Synchronous Buck-Boost DC/DC Regulator

Features

- Synchronous Rectification up to 95% Efficiency
- Single Inductor
- Fixed Frequency Operation with Battery Voltages Above, Below or Equal to the Output
- Quiescent Current: 1mA (50μA low power mode: mode pin high)
- Continuous Output Current up to 1A
- Input Voltage Range: 1.8V to 5.5V
- Programmable Oscillator Frequency from 350kHz to 1.5MHz
- No Schottky Diodes Required (V_{OUT} < 4.3V)
- V_{OUT} Disconnected from V_{IN} During Shutdown
- Shutdown Current: <1μA
- Small Thermally Enhanced 8-pin SOP Package

Applications

- Handheld Instruments
- MP3/MP4 Players
- Palmtop computers
- Digital Cameras

Description

The HX8001 is high efficiency, fixed frequency, Buck-Boost DC/DC converter that operates from input voltages above, below or equal to the output voltage. The devices are suitable for single lithium-ion, multicell alkaline or NiMH applications where the output voltage is within the battery voltage range.

The switching frequencies up to 1.5MHz could be fixed by an external resistor. Also the oscillator could be synchronized to an external clock. The quiescent current is 1mA which maximizes the battery life in portable applications.

Other features include a 1μA shutdown, thermal shutdown and current limit. The HX8001 is available in the 8-pin thermally enhanced SOP package (or upon request).

Order Information

HX8001- ① ② ③:

SYMBOL	DESCRIPTION
①	Denotes the Output Voltage: A: Adjustable
②	Denotes the Package Types: P: SOP8-PP
③	Internal Definition

Typical Application Circuit

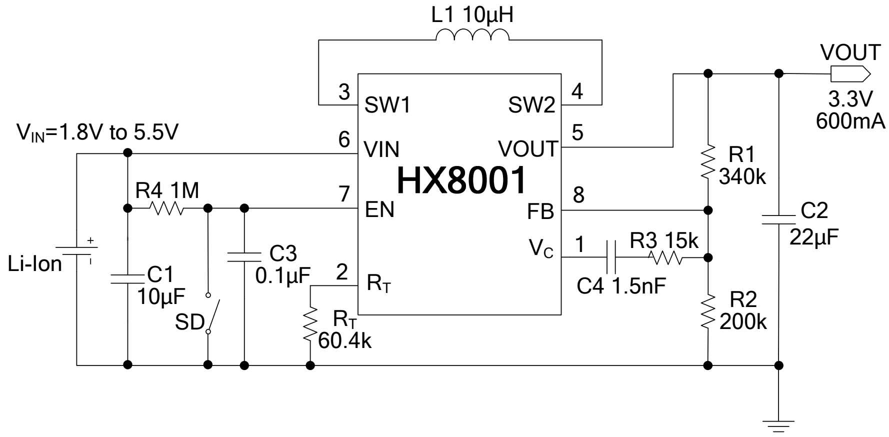


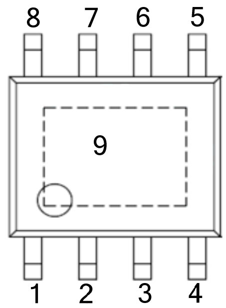
Figure1. Li-Ion to 3.3V at 600mA Buck-Boost Regulator

*MODE/SYNC = GND: FIXED FREQUENCY.

*V_{OUT} = 1.212 • (1+R1/R2).

Pin Assignment

TOP VIEW



SOP8-PP(Exposed Pad)
*The exposed pad (Pin 9) must be soldered to a large PCB.

PIN	NAME	FUNCTION
1	V_C	Error Amp Output
2	R_T	Program the Oscillator Frequency
3	SW1	Switch 1
4	SW2	Switch 2
5	VOUT	Output
6	VIN	Input
7	EN	ON/OFF Control (High Enable)
8	FB	Feedback
9(Exposed Pin)	GND	Ground

Absolute Maximum Ratings (Note 1)

- V_{IN}, EN Voltage……………………………………...………………….……....…..………-0.3V ～ 7.5V
- V_{OUT}, SWA, SW2 Voltage ……………………………...………………...…..……………….-0.3V ～ 6V
- R_T, FB, V_C, MODE/SYNC Voltage …………………….….………….…...…….…..……..-0.3V ～ 6V
- Operating Temperature Range (Note 2) ……....…………………….….…..………......-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.

