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 (50uA low power mode: mode pin high)
- Up to 1A Continuous Output Current
- 2.7V to 5.5V Input and Output Voltage range
- Programmable oscillator frequency from 350kHz to 1.5MHz
- No Schottky Diodes required（VOUT<4.3V）
- V_{OUT} Disconnected from V_{IN} During Shutdown
- ＜1μA Shutdown Current
- Package: Small Thermally Enhanced 10-pin MSOP

Applications

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

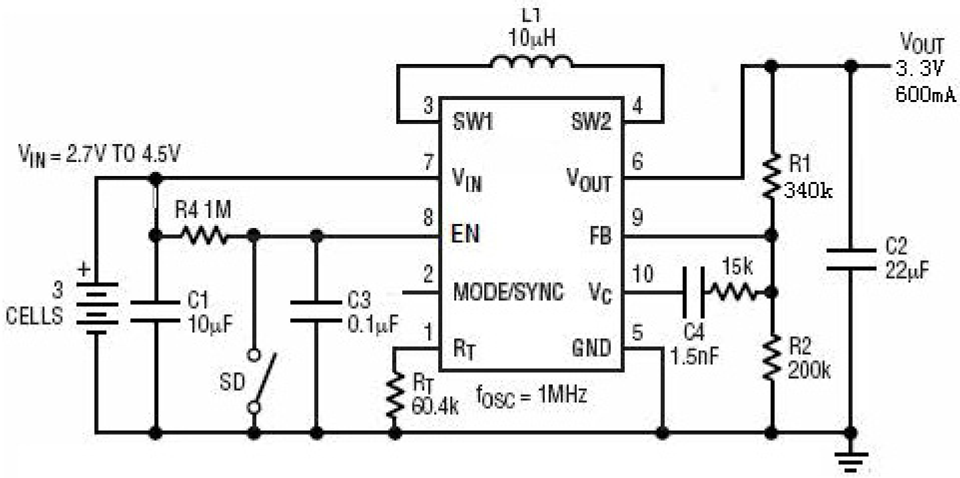
Description

The HM3440 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.

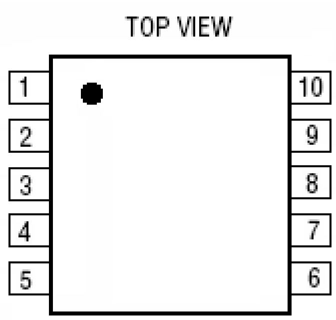
The switching frequencies up to 1.5 MHz could be fixed by employing an external resistor, and the oscillator could be synchronized to an external clock. The quiescent current is 1mA, and this feature maximizing the battery life in portable applications.

Other features include a 1μA shutdown, thermal shutdown and current limit. The HM3440 is available in the 10-pin thermally enhanced MSOP packages (or upon request).

Typical Application Circuit



Pin Assignment



MSOP-10L

PIN NUMBER MSOP-10L	PIN NAME	FUNCTION
1	R_T	Program the Oscillator Frequency
2	MODE/SYNC	Synchronization of the Internal Oscillator
3	SW1	Switch 1
4	SW2	Switch 2
5	GND	Ground
6	V_{OUT}	Output
7	V_{IN}	Input
8	EN	ON/OFF Control (High Enable)
9	FB	Feedback
10	V_C	Error Amp Output

Absolute Maximum Ratings (Note 1)

- V_{IN} , V_{OUT} Voltage ………………………………………………….…………………- 0.3 V ～ + 6 V
- R_T, FB, V_C, EN, MODE/SYNC Voltage …………………………….……………….…- 0.3 V ～+ 6 V
- SW1, SW2 Voltage …………………….…………………..………..………..……- 0.3 V ～ + 6 V
- Operating Temperature Range (Note 2) ……….....…………………......………........- 40℃ ～ + 85℃
- Lead Temperature (Soldering 10 sec.) …..………………..……….....…..……………………+ 300℃
- Storage Temperature Range ………………...………………………….….……..- 65℃ ～ + 150℃

Note 1: Absolute Maximum Ratings are those values beyond which the life of the device may be impaired.

