1.0MHz, 2A Synchronous Step-Down DC/DC Converter

FEATURES

- High Efficiency: Up to 95% (@3.3V)
- 1.0MHz Constant Frequency Operation
- 2A Output Current
- No Schottky Diode Required
- 2.3V to 6.0V Input Voltage Range
- Output Voltage as Low as 0.6V
- PFM Mode for High Efficiency in Light Load
- 100% Duty Cycle in Dropout Operation
- Low Quiescent Current: 40µA
- Short Circuit Protection
- Thermal Fault Protection
- Inrush Current Limit and Soft Start
- Input Over Voltage Protection(OVP)
- <1µA Shutdown Current
- SOT23-5 Package

APPLICATIONS

- Cellular and Smart Phones
- Wireless and DSL Modems
- PDAs
- Portable Instruments
- Digital Still and Video Cameras
- PC Cards

DESCRIPTION

The AIC2386B is a 1.0MHz constant frequency, current mode step-down converter. It is ideal for portable equipment requiring very high current up to 2A from single-cell Lithium-ion batteries while still achieving over 90% efficiency during peak load conditions. The AIC2386B also can run at 100% duty cycle for low dropout operation, extending battery life in portable systems while light load operation provides very low output ripple for noise sensitive applications. The AIC2386B can supply up to 2A output load current at 5V input voltage and the output voltage can be regulated as low as 0.6V. The high switching frequency minimizes the size of external components while keeping switching losses low. The internal slope compensation setting allows the device to operate with smaller inductor values to optimize size and provide efficient operation. The AIC2386B is offered in SOT23-5 package, and is available in an adjustable version.

This device offers two operation modes, PWM control and PFM Mode switching control, which allows a high efficiency over the wider range of the load.

APPLICATIONS CIRCUIT

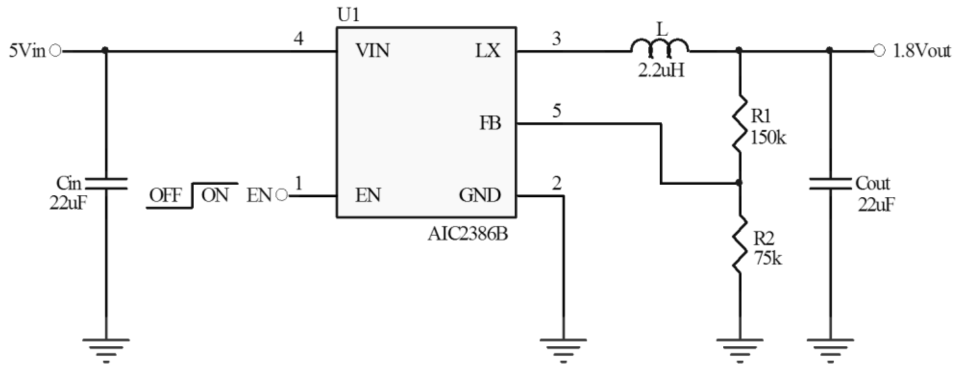


Fig. 1 Typical Application Circuit

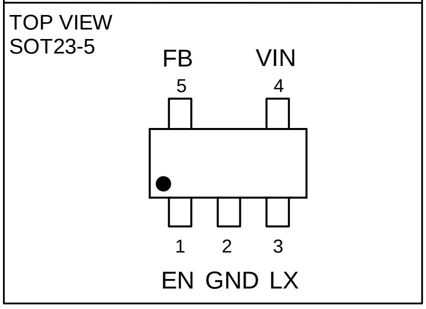
ORDERING INFORMATION

AIC2386BXXXXX

- PACKING TYPE
  TR: TAPE & REEL
  BG: BAG
- PACKAGE TYPE
  U5: SOT23-5
- G: Green Package

Example: AIC2386BGU5TR
→ in SOT23-5 Green Package and Tape & Reel Packing Type

PIN CONFIGURATION



- **Marking**

Top Mark:T26XXX (T26:Device Code, XXX: Inside Code)