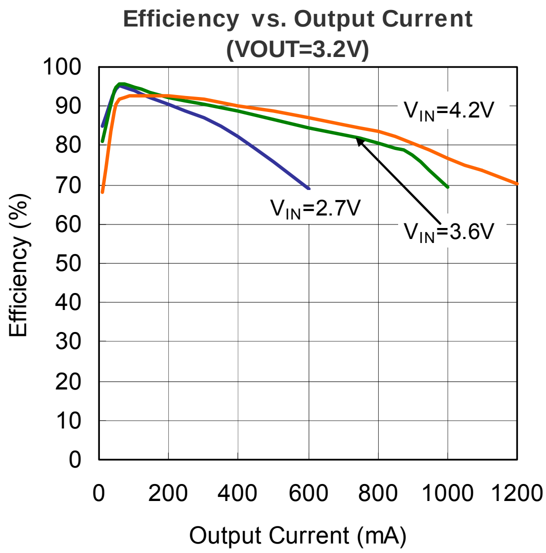
Note 2: The HX8001 is guaranteed to meet performance specifications from 0℃ to 70℃. Specifications over the – 40℃ to 85℃ operating temperature range are assured by design, characterization and correlation with statistical process controls.

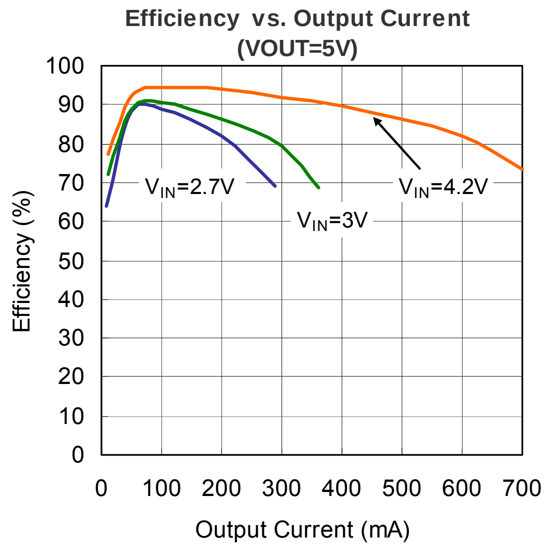
Electrical Characteristics

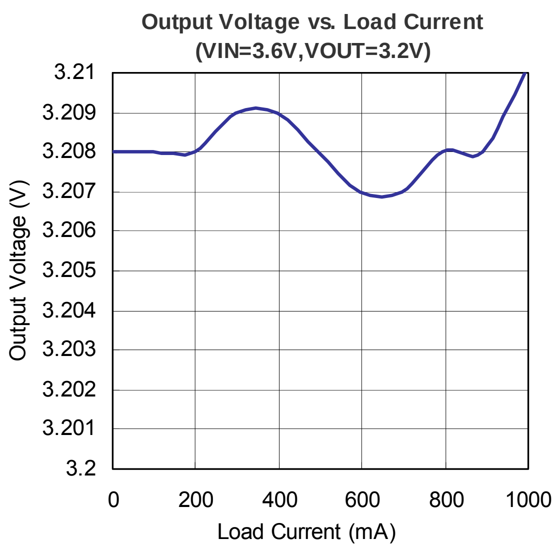
Operating Conditions: T_A=25℃, V_{IN}=3.6V, unless otherwise specified.

