2.5MHz 5V 5A Fast PWM Synchronous Step-Down Converter

FEATURES

- Wide Input Range from 2.7V to 6V
- Continuous 5A Output Current, Peak up to 6A
- High Efficiency up to 97%
- Output Voltage as low as 0.8V
- 100% Duty Cycle Operation
- +/-1% 0.8V Feedback Voltage Accuracy
- 2.5MHz Pseudo Constant Switching Frequency
- 17µA Quiescent Current
- Built-in 30mΩ HS and 25mΩ LS Power Switches
- Cycle-by-cycle Current Limit Protection
- Hiccup Mode for Short Circuit and Over-Load Protection
- Open Drain Power Good Indication with Internal Pull-up Resistor
- Thermal Shutdown Protection
- Stable with low ESR ceramic Output Capacitors
- Available in a Small DFN-7 (2mmx2mm) Package

DESCRIPTION

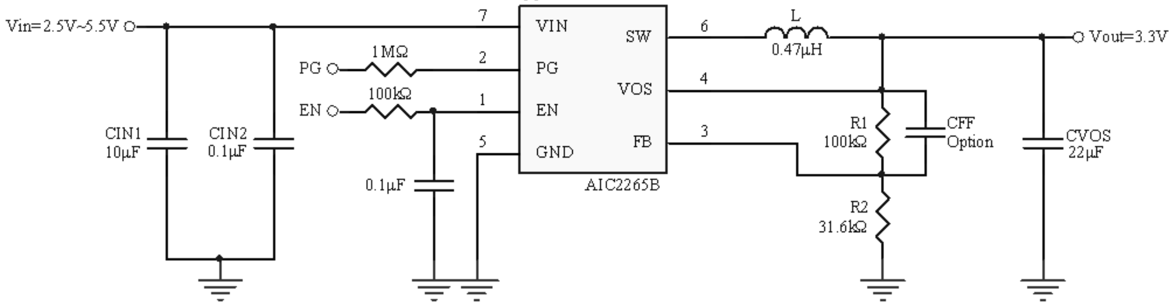
The AIC2265B is a 5A high efficiency constant on-time controlled synchronous step-down converter. It operates with input voltage from 2.5V to 6V and provides output range from 0.8V to as high as input level, thanks to its 100% duty cycle operation. Its advanced constant on-time control Fast-PWM scheme simplifies loop compensation and offers excellent load transient response while maintaining a relatively constant 2.5MHz switching frequency. AIC2265B consumes extremely low 17µA quiescent current hence achieves superior light load efficiency. The high gain error amplifier in the control loop provides excellent load and line regulation. For fault tolerant operation, AIC2265B has cycle-by-cycle current limit protection and hiccup mode for short circuit or over-load condition.

AIC2265B is available in DFN-7 (2mmx2mm) package and ideal for high performance, portable applications.

APPLICATIONS

- Solid-State and Hard Disk Drives
- Portable / Handheld Devices
- WiFi Moudule/ Set-top Boxes
- DC/DC Micro Modules

APPLICATIONS CIRCUIT



Typical Application Circuit

ORDERING INFORMATION

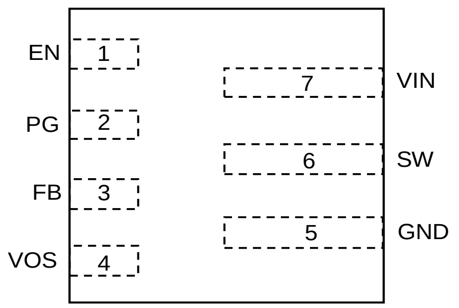
AIC2265B X XXX XX

- PACKING TYPE
  TR: TAPE & REEL
  BG: BAG
- PACKAGE TYPE
  D7A: DFN-7 (2x2)
- G: Green Package

Example: AIC2265BGD7ATR
→ in DFN-7 (2x2) Green Package and Tape & Reel Packing Type