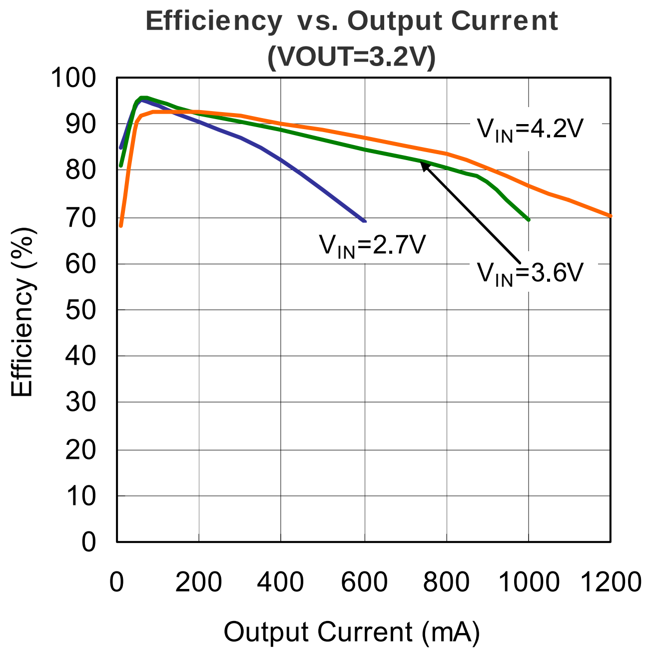
Note 2: The HM3440 is guaranteed to meet performance specifications from 0°C to 70°C. Specifications over the – 40°C to 85°C operating temperature range are assured by design, characterization and correlation with statistical process controls.