Part No.	Marking
AIC2386BGU5	T26XXX

ABSOLUTE MAXIMUM RATINGS

VIN Pin Voltage .... -0.3 V to 6.5V
LX Pin Voltage .... -0.3 V to 6.5V
EN Pin and FB Pin Voltage .... -0.3 V to 6.5V
Operating Ambient Temperature Range T_A .... -40°C to 85°C
Operating Maximum Junction Temperature(Note2) T_J .... 160°C
Storage Temperature Range T_{STG} .... -65°C to 150°C
Lead Temperature (Soldering 10 Sec.) .... 260°C
Power Dissipation 600mW
(Assume no Ambient Airflow, no Heat sink)

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

ELECTRICAL CHARACTERISTICS

(T_A=25°C, V_{IN}=V_{EN}=3.6V, V_{OUT}=1.8V unless otherwise specified.) (Note 1)

PARAMETER	CONDITIONS	SYMBOL	MIN	TYP	MAX	UNITS
Input Voltage Range		V_{IN}	2.3		6.0	V
OVP Threshold		V_{OVP}		6.5		V
UVLO Threshold		V_{UVLO}	1.7	1.9	2.1	V
Quiescent Current	V_{EN}=2.0V, I_{OUT}=0, V_{FB}=V_{REF}*105%	I_Q		40	75	μA
Shutdown Current	V_{EN} =0V	I_{SHDN}		0.1	1.0	μA
Regulated Feedback Voltage	T_A = 25°C	V_{FB}	0.588	0.600	0.612	V
Reference Voltage Line Regulation	V_{IN} = 2.5V to 5.5V			0.1		%/V
Output Voltage Accuracy	V_{IN} = 3.6V to 5.5V, I_{OUT}=10mA to 2000mA		-3		+3	%V
Output Voltage Load Regulation	I_{OUT}=10mA to 2000mA			0.2		%
Oscillation Frequency	V_{OUT}=100%	f_{OSC}		1.0		MHz
	V_{OUT}=0V			300		kHz
On Resistance of PMOS	I_{LX}=100mA	$P_{RDS(ON)}$		150		mΩ
On Resistance of NMOS	I_{LX}=-100mA	$N_{RDS(ON)}$		70		mΩ
Peak Current Limit	V_{IN}=5V,V_{OUT}=90%	I_{PK}		2.5		A
EN Threshold			0.30	1.0	1.50	V
EN Leakage Current				±0.01	±1.0	μA
LX Leakage Current	V_{EN}=0V,V_{IN}=V_{LX}=5V			±0.01	±1.0	μA

Note 1: Specifications are production tested at T_A=25°C. Specifications over the -40°C to 85°C operating temperature range are assured by design, characterization and correlation with Statistical Quality Controls (SQC).

Note 2: T_J is calculated from the ambient temperature T_A and power dissipation P_D according to the following formula: $T_J = T_A + (P_D)$ x (250°C/W).

Note 3: Dynamic supply current is higher due to the gate charge being delivered at the switching frequency.

■ TYPICAL PERFORMANCE CHARACTERISTICS

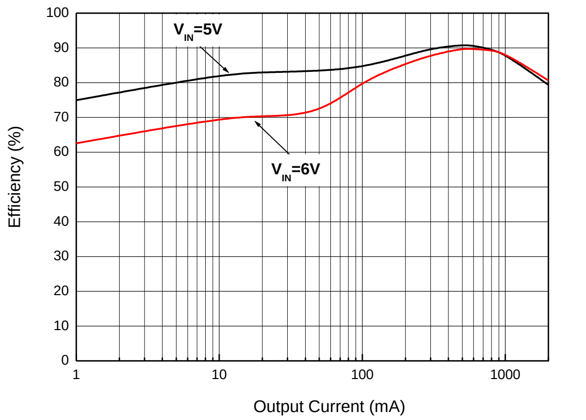


Fig. 2 Efficiency vs. Output Current (V_{OUT}=1.8V)

