BL3406B

1.5 MHz, 600mA Synchronous Buck Converter

FEATURES

- High Efficiency: Up to 96%
- 1.5MHz Constant Switching Frequency
- Current Mode Operation for Excellent Line and Load Transient Response
- No Schottky Diode Required
- 2.5V to 5.5V Input Voltage Range
- 1.0V,1.2V,1.5V,1.8V,2.5V and 3.3V Fixed/Adjustable Output Voltage
- 100% Duty Cycle in Dropout Mode
- Low Quiescent Current: 200µA
- Over temperature Protection
- Short Circuit Protection
- Shutdown Quiescent Current < 1µA
- Space Saving 5-Pin Thin SOT23 Package

APPLICATIONS

- Cellular and Smart Phones
- Wireless Handsets and DSL Modems
- Microprocessors and DSP Core Supplies
- PDAs
- Digital Still and Video Cameras
- MP3/MP4/MP5 Players
- Portable Instruments
- GPS Receivers

DESCRIPTION

The BL3406B is a constant frequency, 1.5MHz, slope compensated current mode PWM step-down converter working under an input voltage range of 2.5V to 5.5V. This feature makes the BL3406B suitable for single cell Li-ion battery-powered applications. The internal synchronous rectifier is desired to increase efficiency without an external Schottky diode. 100% duty cycle capability extends battery life in portable devices, while the quiescent current is 200µA at no load, and drops to < 1µA in shutdown. Pulse Skipping Mode operation increases efficiency at light loads, further extending battery life.

The BL3406B is offered in a low profile (1mm) 5-pin, thin SOT23 package, and is available in an adjustable version and fixed output versions of 1.0V, 1.2V, 1.5V , 1.8V, 2.5V and 3.3V.

ORDERING INFORMATION

BL3406B –XX X XXX

Package：
TRN:TSOT23-5
RN:SOT23-5

Features：
P： Standard (default, lead free）
C： Customized

Output Voltage：
10······1.0V
12······1.2V
15······1.5V
18······1.8V
25······2.5V
33······3.3V
Default： Adjustable

TYPICAL APPLICATION

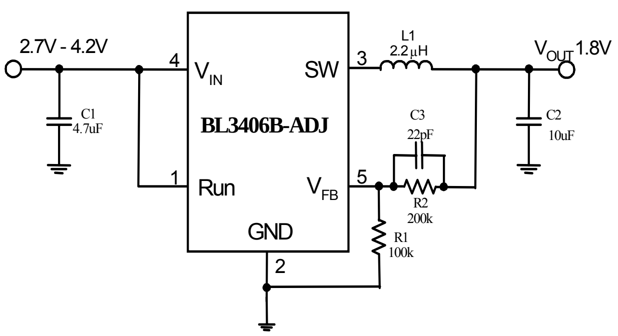


Figure 1. BL3406B-ADJ Typical Application Circuit

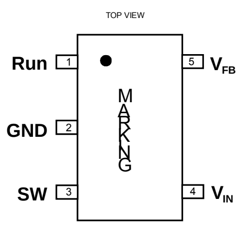
Absolute Maximum Rating (Note 1)

Input Supply Voltage····················-0.3V to +6V
RUN, V_{FB} Voltages·······················-0.3V to $+V_{IN}$
SW Voltages·······················-0.3V to (V_{IN}+0.3V)
P-Channel Switch Source Current (DC) ······800mA
N-Channel Switch Sink Current (DC) ······800mA

Peak SW Sink and Source Current··············1.3A
Operating Temperature Range·········-40°C to +85°C
Junction Temperature (Note2) ··················+125°C
Storage Temperature Range·········-65°C to +150°C
Lead Temperature (Soldering, 10s) ·········+300°C