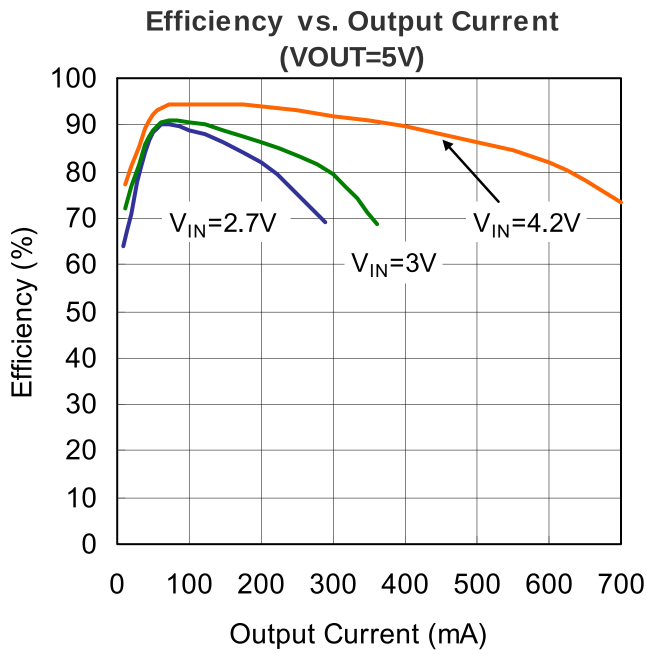
Electrical Characteristics

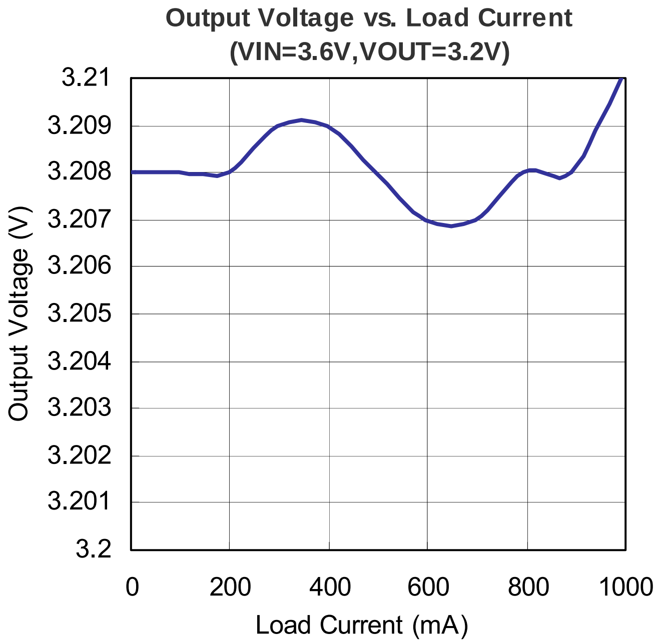
Operating Conditions: T_A=25℃, V_{IN}=3.6V unless otherwise specified.

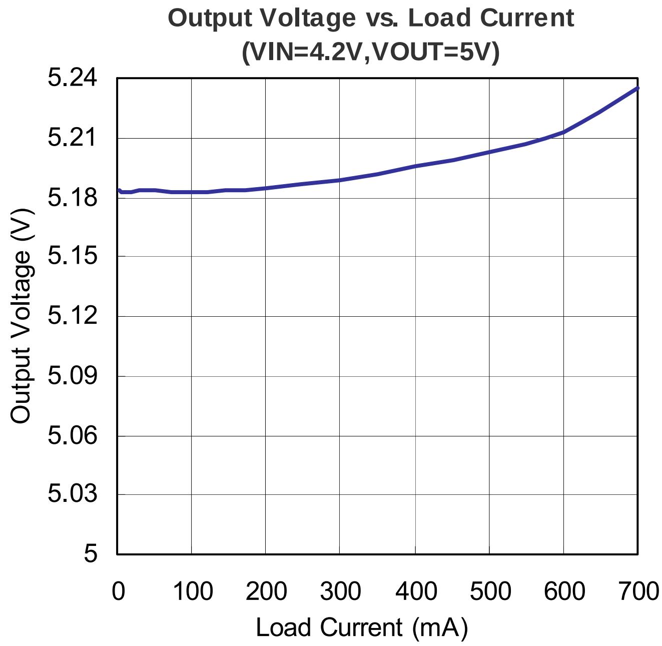
PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Input Start-Up Voltage			1.9		V
Input Operating Range		1.9		5.5	V
Output Voltage Adjust Range		2.7		5.5	V
Feedback Voltage			1.212		V
Quiescent Current, Shutdown	EN=0V, Not Including Switch Leakage		0.1	1	µA
Quiescent Current, Active	V_{IN}=2.7V		1		mA
NMOS Switch Leakage	Switches B and C		0.1	5	µA
PMOS Switch Leakage	Switches A and D			10	µA
NMOS Switch On Resistance	Switches B and C		0.19		Ω
PMOS Switch On Resistance	Switches A and D		0.22		Ω
Input Current Limit		1			A
Maximum Duty Cycle	Boost (% Switch C On)	55	75		%
	Buck (% Switch A On)	100			%
Minimum Duty Cycle				0	%
SYNC Input High		2			V
SYNC Input Low				0.4	
SYNC Input Current	V_{SYNC}=5.5V		0.01	1	µA
EN Input High	When IC is Enabled	1.8			V
EN Input Low				0.4	
EN Input Current	V_{EN}=5.5V		0.01	1	µA