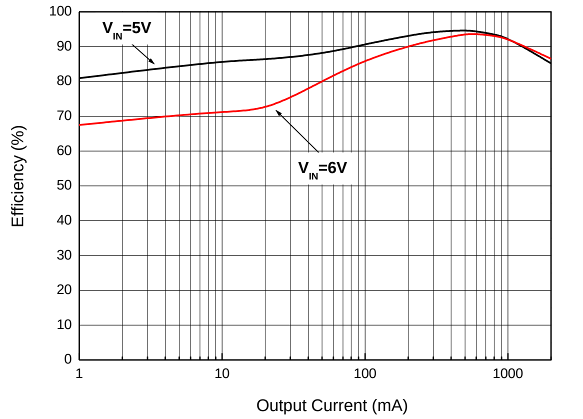


Fig. 3 Efficiency vs. Output Current (V_{OUT}=3.3V)

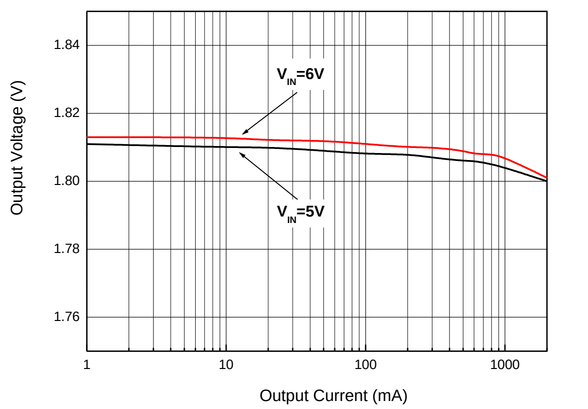


Fig. 4 Output Voltage vs. Output Current (V_{OUT}=1.8V)

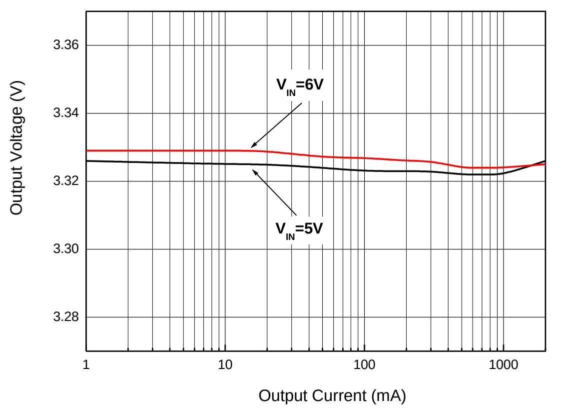
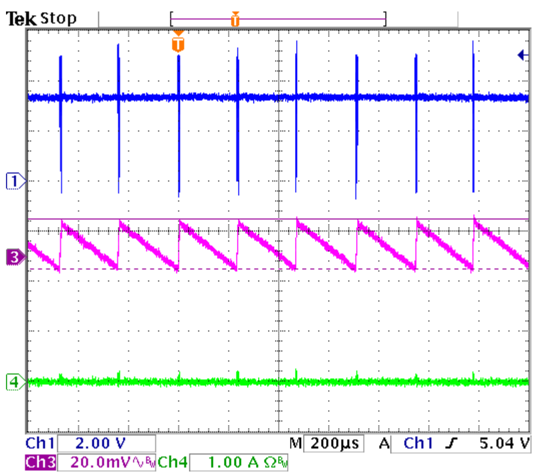
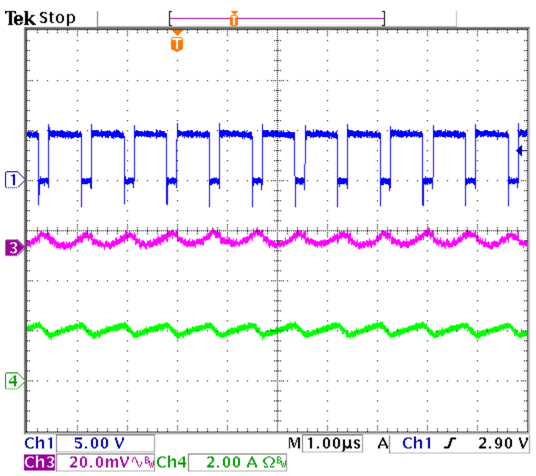