Package Information

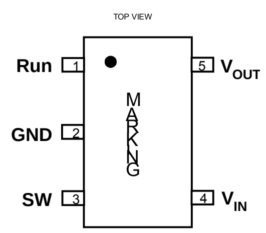
Adjustable Output Version



TSOT23-5

Part Number	Top Mark	Temp Range
BL3406B-Adj	X V Y M (Note3)	-40°C to +85°C

Fixed Output Versions



TSOT23-5

Part Number	Top Mark	Temp Range
BL3406B-1.0	X V Y M	-40°C to +85°C
BL3406B-1.2	X V Y M	
BL3406B-1.5	X V Y M	
BL3406B-1.8	X V Y M	
BL3406B-2.5	X V Y M	
BL3406B-3.3	X V Y M	

Thermal Resistance (Note 4)

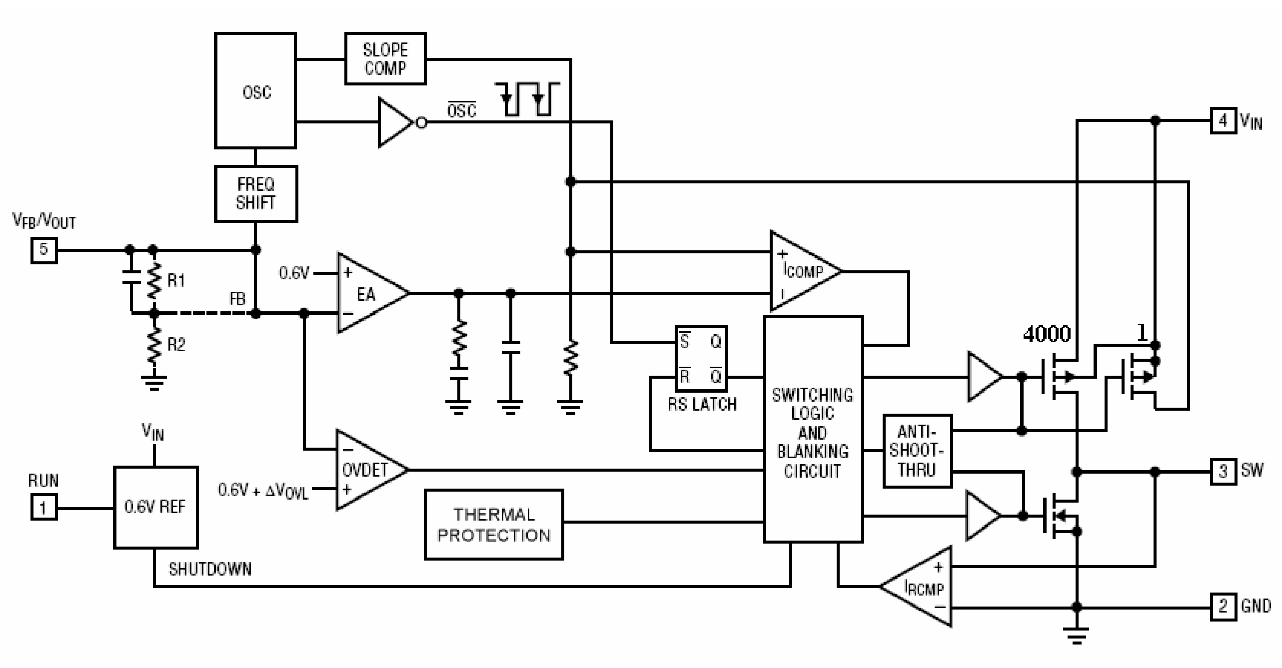
Package	Θ_{JA}	Θ_{JC}
TSOT23-5	220°C/W	110°C/W

Note 1: Absolute Maximum Ratings are those values beyond which the life of a device may be impaired.
Note 2: T_J is calculated from the ambient temperature T_A and power dissipation P_D according to the following formula:
$T_J = T_A + (P_D) \times (220°C/W)$.
Note 3:. X:Product Code V:Voltage Code Y:Year M:Month
Note 4: Thermal Resistance is specified with approximately 1 square of 1 oz copper.