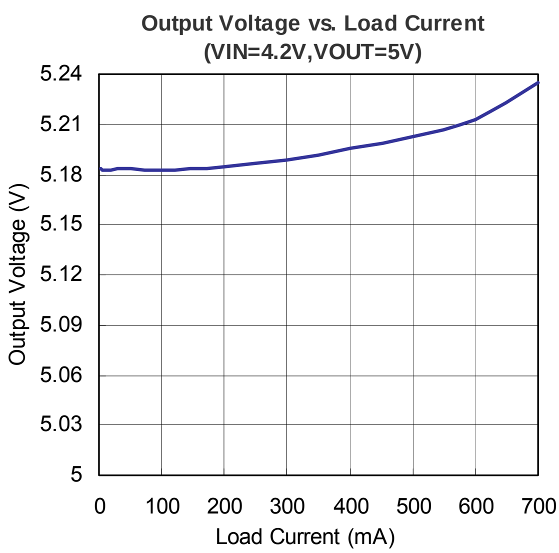
SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
V_{START}	Input Start-up Voltage			1.8		V
V_{IN}	Input Operating Range		1.8		5.5	V
V_{OUT}	Output Voltage Adjust Range		1.8		5.5	V
V_{FB}	Feedback Voltage			1.212		V
I_{SHDN}	Quiescent Current, Shutdown	EN=0V, Not Including Switch Leakage		0.1	1	μA
I_Q	Quiescent Current, Active	V_{IN}=2.7V		1		mA
I_{NLK}	NMOS Switch Leakage	Switches B and C		0.1	5	μA
I_{PLK}	PMOS Switch Leakage	Switches A and D			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			A
DC_{MAX}	Maximum Duty Cycle	Boost (% Switch C On)	55	75		%
		Buck (% Switch A On)	100			%
DC_{MIN}	Minimum Duty Cycle				0	%
V_{ENH}	EN Input High	When IC is Enabled	1.8			V
V_{ENL}	EN Input Low				0.4	V
I_{EN}	EN Input Current	V_{EN}=5.5V		0.01	1	μA