Fig. 5 Output Voltage vs. Output Current (V_{OUT}=3.3V)



(CH1: V_{LX}, CH3: $V_{OUT(ac)}$, CH4: I_L)

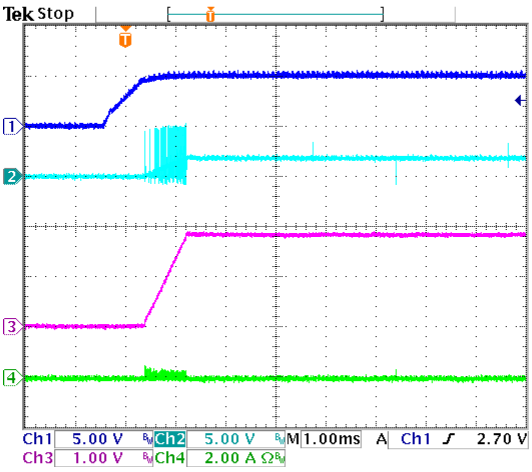
Fig. 6 Output Ripple (V_{IN}=5V, V_{OUT}=3.3V, I_{OUT}=1mA)



(CH1: V_{LX}, CH3: $V_{OUT(ac)}$, CH4: I_L)

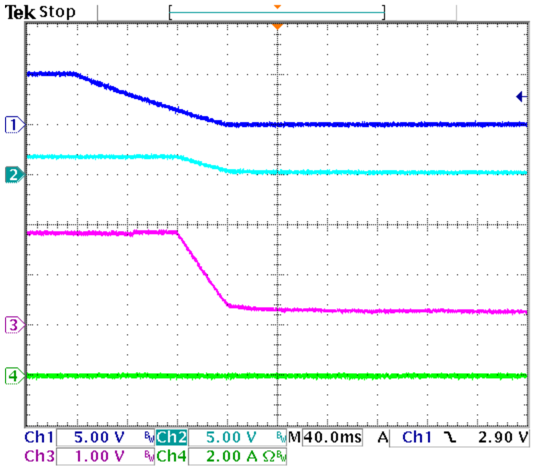
Fig. 7 Output Ripple (V_{IN}=5V, V_{OUT}=3.3V, I_{OUT}=2A)

TYPICAL PERFORMANCE CHARACTERISTICS (Continued)



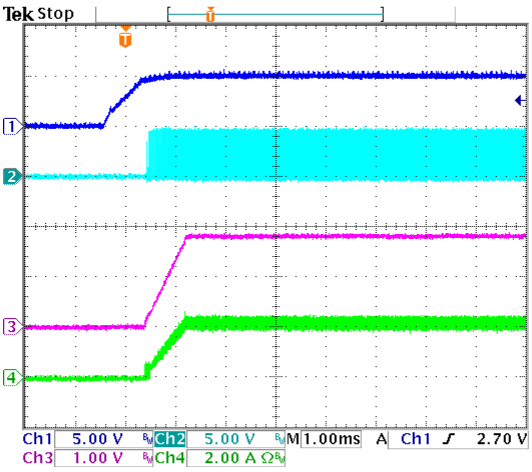
(CH1: V_{IN}, CH2: V_{LX}, CH3: V_{OUT}, CH4: I_L)

Fig. 8 V_{IN} Power On (V_{IN}=5V, V_{OUT}=1.8V, I_{OUT}=0A)