Pin Description

PIN	NAME	FUNCTION
1	RUN	Regulator Enable Control Input. Drive RUN above 1.5V to turn on the part. Drive RUN below 0.3V to turn it off. In shutdown, all functions are disabled drawing <1µA supply current. Do not leave RUN floating.
2	GND	Ground
3	SW	Power Switch Output. It is the switch node connection to external inductor. This pin connects to the drains of the internal P-Channel and N-Channel MOSFET switches.
4	V_{IN}	Supply Input Pin. Must be closely decoupled to GND, Pin 2, with a 2.2µF or greater ceramic capacitor.
5	V_{FB}/V_{OUT}	V_{FB} (BL3406B-Adj): Feedback Input Pin. Connect FB to the center point of the external resistor divider. The regulated voltage on this pin is 0.6V. V_{OUT} (BL3406B-1.2/BL3406B-1.5/BL3406B-1.8): Output Voltage Feedback Pin. An internal resistive divider divides the output voltage down for comparison to the internal reference voltage.

Block Diagram



Electrical Characteristics (Note 5)

(V_{IN} =V_{RUN}= 3.6V, TA = 25°C, unless otherwise noted.)

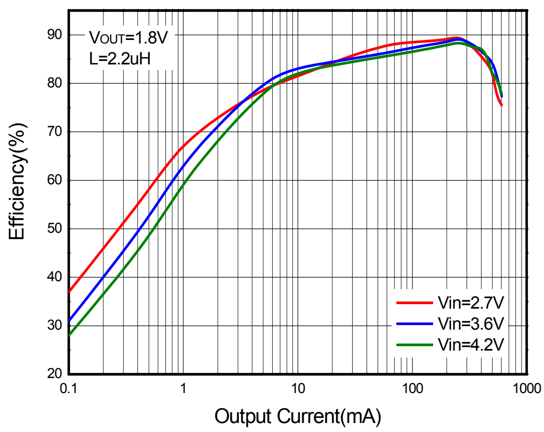
Parameter	Conditions	MIN	TYP	MAX	Unit
Input Voltage Range		2.5		5.5	V
Input DC Supply Current Active Mode Shutdown Mode	 V_{FB}=0.5V or V_{OUT}=90% V_{FB}=0V, V_{IN}=4.2V		 200 0.1	 300 1.0	 μA μA
Regulated Feedback Voltage	T_A = +25°C	0.5880	0.6000	0.6120	V
	T_A= 0°C ≤ T_A ≤ 85°C	0.5865	0.6000	0.6135	V
	T_A= -40°C ≤ T_A ≤ 85°C	0.5850	0.6000	0.6150	V
V_{FB} Input Bias Current	V_{FB} = 0.65V			±30	nA
Reference Voltage Line Regulation	V_{IN} = 2.5V to 5.5V,		0.04	0.4	%/V
Regulated Output Voltage	BL3406B-1.2, -40°C ≤ T_A ≤ 85°C	1.164	1.200	1.236	V
	BL3406B-1.8, -40°C ≤ T_A ≤ 85°C	1.746	1.800	1.854	V
Output Overvoltage Lockout	$\Delta V_{OVL} = V_{OVL} - V_{FB}$, Adjustable Version	20	50	80	mV
	$\Delta V_{OVL} = V_{OVL} - V_{OUT}$, Fixed Version	2.5	7.8	13	%
Output Voltage Line Regulation	VIN = 2.5V to 5.5V		0.04	0.40	%
Output Voltage Load Regulation			0.5		%
Peak Inductor Current	V_{IN}=3V, V_{FB}=0.5V or V_{OUT}=90% Duty Cycle <35%	0.75	1.00	1.25	A
Oscillator Frequency	V_{FB}=0.6V or V_{OUT}=100%	1.2	1.5	1.8	MHz
$R_{DS(ON)}$ of P-CH MOSFET	I_{SW} = 300mA		0.40	0.50	Ω
$R_{DS(ON)}$ of N-CH MOSFET	I_{SW} = -300mA		0.35	0.45	Ω
SW Leakage	V_{RUN} = 0V, V_{SW}= 0V or 5V, V_{IN} = 5V		±0.01	±1	μA
RUN Threshold	-40°C ≤ T_A ≤ 85°C	0.3	1.1	1.30	V
RUN Leakage Current			±0.01	±1	μA

Note 5: 100% production test at +25°C. Specifications over the temperature range are guaranteed by design and characterization.

