Description

The YB1680 is a 1.5MHz constant frequency, slope compensated current mode PWM step-down converter. The device integrates a main switch and a synchronous rectifier for high efficiency without an external Schottky diode. It is ideal for powering portable equipment that runs from a single cell lithium-Ion (Li+) battery. The YB1680 can supply 600mA of load current from a 2.5V to 5.5V input voltage. The output voltage can be regulated as low as 0.6V. The YB1680 can also run at 100% duty cycle for low dropout operation, extending battery life in portable system. Idle mode operation at light loads provides very low output ripple voltage for noise sensitive applications.

The YB1680 is offered in a low profile 5-pin, SOT package, and is available in an adjustable version.

Features

- High Efficiency : Up to 94%
- 1.5MHz Constant Switching Frequency
- 600mA Output Current at V_{IN}=3V
- Integrated Main Switch and Synchronous Rectifier. No Schottky Diode Required
- 2.5V to 5.5V Input Voltage Range
- Output Voltage as Low as 0.6V
- 100% Duty Cycle in Dropout
- Low Quiescent Current : 300μA
- Slope Compensated Current Mode Control for Excellent Line and Load Transient Response
- Short Circuit Protection
- Thermal Fault Protection
- <1μA Shutdown Current
- Space Saving 5-Pin SOT23 Package
- Pb-free Package

Applications

- Cellular and Smart Phones
- Microprocessors and DSP Core Supplies
- Wireless and DSL Modems
- PDAs
- MP3 Player
- Digital Still and Video Cameras
- Portable Instruments

Typical Application Circuit

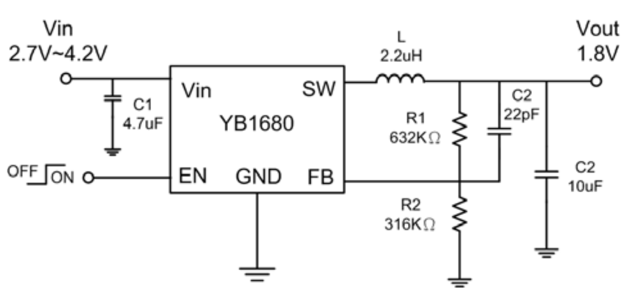
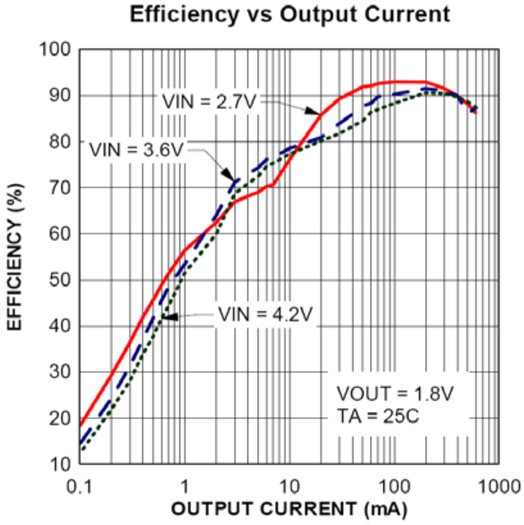


Figure 1: Typical Application Circuit



Pin Configuration

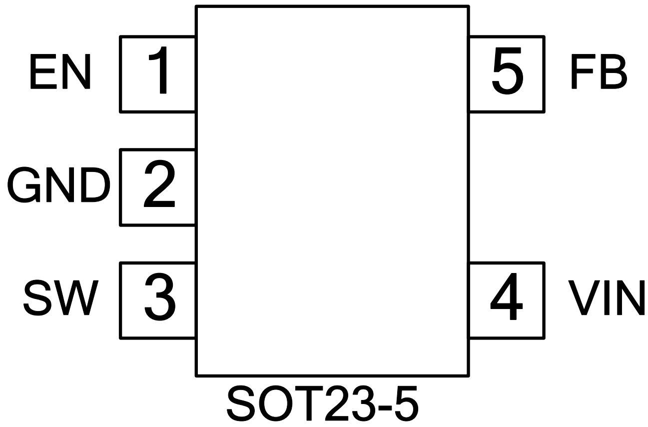


Figure 2: Pin Configuration

Pin Description

Table 1

Pin	Name	Description
1	EN	Regulator Enable control input. Drive EN above 1.5V to turn on the part. Drive EN below 0.3V to turn it off. In shutdown, all functions are disabled drawing <1μA supply current. Do not leave EN floating.
2	GND	Ground.
3	SW	Power Switch Output. It is the Switch note connection to Inductor. This pin connects to the drains of the internal P-CH and N-CH MOSFET switches.
4	VIN	Supply Input Pin. Must be closely decoupled to GND, Pin 2, with a 2.2μF or greater ceramic capacitor.
5	FB	VFB (Adjustable Version) : Feedback Input Pin. Connect FB to the center point of the external resistor divider. The feedback threshold voltage is 0.6V.