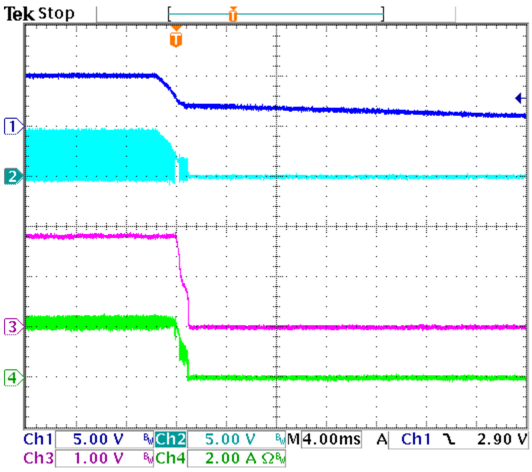
(CH1: V_{IN}, CH2: V_{LX}, CH3: V_{OUT}, CH4: I_L)

Fig. 9 V_{IN} Power Off (V_{IN}=5V, V_{OUT}=1.8V, I_{OUT}=0A)



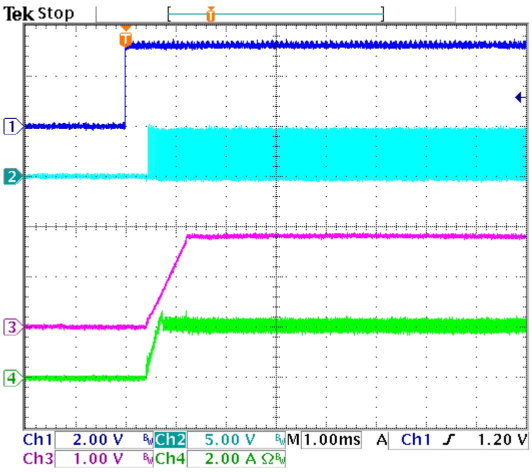
(CH1: V_{IN}, CH2: V_{LX}, CH3: V_{OUT}, CH4: I_L)

Fig. 10 V_{IN} Power On (V_{IN}=5V, V_{OUT}=1.8V, I_{OUT}=2A)



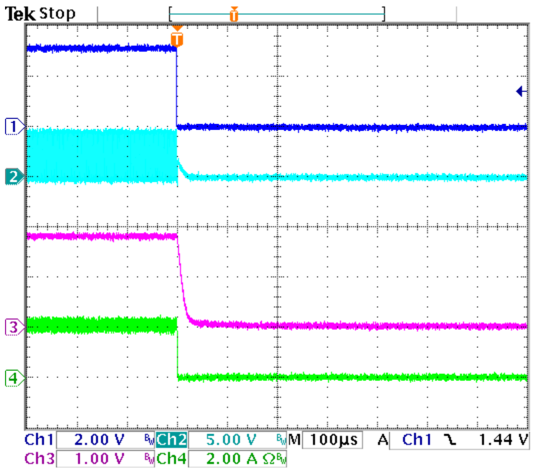
(CH1: V_{IN}, CH2: V_{LX}, CH3: V_{OUT}, CH4: I_L)

Fig. 11 V_{IN} Power Off (V_{IN}=5V, V_{OUT}=1.8V, I_{OUT}=2A)



(CH1: V_{EN}, CH2: V_{LX}, CH3: V_{OUT}, CH4: I_L)

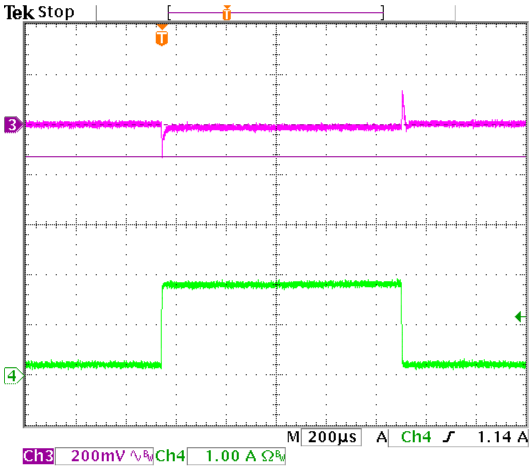
Fig. 12 Enable On (V_{IN}=5V, V_{OUT}=1.8V, I_{OUT}=2A)