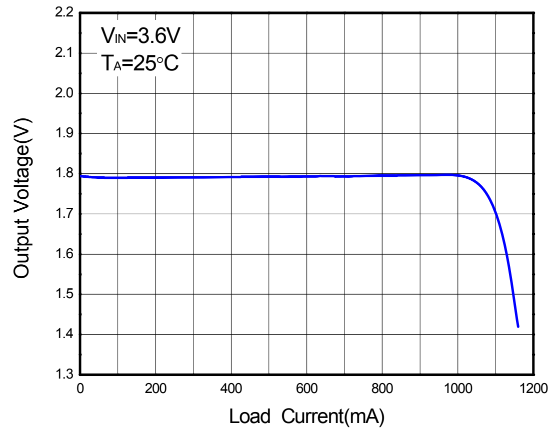
Typical Performance Characteristics

(Test Figure 1 above unless otherwise specified)

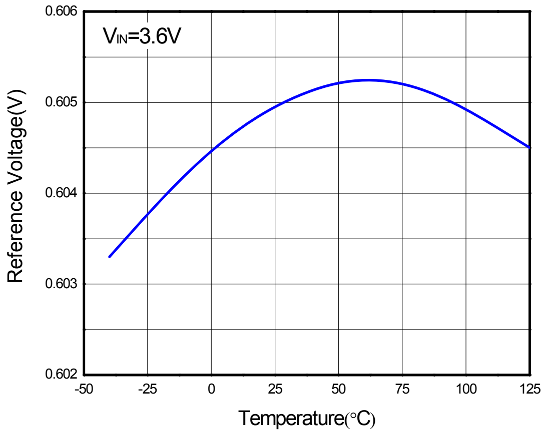
Efficiency VS Output Current



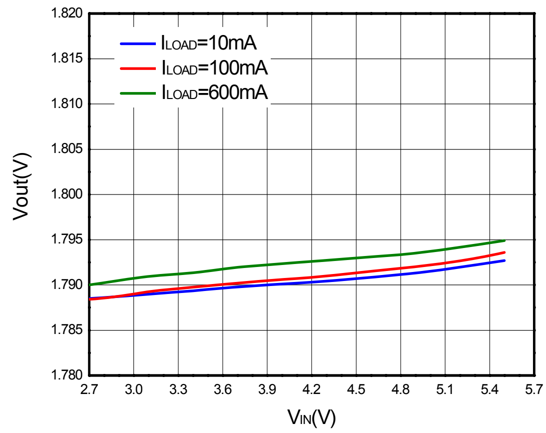
Output Voltage vs Load Current



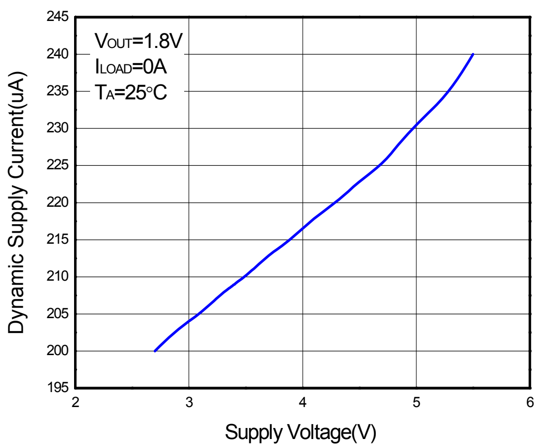
Reference Voltage vs Temperature



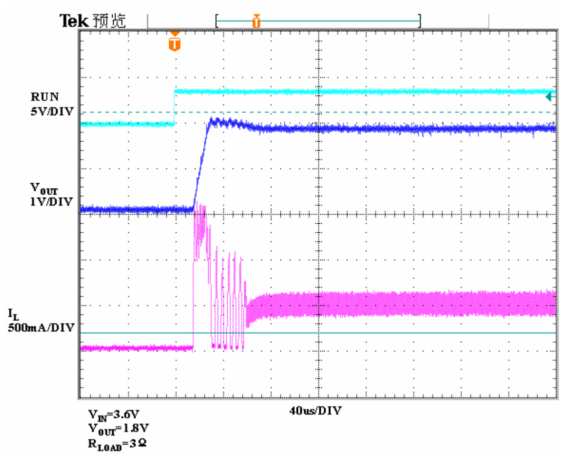
Output Voltage vs Input Voltage