Ordering Information

Order Number	Package Type	Supplied As	Package Marking
YB1680ST25XADJP	SOT23-5	3000 units Tape & Reel	A1XY (Note 1)

Note 1: XY = Manufacturing Date Code

Absolute Maximum Ratings

Input Supply Voltage .... -0.3V to 6V
EN, V_{FB} Voltage .... -0.3V to V_{IN}+0.3V
SW, V_{OUT} Voltage.............. -0.3V to V_{IN}+0.3V
Peak SW Sink and Source Current........1.5A
Operating Temperature Range..-40°C to 85°C
Junction Temperature .... 125°C
Storage Temperature Range ...-65°C to 150°C
Lead Temperature (Soldering, 10s)..300°C

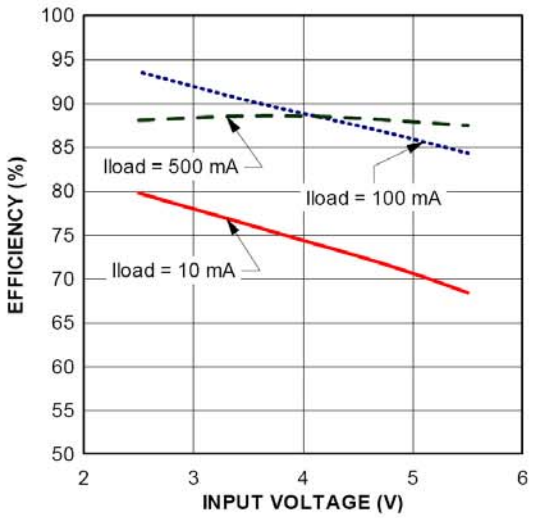
Electrical Characteristics

Table 2 (V_{IN} = V_{RUN} = 3.6V, T_A=25°C, Test Circuit Figure 1, unless otherwise noted.)

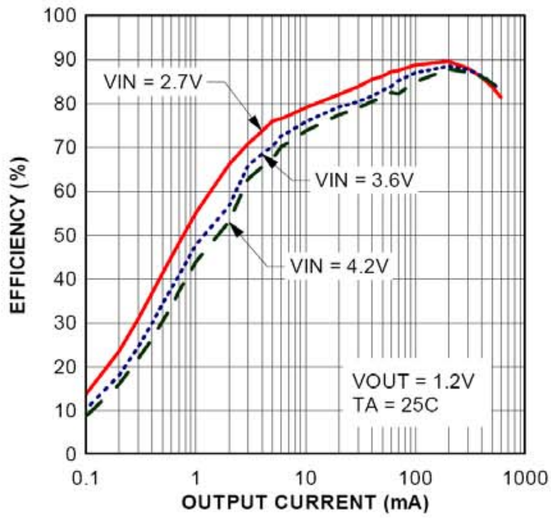
Description	Symbol	Test Conditions	MIN	TYP	MAX	Units
Input Voltage Range	V_{IN}		2.5		5.5	V
Input DC Supply Current Active Mode Shutdown Mode	I_Q	V_{FB} = 0.5V V_{FB} = 0V, V_{IN} = 4.2V		270 0.08	400 1.0	μA
Regulated Feedback Voltage	V_{FB}	T_A = +25℃	0.5880	0.6000	0.6120	V
		T_A = 0℃ ≦ T_A ≦ 85℃	0.5865	0.6000	0.6135	
		T_A = -40℃ ≦ T_A ≦ 85℃	0.5850	0.6000	0.6150	
V_{FB} Input Bias Current	I_{FB}	V_{FB} = 0.65V			±30	nA
Reference Voltage Line Regulation		V_{FB} = 2.5V to 5.5V, V_{OUT} = V_{FB} (R2=0)		0.11	0.63	%/V
Output Voltage Line Regulation		V_{IN} = 2.5V to 5.5V, I_{OUT} = 10mA		0.11	0.63	%/V
Output Voltage Load Regulation		I_{OUT} from 0 to 600mA		0.0015		%/mA
Maximum Output Current		V_{IN} = 3.0V	600			mA
Oscillator Frequency	F_{OSC}	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		0.30	0.50	Ω
$R_{DS(ON)}$ of N-CH MOSFET		I_{SW} = -300mA		0.20	0.45	Ω
Peak Inductor Current		V_{IN} = 3V, V_{FB} = 0.5V or V_{OUT} = 90% Duty Cycle < 35%		1.20		A
SW Leakage		V_{RUN} = 0V, V_{SW} = 0V or 5V, V_{IN} = 5V		±0.01	±1	μA
Output Over Voltage Lockout		ΔV_{OVL} = V_{OVL} - V_{FB}		60		mV
EN Threshold	V_{EN}	-40℃ ≦ T_A ≦ 85℃	0.3	0.45	1.30	V
EN Leakage Current	I_{EN}			±0.1	±1	μA