Typical Performance Characteristics

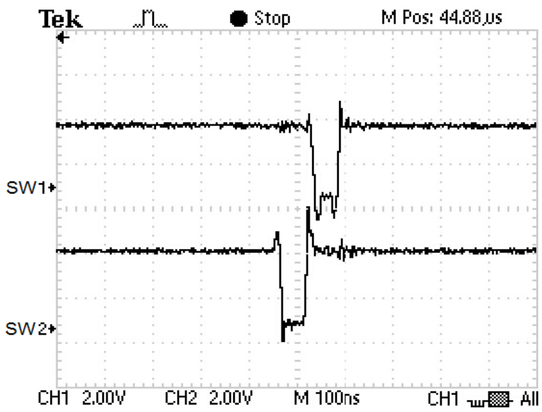




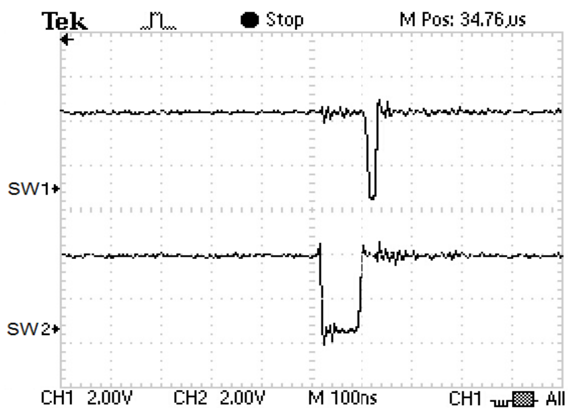




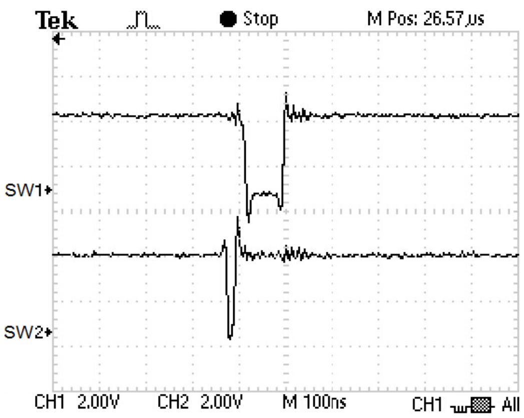
Switch Pins on the Edge of Buck/Boost and Approaching Buck
(V_{IN}=3.543V, V_{OUT}=3.3V, I_{IOAD}=250mA)



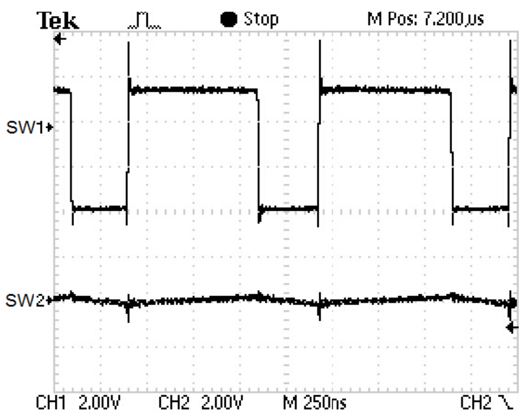
Switch Pins on the Edge of Buck/Boost and Approaching Boost
(V_{IN}=3.37V, V_{OUT}=3.3V, I_{IOAD}=250mA)



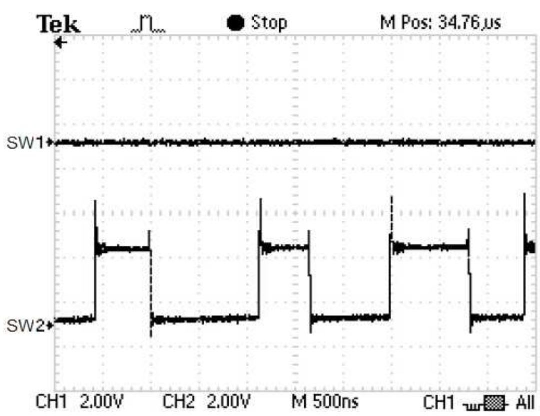
Switch Pins During Buck/Boost
(V_{IN}=3.235V, V_{OUT}=3.3V, I_{IOAD}=250mA)



