW2. An optional Schottky diode can be connected from SW1 to ground. Minimize trace length to keep EMI down.

SW2 (Pin 3): Switch Pin where the Internal Switches C and D are connected. For applications with output voltages over 4.3V, a Schottky diode is required from SW2 to VOUT to ensure the SW pin does not exhibit excess voltage.

GND (Pin 4): Signal and Power Ground for the IC.

VOUT (Pin 5): Output of the Synchronous Rectifier. A filter capacitor is placed from VOUT to GND.

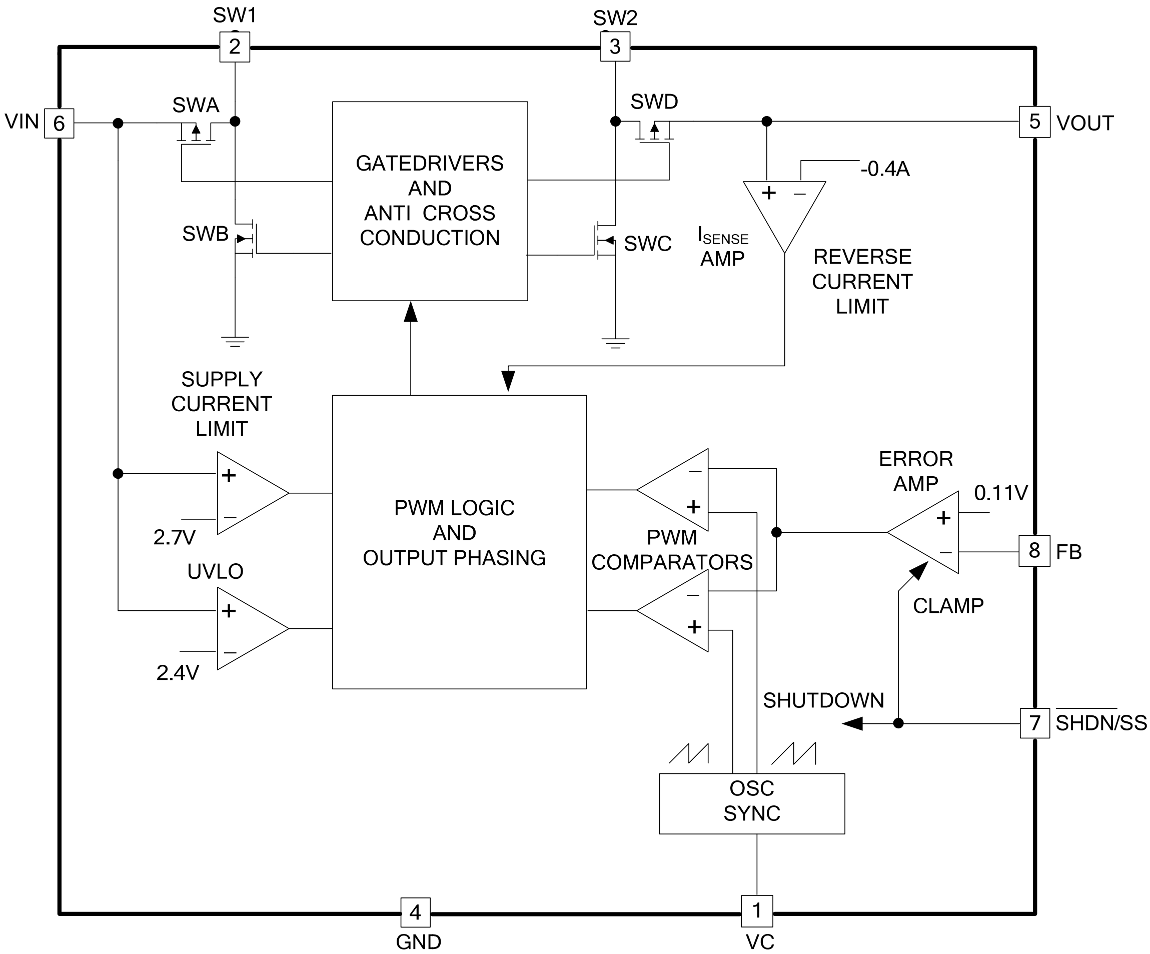
VIN (Pin 6): Input Supply Pin, Internal VCC for the IC. A ceramic bypass capacitor as close to the VIN pin and GND (Pin 4) is required.