Typical Performance Characteristics

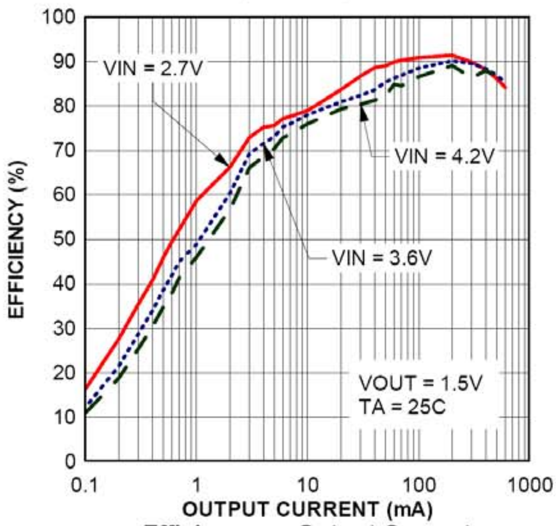
Efficiency vs Input Voltage



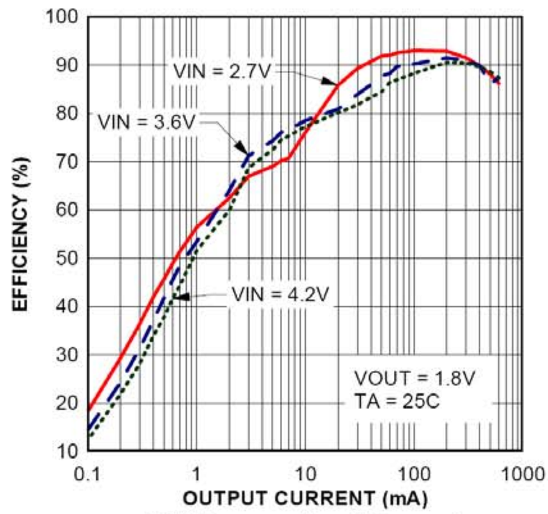
Efficiency vs Output Current



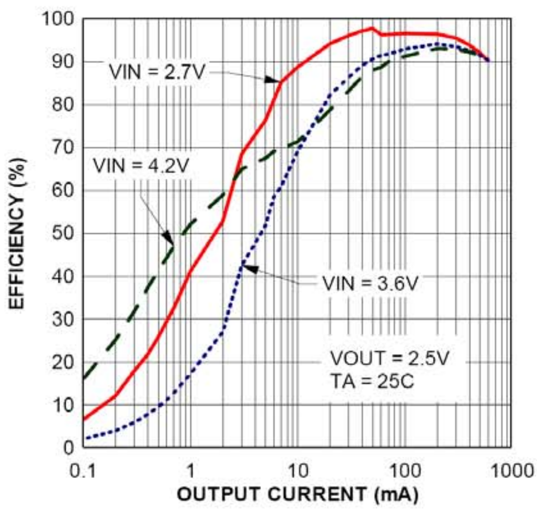
Efficiency vs Output Current