PIN CONFIGURATION

DFN-7 (2x2)
TOP VIEW



- **Marking**

(Y: Year, WW: Week)

Part No.	Marking
AIC2265BGD7A	YWxx

ABSOLUTE MAXIMUM RATINGS

SW Pin Voltage .... -0.5 V to V_{IN}+1V
Dynamic V_{SW} in 10ns Duration .... -2V to V_{IN}+2V
VIN Pin Voltage .... -0.3 V to 6.5V
EN Pin, VOS Pin, FB Pin and PG Pin Voltage .... -0.3 V to 6V
Junction Temperature T_J .... -40°C to 150°C
Storage Temperature Range T_{STG} .... -65°C to 150°C
Lead Temperature (Soldering 10 Sec.) .... 260°C
Operating Ambient Temperature Range T_A .... -40°C to 85°C
Thermal Resistance Junction to Case (θ_{JC}) DFN-7 (2mmx2mm)* .... 27.3°C/W
Thermal Resistance Junction to Ambient (θ_{JA}) DFN-7 (2mmx2mm)* .... 69.7°C/W
Maximum Power Dissipation (T_A=25°C) (Note 3) DFN-7 (2mmx2mm)* 1.4W
(Assume no Ambient Airflow, no Heat sink)

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

* Measured on JESD51-7, 4-Layer PCB.

ELECTRICAL CHARACTERISTICS

(T_A = 25°C, V_{IN}=5V, unless otherwise specified. Typical values are at V_{BAT} = V_{EN} = 3.6V and V_{OUT} = 5V.) (Note 1)

PARAMETER	CONDITIONS	SYMBOL	MIN	TYP	MAX	UNITS
Input Voltage Range		V_{IN}	2.7		6	V
Shutdown Current	V_{EN} = 0V, V_{IN} = 5.5V			0.1	5	µA
Input Under Voltage Lockout Threshold	V_{IN} Increasing			2.4		V
Input Under Voltage Lockout Hysteresis				280		mV
Input Over Voltage Lockout Threshold	V_{IN} Increasing			6.5		V
Input Over Voltage Lockout Hysteresis				500		mV
Output Over-voltage Protection	V_{FB} with ramp to over voltage			+20		%
Quiescent Current	V_{FB} = 0.63V	I_Q		17		µA
Feedback Voltage		V_{FB}	792	800	808	mV
Feedback Current		I_{FB}		1		nA
HS Switch Current Limit				8		A
HS Switch On Resistance				30		mΩ
LS Switch On Resistance				25		mΩ
HS Leakage Current	V_{IN} = 5.5V, V_{EN} = V_{SW}= 0V			0.1	10	µA
LS Leakage Current	V_{IN} = V_{SW}= 5.5V, V_{EN} = 0V			0.1	10	µA
On-time for HS Switch	V_{IN} = 5V, V_{OUT} = 1.2V			95		ns
	V_{IN} = 5V, V_{OUT} = 3.3V			265		ns
PGOOD Output Low Voltage	V_{FB} =0.5V,sink 1mA			0.2	0.3	V
PGOOD Output Leakage Current	V_{FB} =0.63V , V_{PGOOD} = V_{IN} = 5.5V			10	100	nA
PGOOD Under Voltage Rise Threshold	V_{FB} with ramp up from under voltage		-12	-10	-8	%
PGOOD Under Voltage Fall Threshold	V_{FB} ramp down from regulation			-15		%
PGOOD Delay	PGOOD going High to Low			30		µs

ELECTRICAL CHARACTERISTICS (Continued)

PARAMETER	CONDITIONS	SYMBOL	MIN	TYP	MAX	UNITS
EN On Threshold				1.21		V
EN Off Threshold				1.10		V
EN Internal Pull Down Resistor				1		MΩ
Thermal Shutdown				160		°C
Thermal Shutdown Hysteresis				30		°C

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: The device is not guaranteed to function outside of the recommended operating conditions.