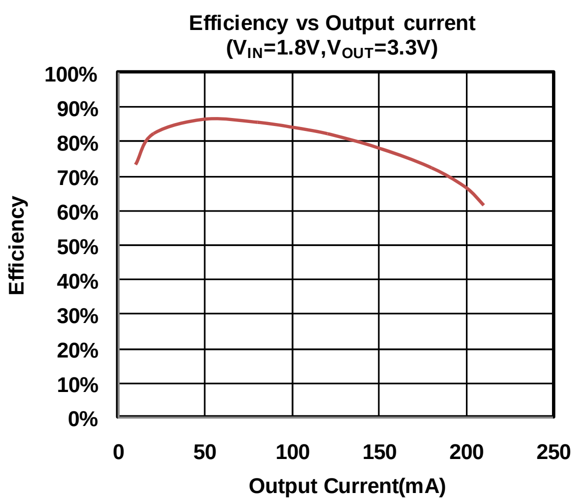
Typical Performance Characteristics

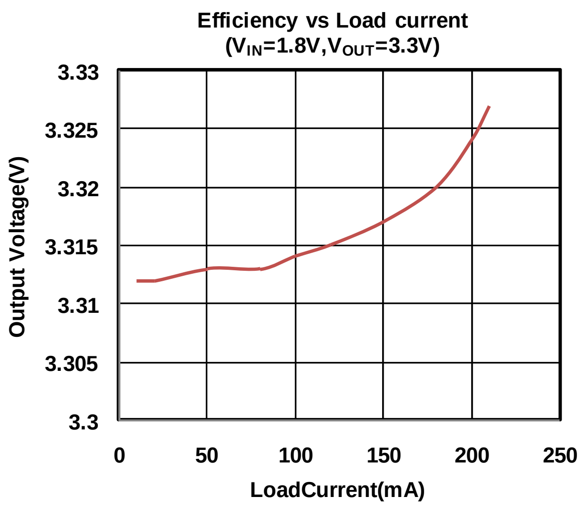




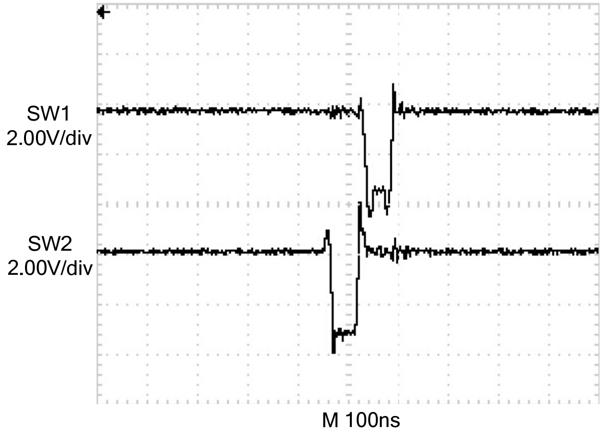




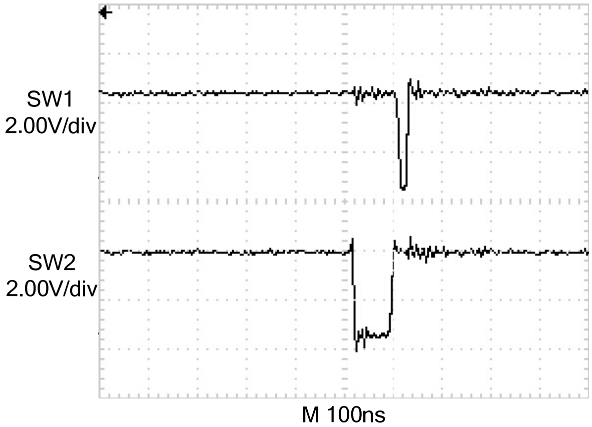




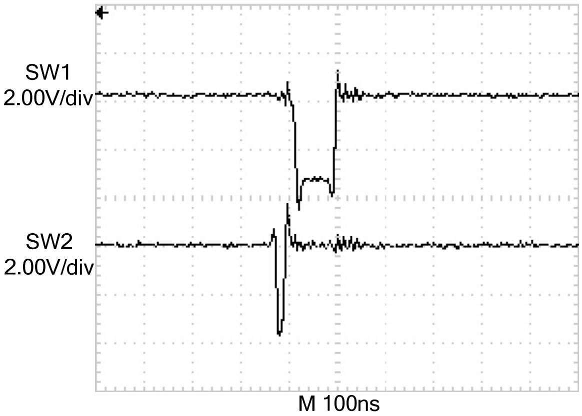
Switch Pins on the Edge of Buck/Boost and Approaching Buck (V_{IN}=3.543V, V_{OUT}=3.3V, I_{IOAD}=250mA)



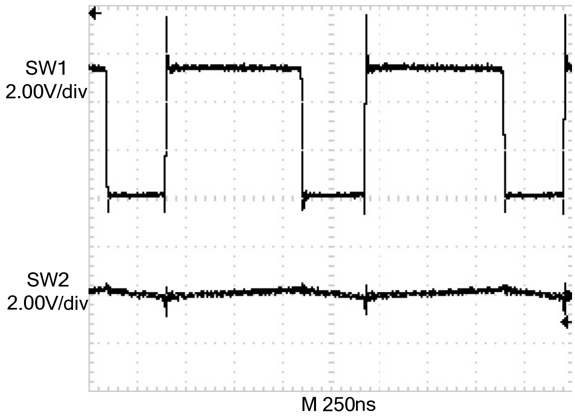
Switch Pins on the Edge of Buck/Boost and Approaching Boost (V_{IN}=3.37V, V_{OUT}=3.3V, I_{IOAD}=250mA)



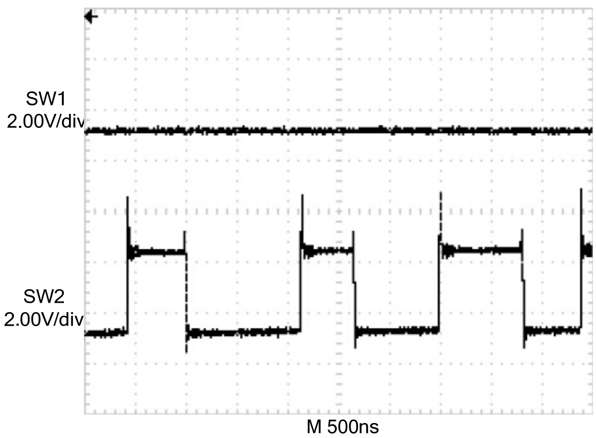
Switch Pins during Buck/Boost (V_{IN}=3.235V, V_{OUT}=3.3V, I_{IOAD}=250mA)