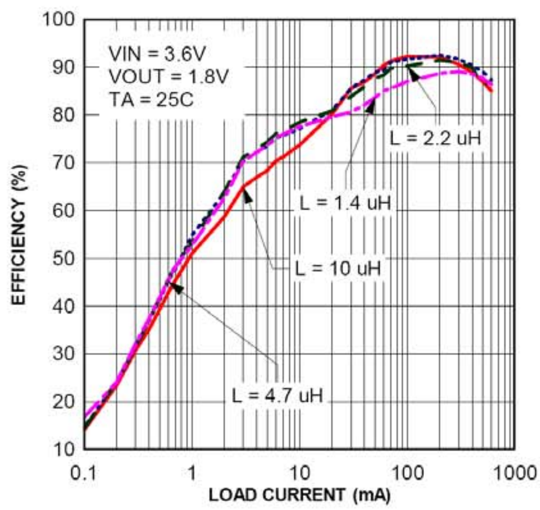
Efficiency vs Output Current



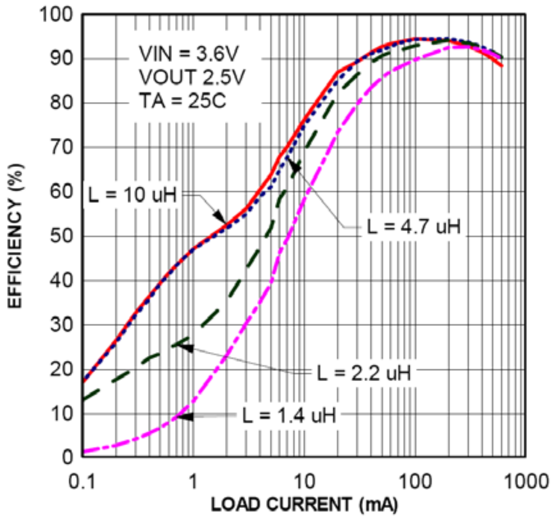
Efficiency vs Output Current



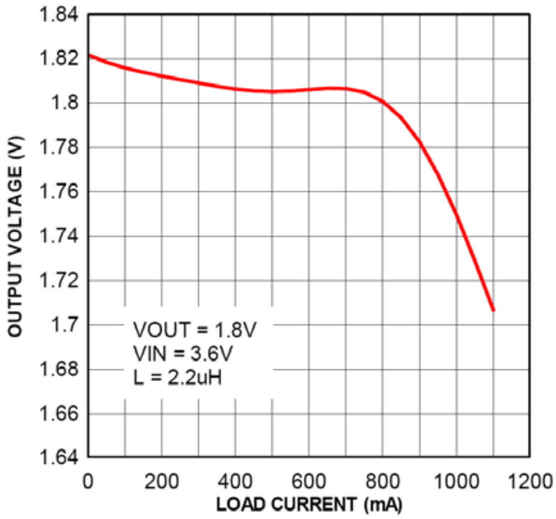
Efficiency vs Load Current



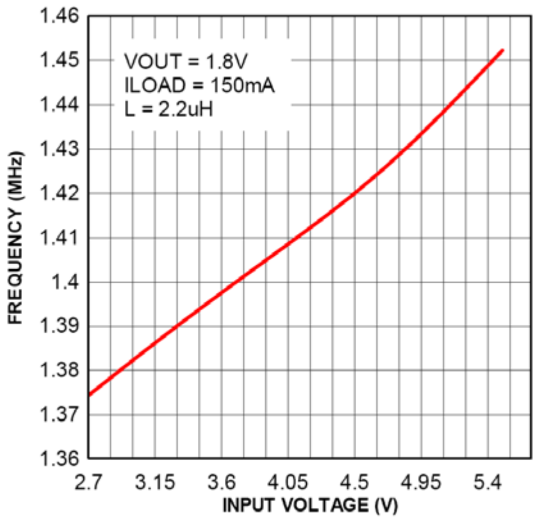
Efficiency vs Load Current