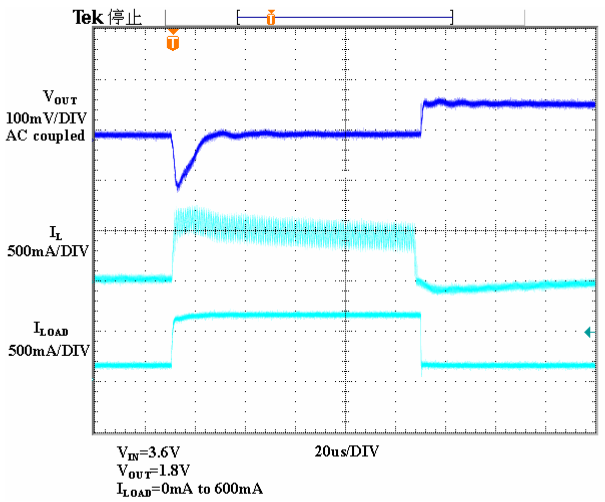
Supply Current vs Supply Voltage



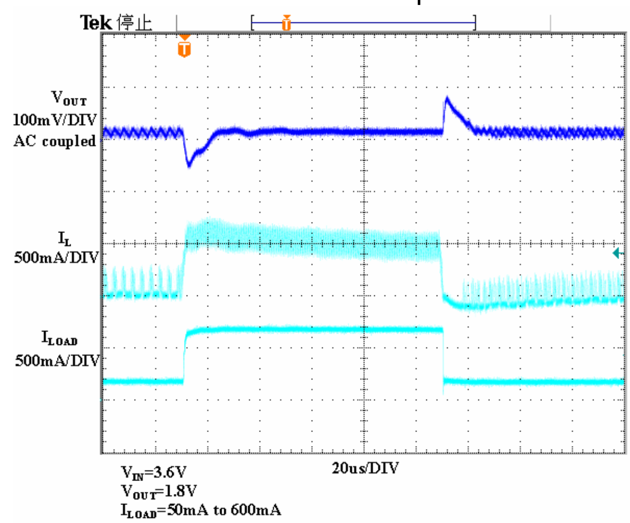
Start_up from Shutdown



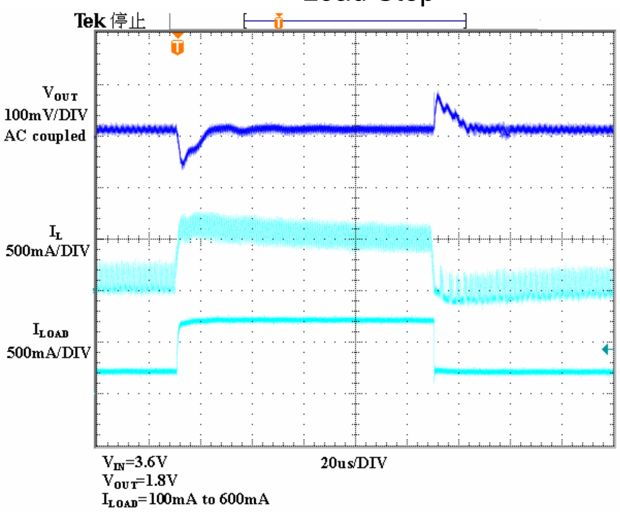
Load Step



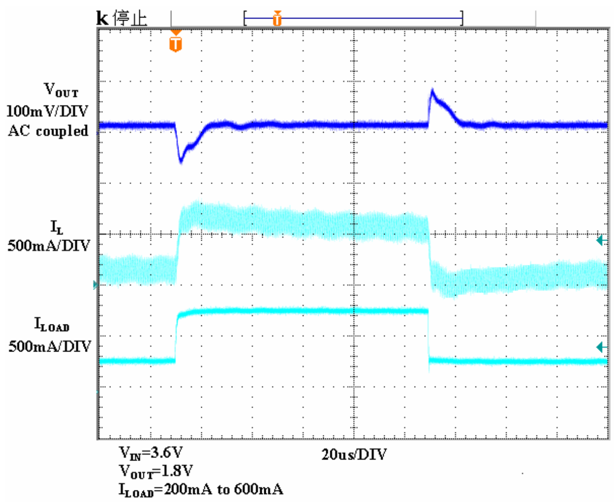
Load Step



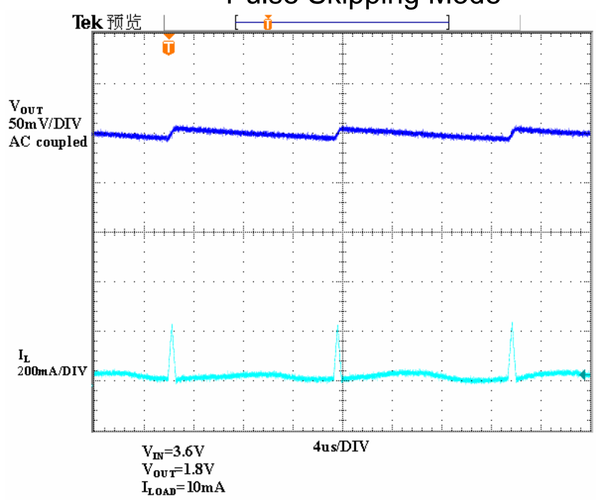
Load Step



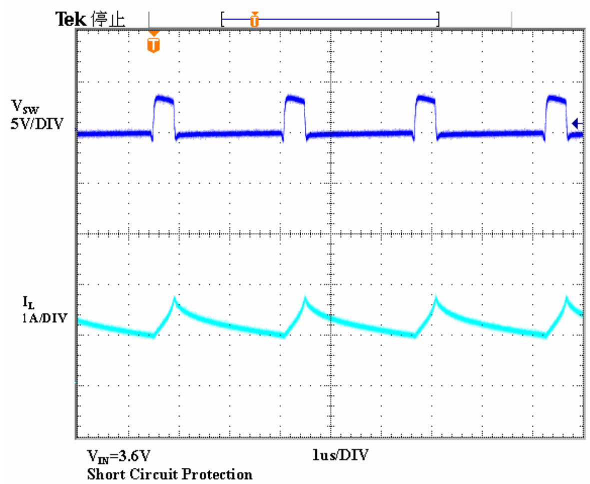
Load Step



Pulse Skipping Mode



Output Short



Operation

The BL3406B uses a constant frequency, current mode step-down architecture. Both the main switch (P-channel MOSFET) and the synchronous rectifier (N-channel MOSFET) are integrated internally. This Step-Down DC-DC Converter can supply 600mA output current over a wide input voltage range from 2.5V to 5.5V. The over voltage comparator OVDET guards against transient overshoots >7.8% by turning the main switch off and keeping it off until the fault is removed.