SHDN/SS (Pin 7): Combined Soft-Start and Shutdown. Grounding this pin shuts down the IC. Tie to >1.2V to enable the IC and >1.8V to ensure the error amp is not clamped from soft-start. An RC from the shutdown command signal to this pin will provide a soft-start function by limiting the rise time of the V_C pin.

FB (Pin 8): Feedback Pin. The LED Current can be adjusted up to 1A.The feedback reference voltage is typically 0.11V. $I_{LED}=V_{FB}/R_{SET}$.

Exposed Pad (Pin 9): Ground. Internally connected to GND. Mount on board for lower thermal resistance.

Functional Diagram



Applications Information

The HM3441B employs a buck-boost DC/DC converter to generate the output voltage required to drive a high current LED. This architecture permits high efficiency, low noise operation at input voltages above, below or equal to the output voltage by properly phasing four internal power switches. The error amp output voltage on the VC pin determines the duty cycle of the switches.

Since the VC pin is a filtered signal, it provides rejection of frequencies well below the factory trimmed switching frequency of 1MHz. The low $R_{DS\ (ON)}$, low gate charge synchronous switches provide high frequency pulse width modulation control at high efficiency.

Overtemperature Protection

If the junction temperature of the HM3441B exceeds 130℃ for any reason, all four switches are shut off immediately. The overtemperature protection circuit has a typical hysteresis of 11℃.

LED Current Programming and Enable Circuit

The enable pin work in conjunction with external resistor to program LED current to one of three nonzero settings.

With the enable pin pulled high, the buck-boost will regulate the output voltage at the current programmed by R_{SET}.

With both enable pins pulled to GND, the HM3441B is in shutdown and draws zero current. The enable pin is high impedance inputs and should not be floated.

Inductor Selection

The high frequency operation of the HM3441B allows the use of small surface mount inductors. The inductor current ripple is typically set to 20% to 40% of the maximum average inductor current. For a given ripple the inductance term in boost mode is:

$$L > \frac{V_{IN(MIN)}{}^2 \bullet \left(V_{OUT} - V_{IN(MIN)}\right) \bullet 100\%}{f \bullet I_{OUT(MAX)} \bullet \%Ripple \bullet V_{OUT}{}^2}$$

and in buck mode is:

$$L > \frac{\left(V_{IN(MAX)} - V_{OUT}\right) \bullet V_{OUT} \bullet 100\%}{f \bullet V_{IN(MAX)} \bullet \%Ripple \bullet I_{OUT}}$$

where f = operating frequency, Hz

%Ripple = allowable inductor current ripple, %

$V_{IN\ (MIN)}$ = minimum input voltage, V

$V_{IN\ (MAX)}$ = maximum input voltage, V

V_{OUT} = output voltage, V

$I_{OUT\,(MAX)}$ = maximum output load current

For high efficiency, choose an inductor with a high frequency core material, such as ferrite, to reduce core loses.

The inductor should have low ESR (equivalent series resistance) to reduce the I2R losses, and must be able to handle the peak inductor current without saturating.

Molded chokes or chip inductors usually do not have enough core to support peak inductor currents >1A. To minimize radiated noise, use a toroid, pot core or shielded bobbin inductor.

Input Capacitor Selection

Since the VIN pin is the supply voltage for the IC it is recommended to place at least a 2.2μF, low ESR bypass capacitor to ground.