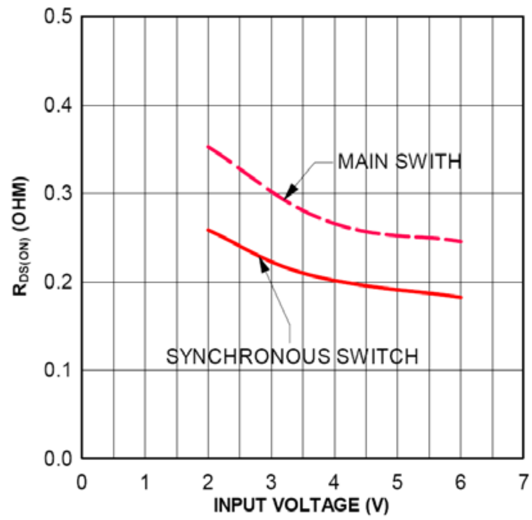
Outpu Voltage vs Load Current



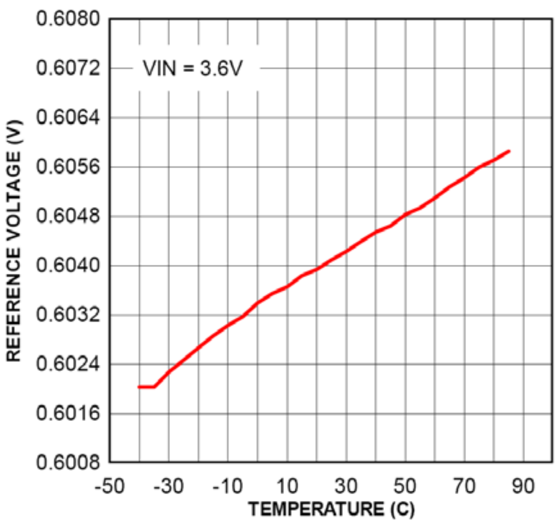
Frequency vs Input Voltage



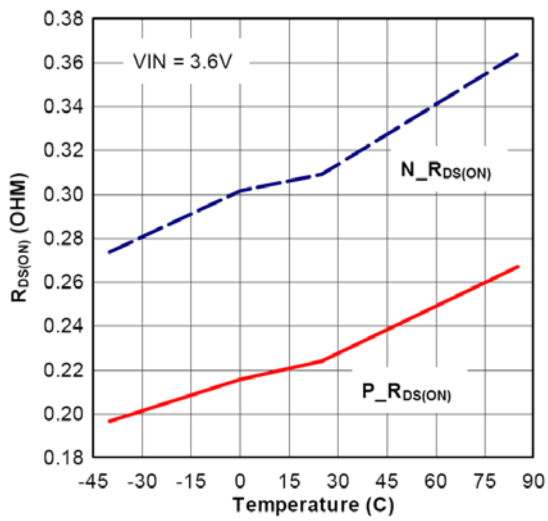
$R_{DS(ON)}$ vs Input Voltage



Reference Voltage vs Temperature



$R_{DS(ON)}$ vs Temperature