(CH1: V_{EN}, CH2: V_{LX}, CH3: V_{OUT}, CH4: I_L)

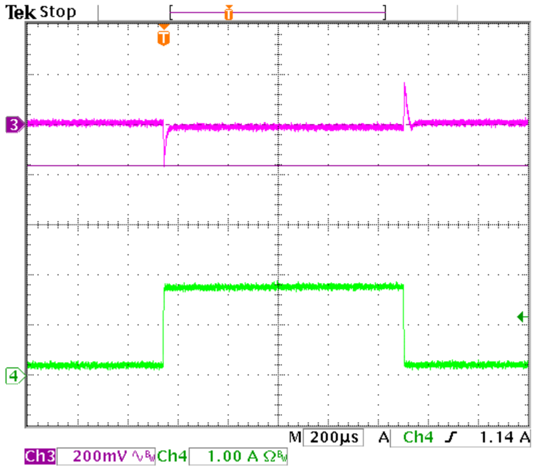
Fig. 13 Enable Off (V_{IN}=5V, V_{OUT}=1.8V, I_{OUT}=2A)

TYPICAL PERFORMANCE CHARACTERISTICS (Continued)



(CH3: $V_{OUT(ac)}$, CH4: I_{OUT})

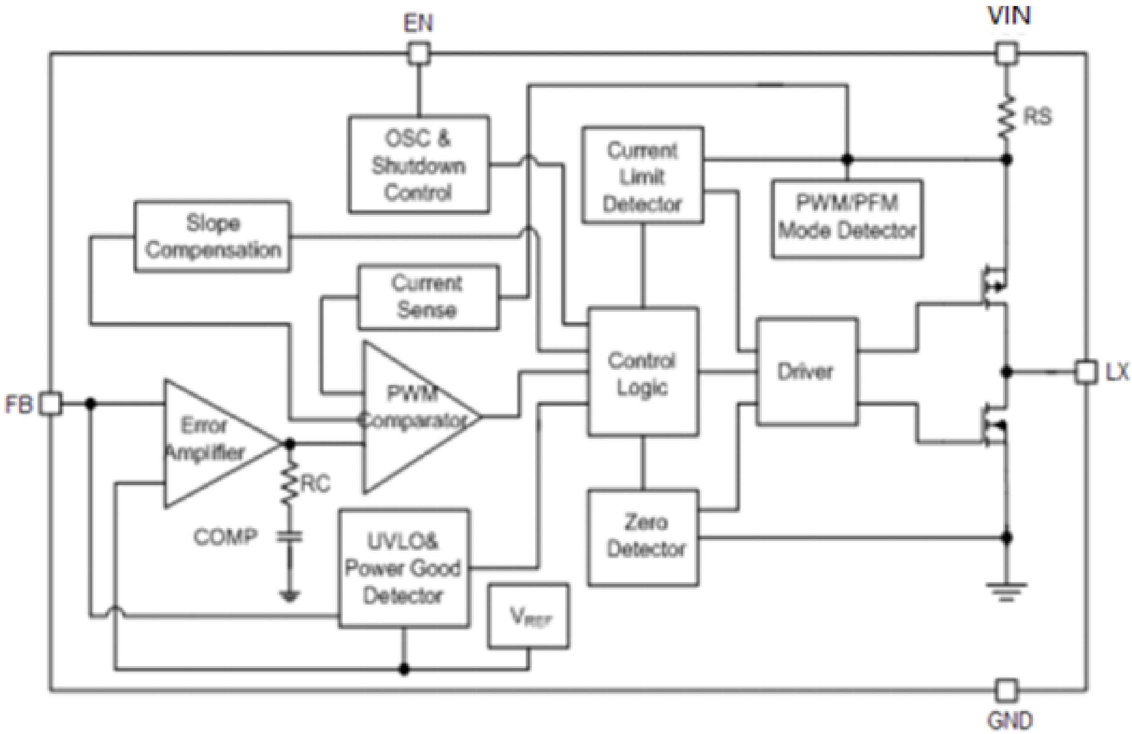
Fig. 14 Load Transient (V_{IN}=5V, V_{OUT}=1.8V, I_O=0.2-1.8A)