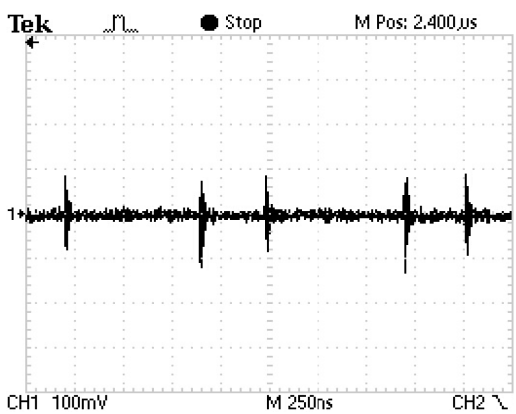
Switch Pins in Buck Mode
(V_{IN}=5V, V_{OUT}=3.3V, I_{IOAD}=250mA)



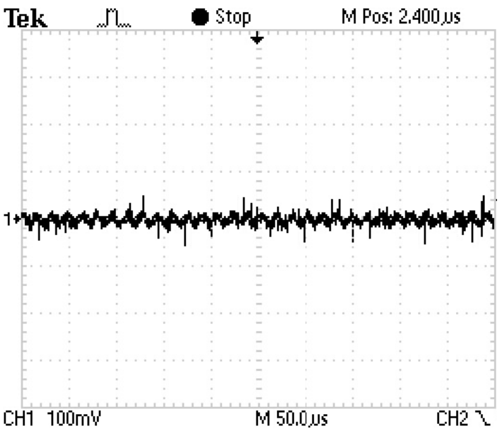
Switch Pins in Boost Mode
(V_{IN}=2.5V, V_{OUT}=3.3V, I_{IOAD}=250mA)



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

R_T (Pin 1): Timing Resistor to Program the Oscillator Frequency. The programming frequency range is 300kHzto 2MHz.

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

MODE/SYNC (Pin 2): MODE/SYNC = External CLK: Synchronization of the internal oscillator. A clock frequency of twice the desired switching frequency and with a pulse width between 100ns and 2µs is applied. The oscillator free running frequency is set slower than the desired synchronized switching frequency to guarantee sync. The oscillator RT component value required is given by:

$$R_T = \frac{8 \bullet 10^{10}}{f_{SW}}$$

Where f_{SW} = desired synchronized switching frequency.
MODE/SYNC = High: Low power running operation, VIN=2.7V, quiescent current=60uA.
MODE/SYNC = Low: Fixed frequency operation, VIN=2.7V, quiescent current =1.5mA.
Do not leave MODE/SYNC floating.

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.

GND (Pin 5): Signal and Power Ground for the IC.

V_{OUT} (Pin 6): Output of the Synchronous Rectifier. A filter capacitor is placed from VOUT to GND.