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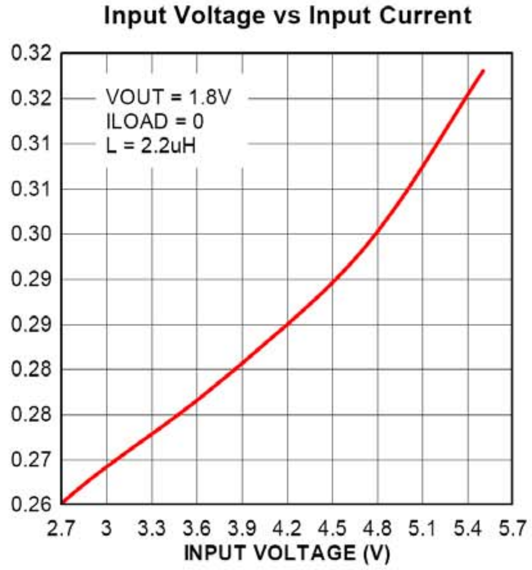
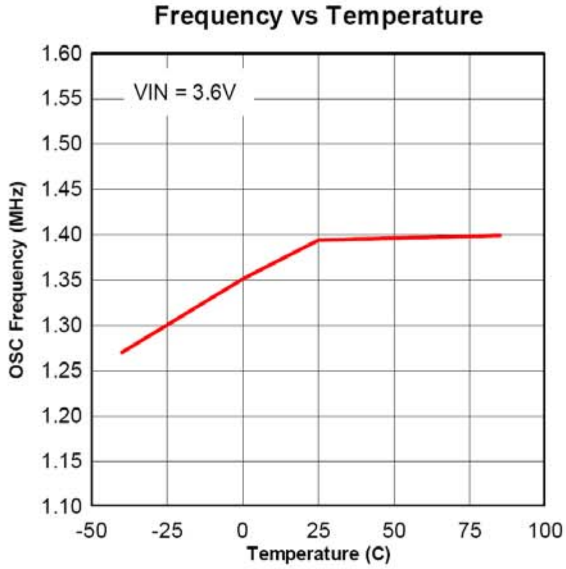
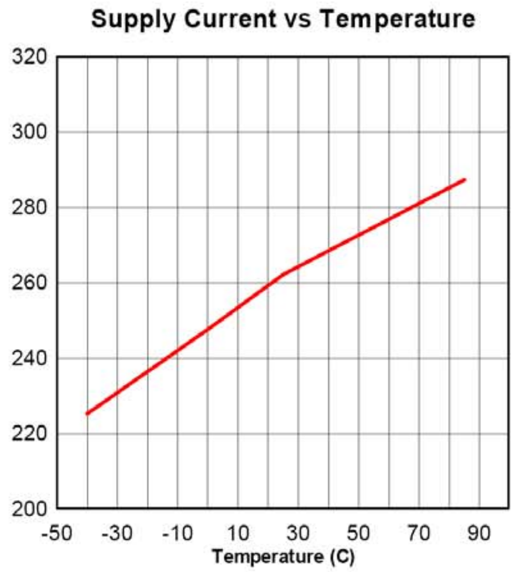
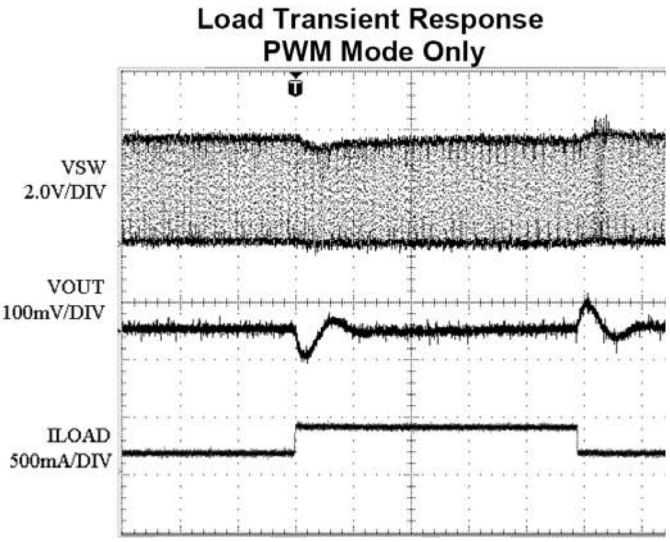
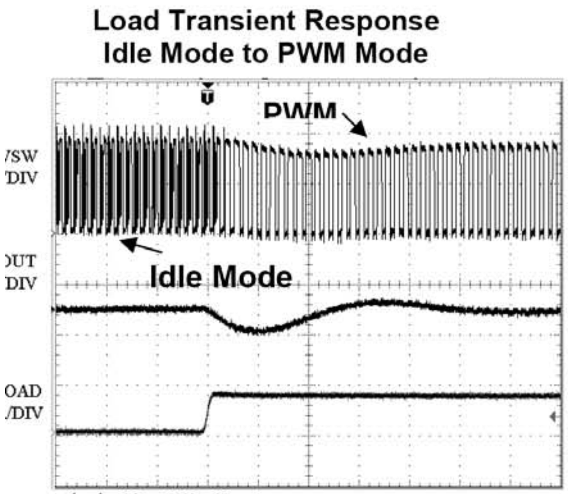