(CH3: $V_{OUT(ac)}$, CH4: I_{OUT})

Fig. 15 Load Transient (V_{IN}=5V, V_{OUT}=3.3V, I_O=0.2-1.8A)

BLOCK DIAGRAM



Functional Block Diagram of AIC2386B

PIN DESCRIPTIONS

Pin No.	Pin Name	Pin Function
1	EN	Chip Enable Pin. Drive EN above 1.5V to turn on the part. Drive EN below 0.3V to turn it off. Do not leave EN floating.
2	GND	Ground pin.
3	LX	Power Switch Output. It is the switch node connection to Inductor. This pin connects to the drains of the internal P-ch and N-ch MOSFET switches.
4	VIN	Power supply input pin.
5	FB	Output Voltage Feedback Pin.

APPLICATION INFORMATION

FUNCTION DESCRIPTION

The AIC2386B is a high output current monolithic switch mode step-down DC-DC converter. The device operates at a fixed 1.0MHz switching frequency, and uses a slope compensated current mode architecture.

This step-down DC-DC converter can supply up to 2A output current at V_{IN} = 5.0V and has an input voltage range from 2.3V to 6V. It minimizes external component size and optimizes efficiency at the heavy load range. The slope compensation allows the device to remain stable over a wider range of inductor values so that smaller values (2.2µH to 10µH) with lower DCR can be used to achieve higher efficiency. Only a small bypass input capacitor is required at the output.

The adjustable output voltage can be programmed with external feedback to any voltage, ranging from 0.6V to near the input voltage. It uses internal MOSFETs to achieve high efficiency and can generate very low output voltages by using an internal reference of 0.6V. At dropout operation, the converter duty cycle increases to 100% and the output voltage tracks the input voltage minus the low $R_{DS(ON)}$ drop of the P-channel high-side MOSFET and the inductor DCR. The internal error amplifier and compensation provides excellent transient response, load and line regulation. Internal soft start eliminates any output voltage overshoot when the enable or the input voltage is applied.

Setting the Output Voltage

Figure 1 shows the basic application circuit for the AIC2386B. The AIC2386B can be externally programmed. Resistors R_1 and R_2 in Figure 1 program the output to regulate at a voltage higher than 0.6V. To limit the bias current required for the external feedback resistor string while maintaining good noise immunity, the minimum suggested value for R_2 is 59kΩ. Although a larger value will further reduce quiescent current, it will also increase the impedance of the feedback node, making it more sensitive to external noise and interference.

The external resistor sets the output voltage according to the following equation:

$$V_{OUT} = 0.6 \times \left(1 + \frac{R_1}{R_2}\right)$$

$$R_1 = \left(\frac{V_{OUT}}{0.6} - 1\right) \times R_2$$

Inductor Selection

For most designs, the AIC2386B 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 result in lower ripple current and small value inductors result in high ripple current. For optimum voltage-positioning load transients, choose an inductor with DC series resistance in the 50mΩ to 150mΩ range.

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 should 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 22µF ceramic capacitor for most applications is sufficient. A large value may be used for improved input voltage filtering.

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 small temperature coefficients. The output ripple ΔV_{OUT} is determined by:

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

A 22µF ceramic can satisfy most applications.