Current Mode PWM Control

Slope compensated current mode PWM control provides stable switching and cycle-by-cycle current limit for excellent load and line responses. During normal operation, the internal main switch is turned on for a certain time to ramp the inductor current at each rising edge of the internal oscillator, and turned off when the peak inductor current reaches the controlled value. When the main switch is off, the synchronous rectifier will be turned on immediately and stay on until either the inductor current starts to reverse, as indicated by the current reversal comparator, I_{RCMP}, or the beginning of the next clock cycle.

Pulse Skipping Mode Operation

At very light loads, the BL3406B will automatically enter Pulse Skipping Mode to increase efficiency, further extending battery life. In this mode, the control loop skips PWM pulses while maintaining output in regulation, and the switching frequency depends on the load condition. This is a kind of PFM mode operation.

Dropout Operation

When the input voltage decreases toward the value of the output voltage, the BL3406B will keep the main switch on for more than one switching cycle and increases the duty cycle (Note 5) until it reaches 100%. The output voltage then is the input voltage minus the voltage drop across the main switch and the inductor. At low input supply voltage, the $R_{DS(ON)}$ of the P-Channel MOSFET increases, and the efficiency of the converter decreases. Caution must be exercised to ensure the heat dissipated not to exceed the maximum junction temperature of the IC.

Note 5: The duty cycle D of a step-down converter is defined as:

$$D = T_{ON} \times f_{OSC} \times 100\% \approx \frac{V_{OUT}}{V_{IN}} \times 100\%$$

where T_{ON} is the main switch on time, and f_{OSC} is the oscillator frequency (1.5MHz).

Maximum Load Current

The BL3406B will operate with input supply voltage as low as 2.5V, however the maximum load current decreases at lower input voltage due to large IR drop on the main switch and synchronous rectifier.

Application Information

Figure 2 below shows the basic application circuit with BL3406B fixed output versions.

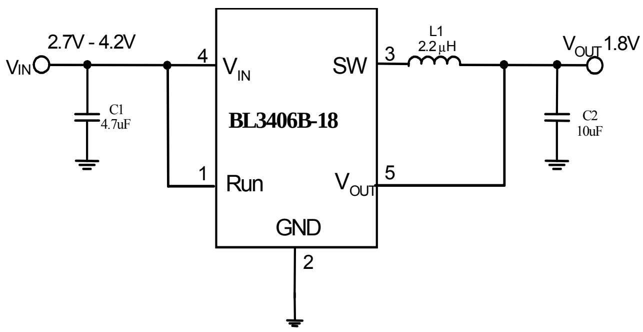


Figure 2. Basic Application Circuit with fixed output versions

Setting the Output Voltage

Figure 1 above shows the basic application circuit with BL3406B adjustable output version. The external resistor sets the output voltage according to the following equation:

$$V_{OUT} = 0.6V \times (1 + \frac{R2}{R1})$$

Inductor Selection

The output inductor is selected to limit the ripple current to some predetermined value, typically 20%~40% of the full load current at the maximum input voltage. In continuous mode, the ripple current is determined by:

$$\Delta I_L = \frac{1}{f \times L} V_{OUT} (1 - \frac{V_{OUT}}{V_{IN}})$$

A reasonable starting point for setting ripple current is ΔI_L=240mA (40% of 600mA). For output voltages above 2.0V, when efficiency at light load condition is important, the minimum recommended inductor is 2.2μH. For optimum voltage-positioning load transients, choose an inductor with DC series resistance below 150mΩ. For higher efficiency at heavy loads (above 200mA), or minimal load regulation (but some transient overshoot), the resistance should be kept below 100mΩ.

The DC current rating of the inductor should be at least equal to the maximum load current plus half the ripple current to prevent core saturation. Thus, a 720mA rated inductor should be enough for most applications (600mA+120mA).