Iload = 100 mA TO 400 mA
L=2.2uH, Cin=10uF, Cout=10uF, Vin=3.6V, Vout=1.8V



Iload = 28 mA TO 400 mA
L=2.2uH, Cin=10uF, Cout=10uF, Vin=3.6V, Vout=1.8V

Function Block

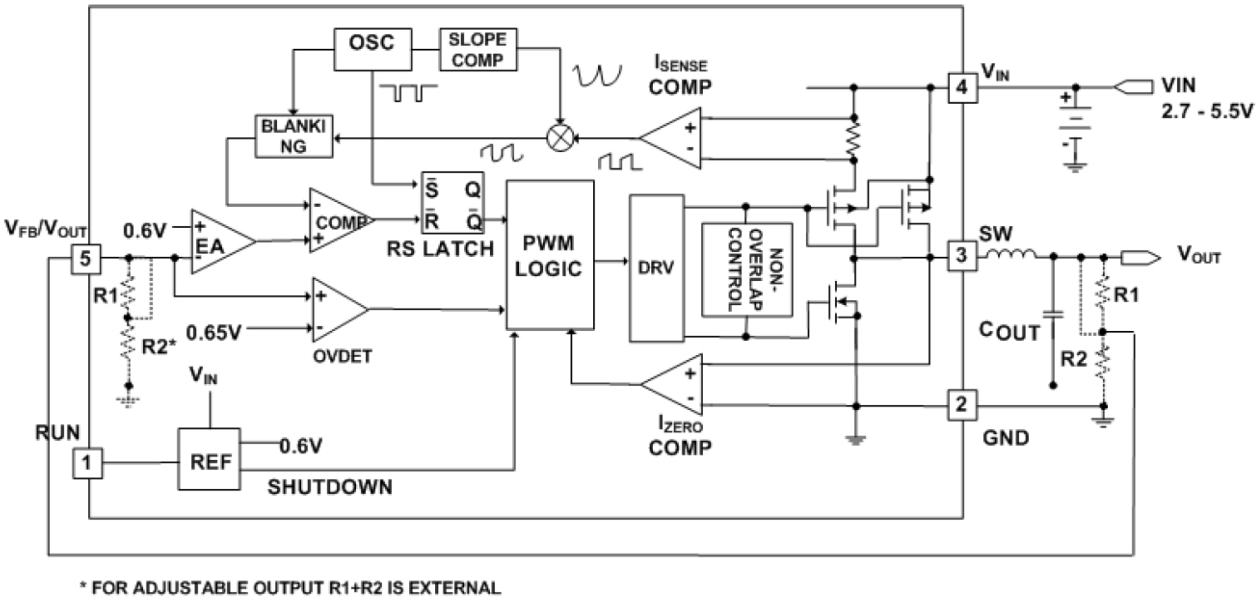


Figure 3: Function Block

Operation

YB1680 is a monolithic switching mode Step-Down DC-DC converter. It utilizes internal MOSFETs to achieve high efficiency and can generate very low output voltage by using internal reference at 0.6V. It operates at a fixed switching frequency, and uses the slope compensated current mode architecture. This Step-Down DC-DC Converter supplies 600mA output current at V_{IN} = 3V with input voltage range from 2.5V to 5.5V.

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 and protection of the internal main switch (P-Ch MOSFET) and synchronous rectifier (N-CH MOSFET). During normal operation, the internal P-Ch MOSFET is turned on for a certain time to ramp the inductor current at each rising edge of the internal oscillator, and switched off when the peak inductor current is above the error voltage. The current comparator, I_{COMP}, limits the peak inductor current. 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_{ZERO}, or the beginning of the next clock cycle. The OVDET comparator controls output transient overshoots by turning the main switch off and keeping it off until the fault is no longer present.

Idle Mode Operation

At very light loads, the YB1680 automatically enters Idle Mode. In the Idle Mode, the inductor current may reach zero or reverse on each pulse. The PWM control loop will automatically skip pulses to maintain output regulation. The bottom MOSFET is turned off by the current reversal comparator, I_{ZERO}, and the switch voltage will ring. This is discontinuous mode operation, and is normal behavior for the switching regulator.

Dropout Operation

When the input voltage decreases toward the value of the output voltage, the YB1680 allows the main switch to remain on for more than one switching cycle and increases the duty cycle 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.

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

Maximum Load Current

The YB1680 will operate with input supply voltage as low as 2.5V, however, the maximum load current decreases at lower input due to large IR drop on the main switch and synchronous rectifier. The slope compensation signal reduces the peak inductor current as a function of the duty cycle to prevent sub-harmonic oscillations at duty cycles greater than 50%. Conversely the current limit increases as the duty cycle decreases.

Application Information

Setting the Output Voltage

Figure 1 above shows the basic application circuit with YB1680 adjustable output version. The external resistor sets the output voltage according to the following equation:

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

R1=300KΩ for all outputs; R2=300KΩ for V_{OUT}=1.2V, R2=200KΩ for V_{OUT}=1.5V, R2=150KΩ for V_{OUT}=1.5V, and R=95.3KΩ for V_{OUT}=2.5V.

Inductor Selection

For most designs, the YB1680 operates with inductors of 1μH to 4.7μH. Low inductance values are physically smaller but require faster switching, which results in some efficiency loss. The inductor value can be derived from the following equation:

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

Where ΔI_L is inductor Ripple Current. Large value inductors lower ripple current and small value inductors result in high ripple currents. Choose inductor ripple current approximately 35% of the maximum load current 600mA, or $\Delta I_L = 210mA$.

For output voltages above 2.0V, when light-load efficiency is important, the minimum recommended inductor is 2.2μH. For optimum voltage-positioning load transients, choose an inductor with DC series resistance in the 50mΩ to 150mΩ range. 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 (600mA+105mA).