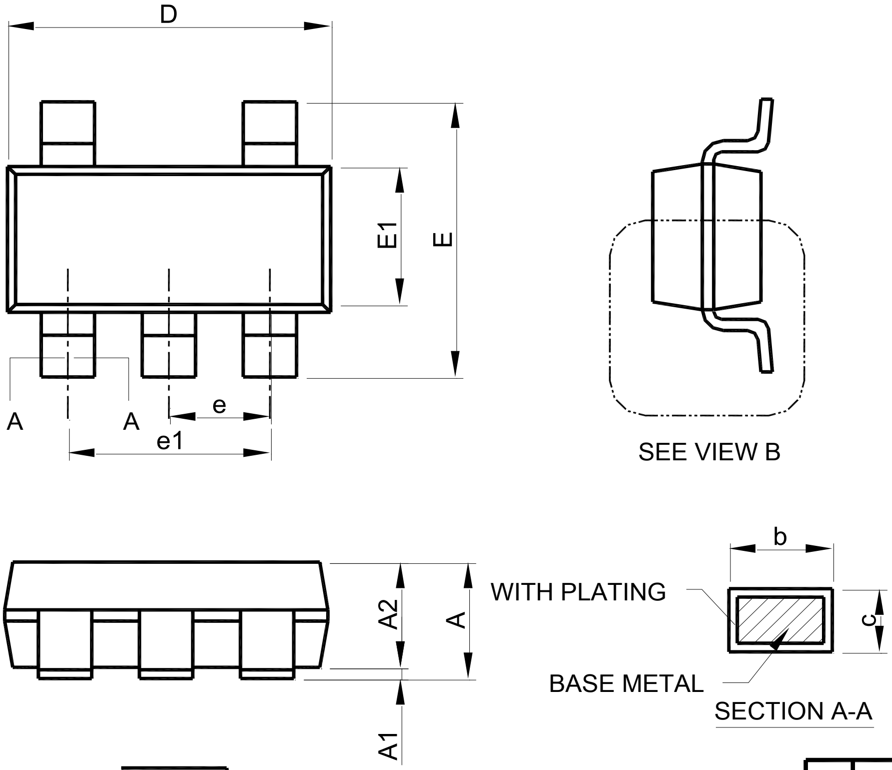
Layout Consideration

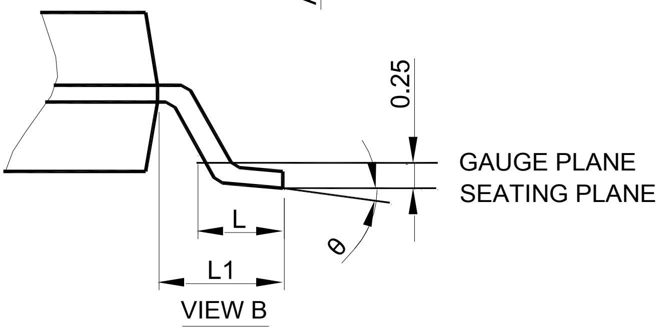
When laying out the printed circuit board, the following checking should be used to ensure proper operation of the AIC2386B. Check the following in your layout:

1. The power traces, consisting of the GND trace, the LX trace and the VIN trace should be kept short, direct and wide.
2. Does the (+) plates of C_{IN} connect to VIN pin as closely as possible. This capacitor provides the AC current to the internal power MOSFETs.
3. Keep the switching node, LX, away from the sensitive VOUT node.
4. Keep the (-) plates of C_{IN} and C_{OUT} as close as possible.

PHYSICAL DIMENSIONS

- **SOT23-5**





SYMBOL	SOT23-5	
	MILLIMETERS	
	MIN.	MAX.
A	0.95	1.45
A1	0.00	0.15
A2	0.90	1.30
b	0.30	0.50
c	0.08	0.22
D	2.80	3.00
E	2.60	3.00
E1	1.50	1.70
e	0.95 BSC	
e1	1.90 BSC	
L	0.30	0.60
L1	0.60 REF	
θ	0°	8°

Note : 1. Refer to JEDEC MO-178AA.
2. Dimension "D" does not include mold flash, protrusions or gate burrs. Mold flash, protrusion or gate burrs shall not exceed 10 mil per side.
3. Dimension "E1" does not include inter-lead flash or protrusions.
4. Controlling dimension is millimeter, converted inch dimensions are not necessarily exact.