Input Capacitor Selection

The input capacitor reduces the surge current drawn from the input and switching noise from the device. The input capacitor impedance at the switching frequency shall be less than input source impedance to prevent high frequency switching current passing to the input

In continuous mode, the source current of the main switch is a square wave of duty cycle V_{OUT}/V_{IN}. To prevent large voltage transients, a low ESR input capacitor sized for the maximum RMS current must be used. The maximum RMS capacitor current is given by:

$$I_{RMS} \approx I_{OMAX} \frac{[V_{OUT}(V_{IN} - V_{OUT})]^{0.5}}{V_{IN}}$$

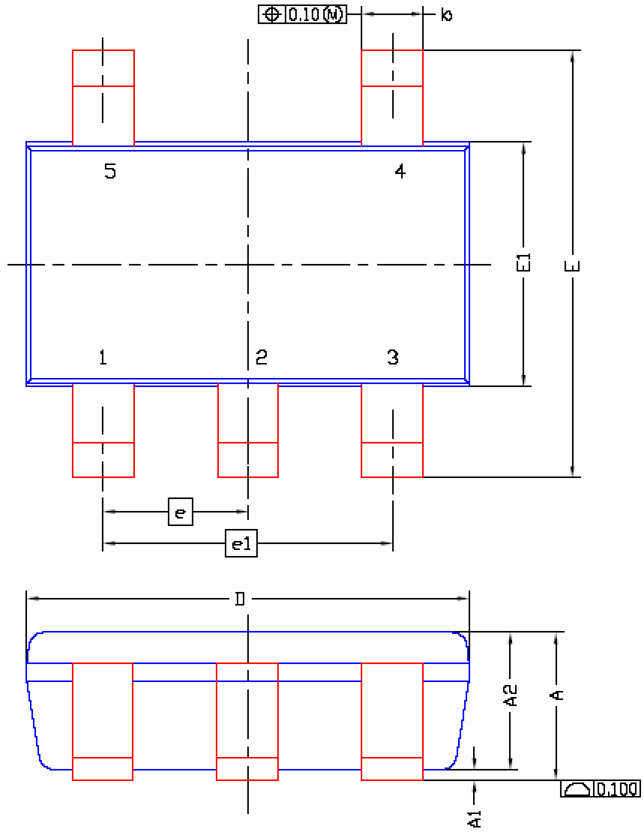
This formula has a maximum at V_{IN} =2V_{OUT}, where I_{RMS} = I_{OUT}/2. This simple worst-case condition is commonly used for design because even significant deviations do not offer much relief. Ceramic capacitors with X5R or X7R dielectrics are recommended due to their low ESR and high ripple current.

Output Capacitor Selection

The output capacitor is required to keep the output voltage ripple small and to ensure regulation loop stability. The output capacitor must have low impedance at the switching frequency. Ceramic capacitors with X5R or X7R dielectrics are recommended due to their low ESR and high ripple current. The output ripple VOUT is determined by:

$$\Delta V_{OUT} \le \frac{V_{OUT} \times (V_{IN} - V_{OUT})}{V_{IN} \times f_{OSC} \times L} \times \left(ESR + \frac{1}{8 \times f_{OSC} \times C_2} \right)$$

Package Description



DIM.	MILLIMETERS			INCHES		
	MIN	NOM	MAX	MIN	NOM	MAX
A	0.80	0.95	1.00	0.0315	0.0374	0.0394
A1	0.00	---	0.10	0.000	---	0.004
A2	0.70	0.875	0.90	0.0276	0.0344	0.0354
b	0.35	0.40	0.50	0.014	0.016	0.020
c	0.10	0.127	0.20	0.004	0.005	0.008
D	2.90 BSC			0.114 BSC		
E	2.80 BSC			0.110 BSC		
E1	1.60 BSC			0.063 BSC		
e	0.95 BSC			0.037 BSC		
e1	1.90 BSC			0.075 BSC		
L	0.30	0.40	0.60	0.0118	0.0157	0.024
L1	0.60REF			0.024REF		
L2	0.254BSC			0.010BSC		
R	0.10	---	---	0.004	---	---
θ	0°	4°	8°	0°	4°	8°
θ1	7°NOM			7°NOM