Output Capacitor Selection

The bulk value of the capacitor is set to reduce the ripple due to charge into the capacitor each cycle. The steady state ripple due to charge is given by:

$$\%Ripple\_Boost = \frac{I_{OUT(MAX)} \bullet \left(V_{OUT} - V_{IN(MIN)}\right) \bullet 100\%}{C_{OUT} \bullet V_{OUT}^{2} \bullet f}$$

$$\%Ripple\_Buck = \frac{\left(V_{IN(MAX)} - V_{OUT}\right) \bullet 100\%}{8 \bullet V_{IN(MAX)} \bullet f^{2} \bullet L \bullet C_{OUT}}$$

where C_{OUT} = output filter capacitor, F

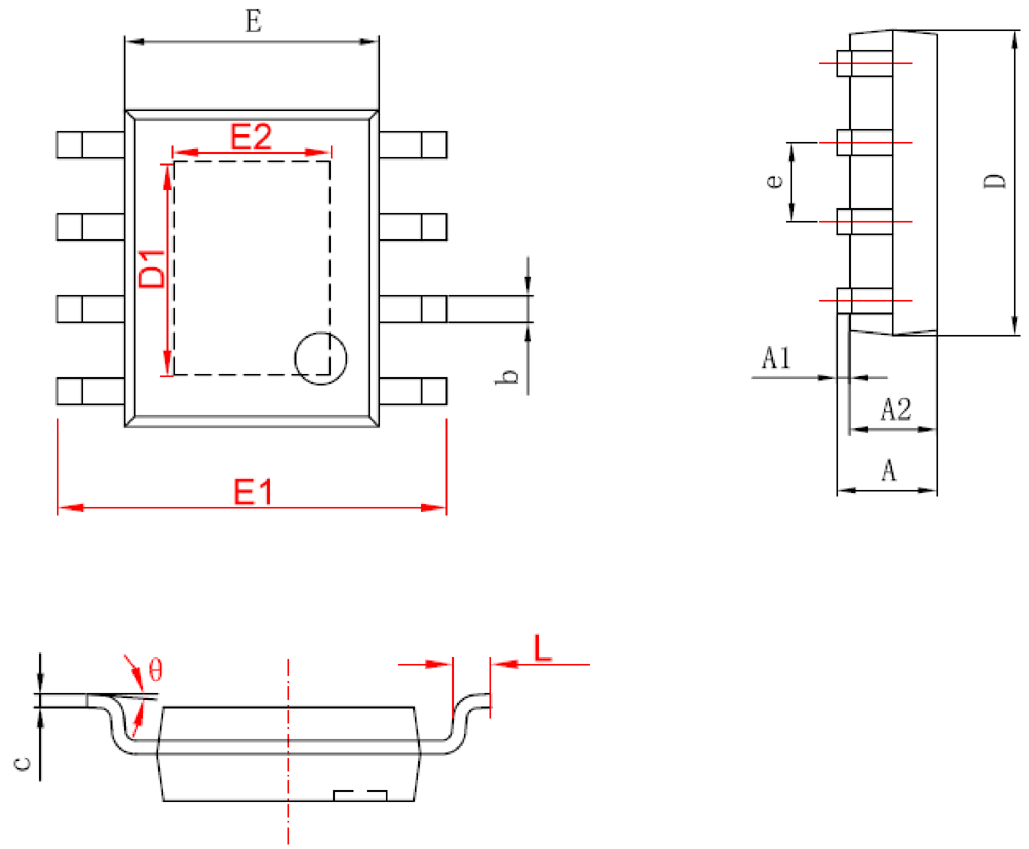
The output capacitance is usually many times larger in order to handle the transient response of the converter. For a rule of thumb, the ratio of operating frequency to unity gain bandwidth of the converter is the amount the output capacitance will have to increase from the above calculations in order to maintain desired transient response.

The other component of ripple is due to ESR (equivalent series resistance) of the output capacitor. Low ESR capacitors should be used to minimize output voltage ripple.

For surface mount applications, Taiyo Yuden, TDK, AVX ceramic capacitors, AVX TPS series tantalum capacitors or Sanyo POSCAP are recommended. For the white LED application, a 10μF capacitor value is recommended.

Packaging Information

SOP8-PP (EXP PAD) Package Outline Dimension



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.350	1.750	0.053	0.069
A1	0.050	0.150	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.006	0.010
D	4.700	5.100	0.185	0.200
D1	3.202	3.402	0.126	0.134
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
E2	2.313	2.513	0.091	0.099
e	1.270(BSC)		0.050(BSC)	
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°