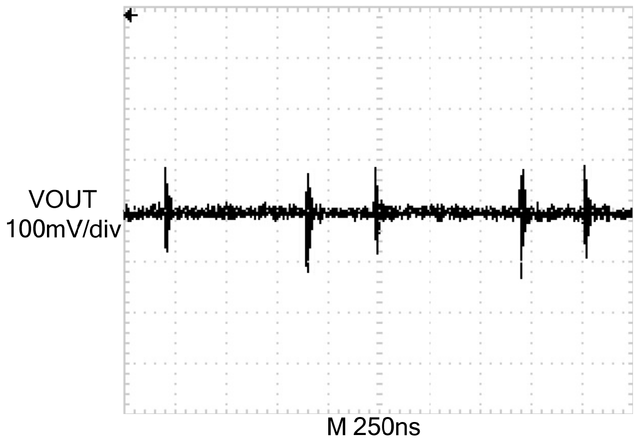
Switch Pins in Buck Mode (V_{IN}=5V, V_{OUT}=3.3V, I_{IOAD}=250mA)



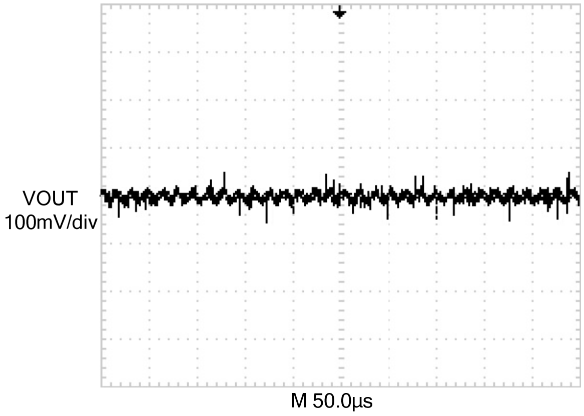
Switch Pins in Boost Mode (V_{IN}=2.5V, V_{OUT}=3.3V, I_{IOAD}=250mA)



V_{OUT} Pins in Buck Mode (V_{IN}=5V, V_{OUT}=3.3V, I_{IOAD}=250mA)



V_{OUT} Pins in Boost Mode
(V_{IN}=2.5V, V_{OUT}=3.3V, I_{IOAD}=250mA)



Pin Description

V_C (Pin 1): Error Amp Output. A frequency compensation network is connected from this pin to the FB pin to compensate the loop.

R_T (Pin 2): Timing Resistor to Program the Oscillator Frequency. The programming frequency range is 350kHz to 1.5MHz.

$$f_{OSC} = \frac{6 \cdot 10^{10}}{R_T} Hz$$

SW1 (Pin 3): 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 4): 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.