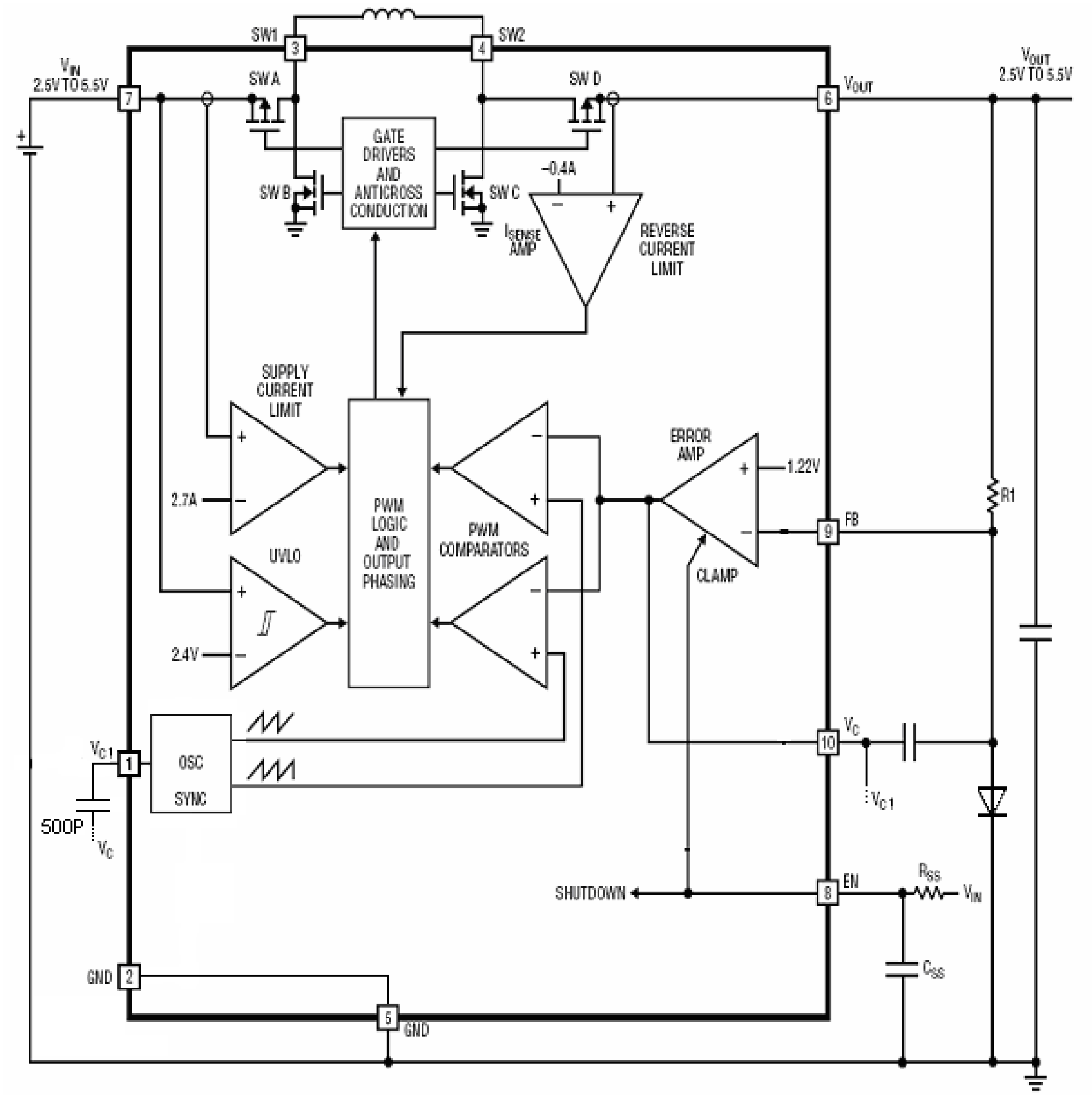
V_{IN} (Pin 7): Input Supply Pin. A ceramic bypass capacitor as close to the VIN pin and GND is required.

EN (Pin 8): 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 9): Feedback Pin. Connect resistor divider tap here. The output voltage can be adjusted from 2.7V to 5.5V. The feedback reference voltage is typically 1.212V.

V_C (Pin 10): Error Amp Output. A frequency compensation network is connected from this pin to the FB pin to compensate the loop.

Block Diagram



Applications Information

The HM3440 provides high efficiency, low noise power for applications such as portable instrumentation. The HM3440 allows input voltages above, below or equal to the output voltage by properly phasing the output switches. The error amp output voltage on the V_C pin determines the output duty cycle of the switches.

Since the V_C 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.

Error Amp

The error amplifier is a voltage mode amplifier. The loop compensation components are configured around the amplifier to provide loop compensation for the converter.

Inductor Selection

The high frequency operation of the HM3440 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:

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

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

where f = operating frequency, MHz

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

VIN (MIN) = minimum input voltage, V

VIN (MAX) = maximum input voltage, V

VOUT = output voltage, V

IOUT (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 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 COUT = 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.