Input Capacitor Selection

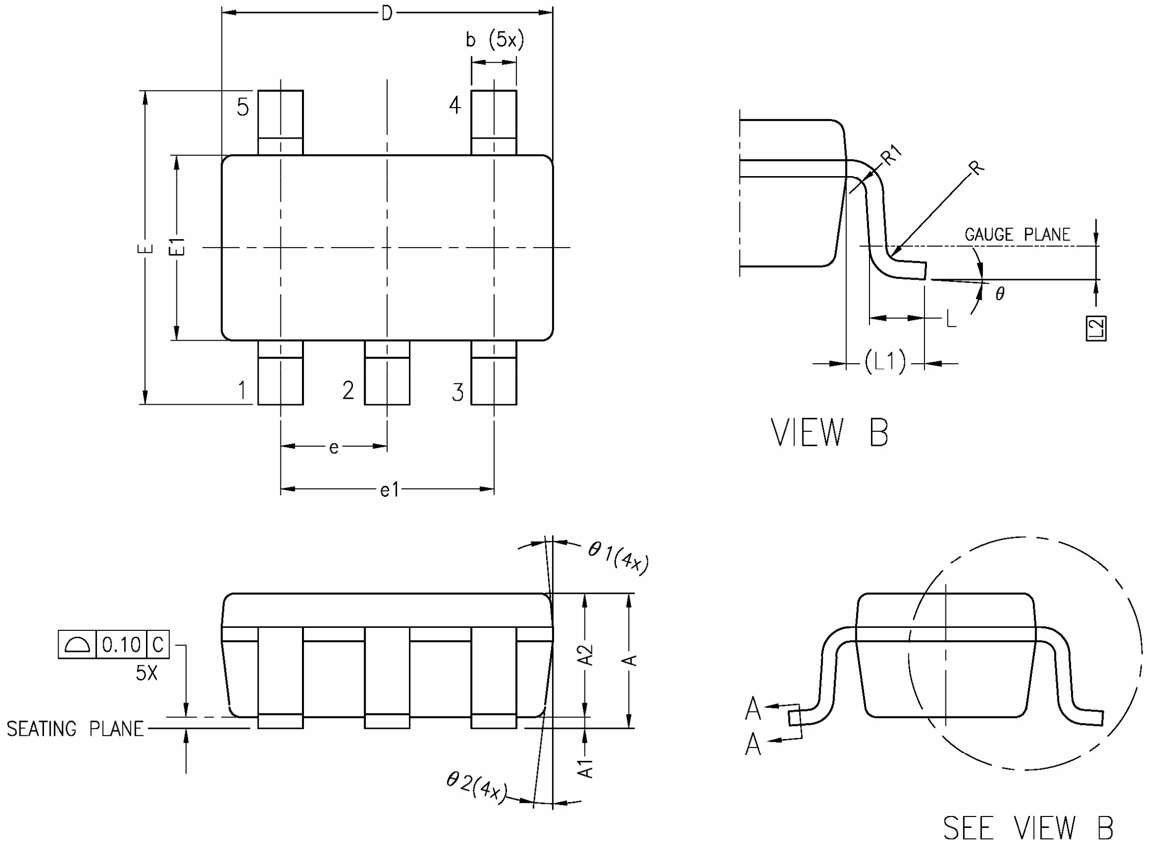
The input capacitor reduces the surge current drawn from the input and switching noise from the device. The input capacitor impedance at the switching frequency shall be less than input source impedance to prevent high frequency switching current passing to the input. A low ESR input capacitor sized for maximum RMS current must be used. Ceramic capacitors with X5R or X7R dielectrics are highly recommended because of their low ESR and small temperature coefficients. A 4.7μF ceramic capacitor for most applications is sufficient.

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 V_{OUT} is determined by:

$$\Delta V_{OUT} \le \frac{V_{OUT} \times (V_{IN} - V_{OUT})}{V_{IN} \times f_{OSC} \times L} \times \left(ESR + \frac{1}{8 \times f_{osc} \times C3} \right)$$

Package Information (SOT23-5)



SYMBOLS	DIMENSIONS IN MILLIMETERS		
	MIN	NOM	MAX
A	1.05	1.20	1.35
A1	0.05	0.10	0.15
A2	1.00	1.10	1.20
b	0.35	———	0.50
b1	0.35	0.40	0.45
c	0.08	———	0.22
c1	0.08	0.13	0.20
D	2.80	2.90	3.00
E	2.60	2.80	3.00
E1	1.50	1.60	1.70
e	0.95 BSC		
e1	1.90 BSC		
L	0.35	0.43	0.60
L1	0.60 REF		
L2	0.25 BSC.		
R	0.10	———	———
R1	0.10	———	0.25
θ	0°	4°	8°
θ1	5°	6°	15°
θ2	5°	8°	15°

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