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

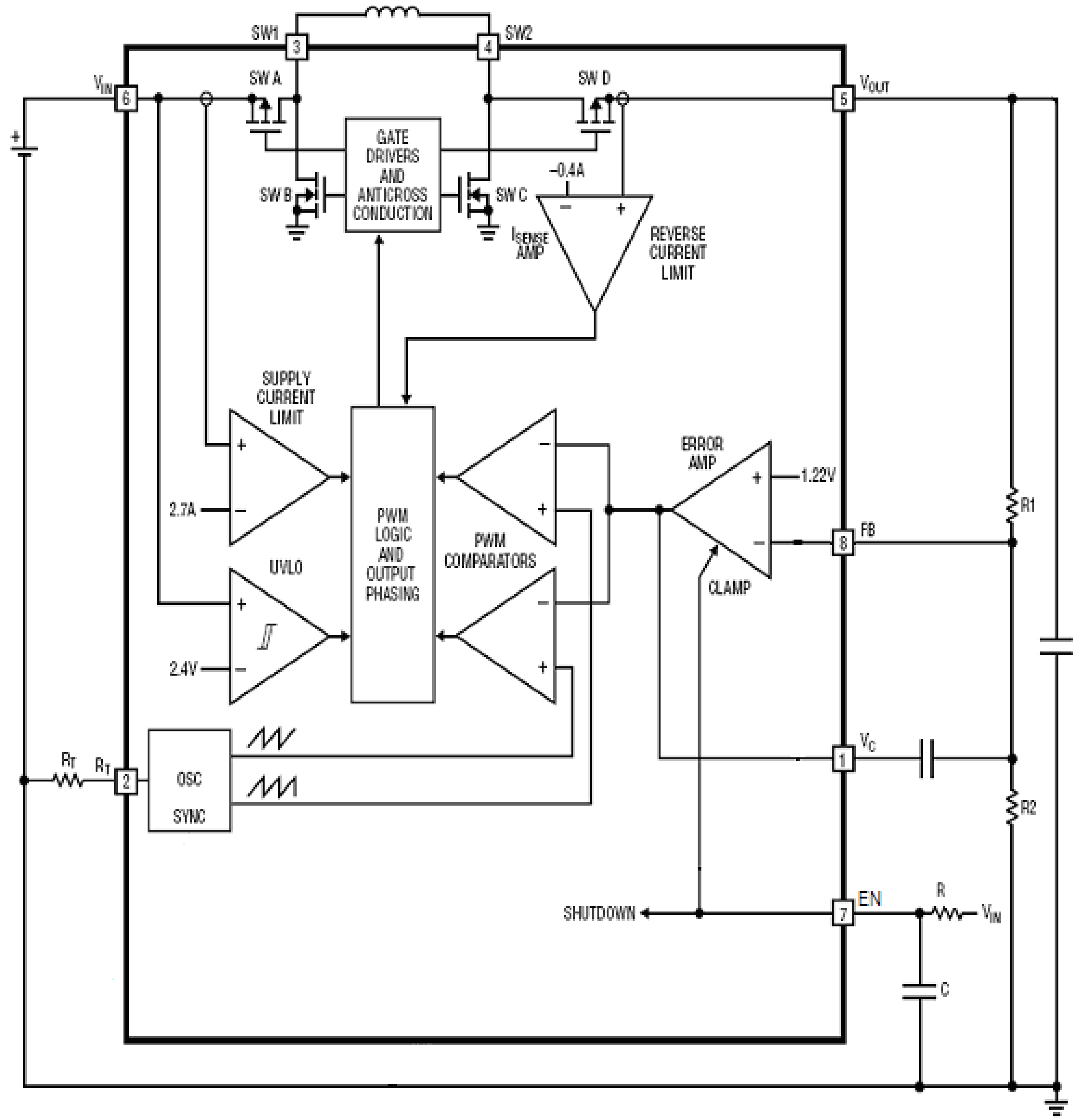
VIN (Pin 6): Input Supply Pin. A ceramic bypass capacitor as close to the VIN pin and GND is required.

EN (Pin 7): Combined Soft-Start and Shutdown. Grounding this pin shuts down the IC. Tie to >1.5V 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 VC pin.

FB (Pin 8): Feedback Pin. Connect resistor divider tap here. The output voltage can be adjusted from 1.8V to 5.5V. The feedback reference voltage is typically 1.212V.

GND (Exposed Pin 9): Signal and Power Ground for the IC.

Block Diagram



Application Information

The HX8001 provides high efficiency, low noise power for applications such as portable instrumentation. It allows input voltages above, below or equal to the output voltage by properly phasing the output switches. The error amp output voltage on the Vc pin determines the output duty cycle of the switches.