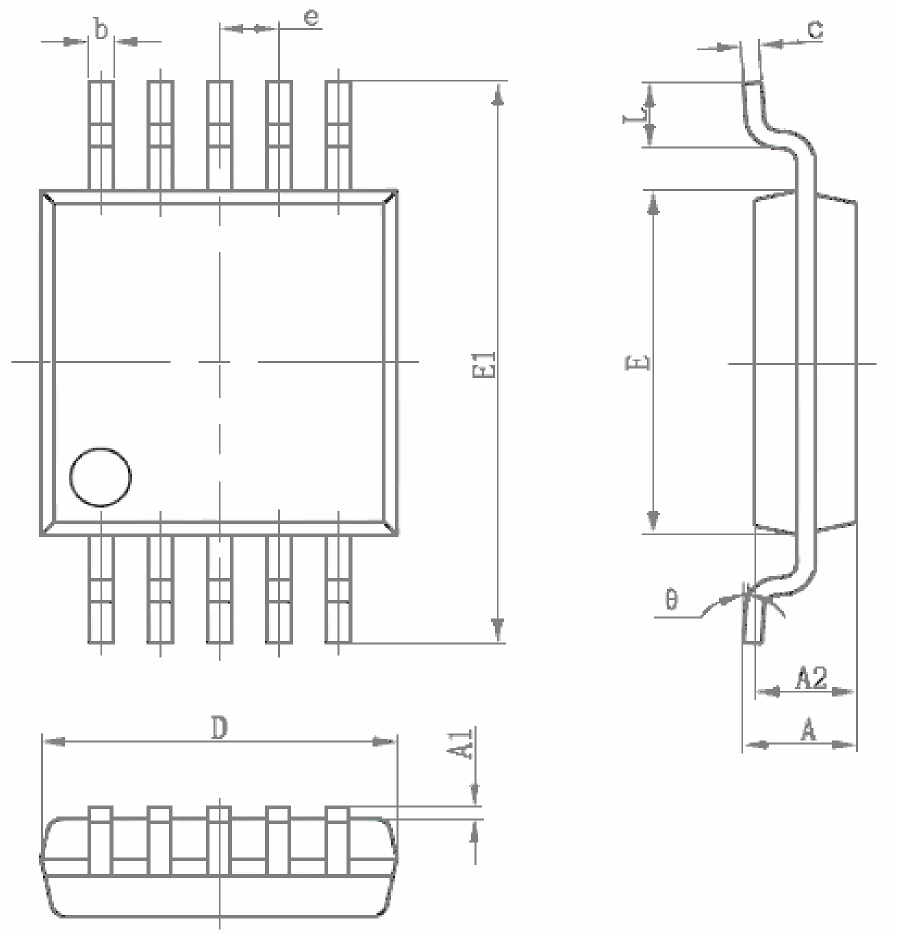
The other component of ripple is due to the ESR (equivalent series resistance) of the output capacitor. Low ESR capacitors should be used to minimize output voltage ripple. For surface mount applications, Taiyo Yuden ceramic capacitors, AVX TPS series tantalum capacitors or Sanyo POSCAP are recommended.

Input Capacitor Selection

Since the V_{IN} pin is the supply voltage for the IC it is recommended to place at least a 4.7μF, low ESR bypass capacitor.

Packaging Information

MSOP-10L Package Outline Dimension



Symbol	Dimensions in Millimeters		Dimensions in Inches	
	Min	Max	Min	Max
A	0.820	1.100	0.032	0.043
A1	0.020	0.150	0.001	0.006
A2	0.750	0.950	0.030	0.037
b	0.180	0.280	0.007	0.011
c	0.090	0.230	0.004	0.009
D	2.900	3.100	0.114	0.122
e	0.50(BSC)		0.020(BSC)	
E	2.900	3.100	0.114	0.122
E1	4.750	5.050	0.187	0.199
L	0.400	0.800	0.016	0.031
	0°	6°	0°	6°