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

Inductor Selection

The high frequency operation of the HX8001 allows the use of small surface mount inductors. The inductor current ripple is typically set to 20% to 40% of the maximum inductor current. For a given ripple the inductance terms are given as follows:

$$L > \frac{V_{IN(MIN)} \bullet (V_{OUT} - V_{IN(MIN)})}{f \bullet I_{OUT(MAX)} \bullet Ripple \bullet V_{OUT}} \mu H,$$

$$L > \frac{V_{OUT} \bullet (V_{IN(MAX)} - V_{OUT})}{f \bullet I_{OUT(MAX)} \bullet Ripple \bullet V_{IN(MAX)}} \mu H$$

where f = operating frequency, MHz

Ripple = allowable inductor current ripple (e.g., 0.2 = 20%)

$V_{IN\ (MIN)}$ = 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 I^2R 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 the peak inductor currents in the 1A to 2A region. To minimize radiated noise, use a toroid, pot core or shielded bobbin inductor.

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

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

$$\%Ripple\_Buck = \frac{I_{OUT(MAX)} \bullet (V_{IN(MAX)} - V_{OUT}) \bullet 100}{C_{OUT} \bullet V_{IN(MAX)} \bullet V_{OUT} \bullet f}\%$$

where C_{OUT} = output filter capacitor, F

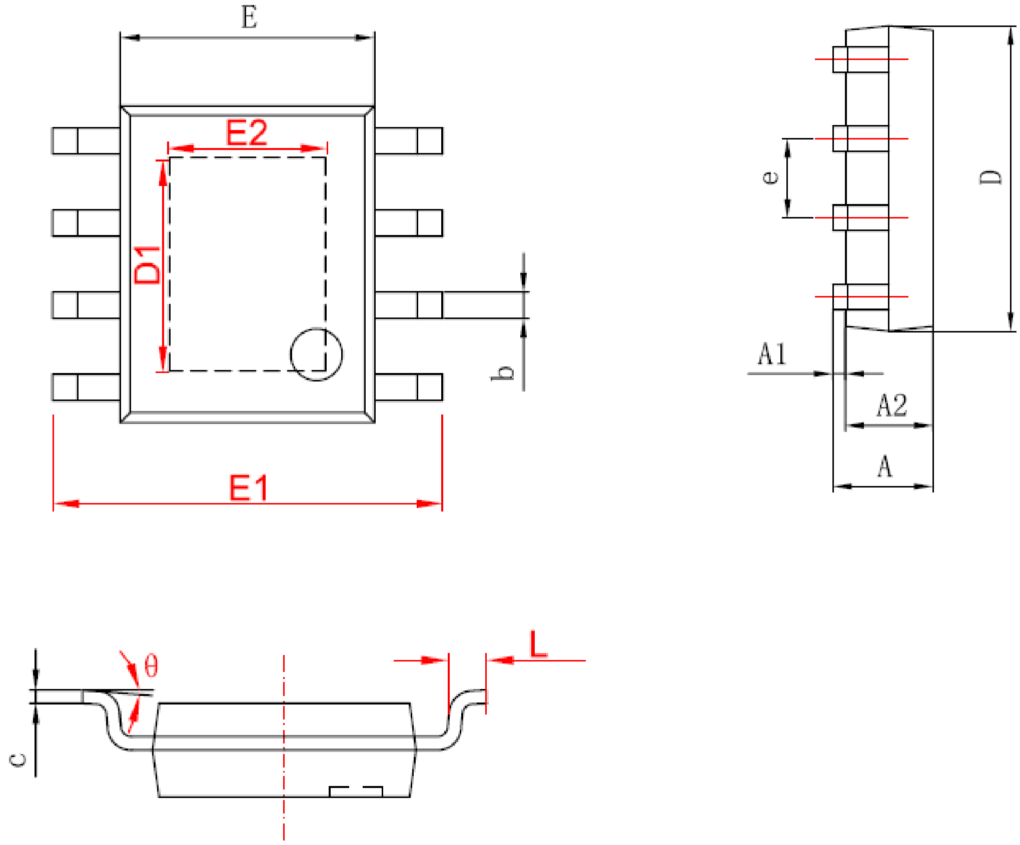
The output capacitance is usually many times larger in order to handle the transient response of the converter.

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

The other component of ripple is due to the 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 ceramic capacitors, AVX TPS series tantalum capacitors or Sanyo POSCAP are 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°

Subject changes without notice.