Note 3: The maximum allowable power dissipation is a function of the maximum junction temperature T_{J_MAX}, the junction to ambient thermal resistance θ_{JA}, and the ambient temperature T_A. The maximum allowable continuous power dissipation at any ambient temperature is calculated by $P_{D\_MAX}=(T_{J\_MAX}-T_A)/\theta_{JA}$. Exceeding the maximum allowable power dissipation will cause excessive die temperature, and the regulator will go into thermal shutdown. Internal thermal shutdown circuitry protects the device from permanent damage.

TYPICAL PERFORMANCE CHARACTERISTICS

(C_{IN}=10µF+0.1µF,C=22µF, L=0.47µH, T_A =25°C)

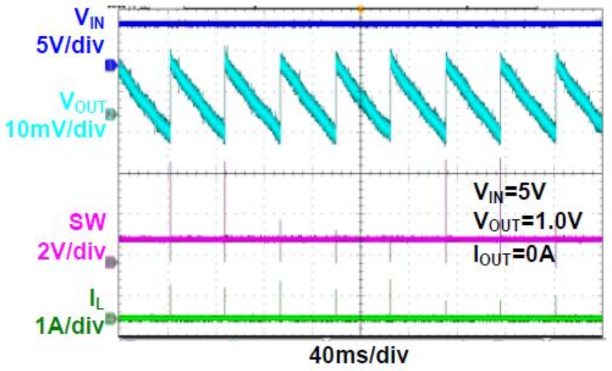


Fig. 1 Steady State Test

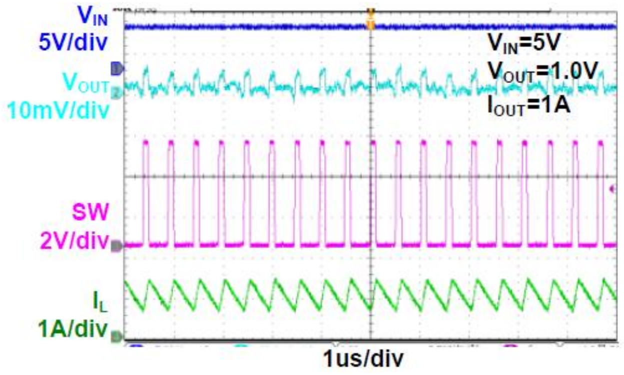


Fig. 2 Steady State Test

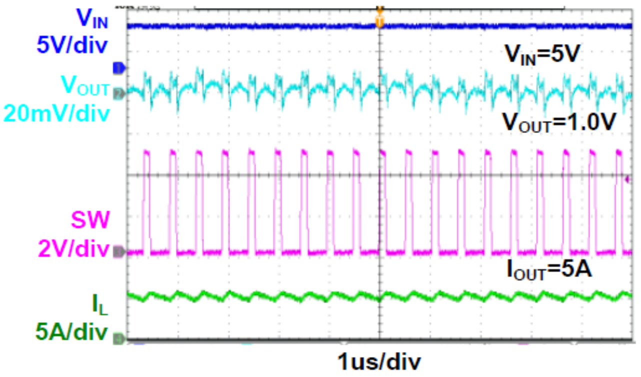


Fig. 3 Steady State Test

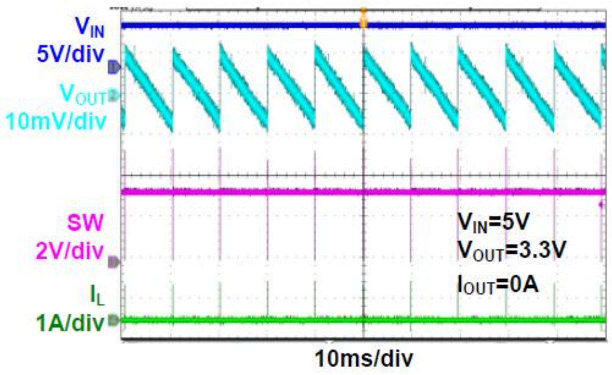


Fig. 4 Steady State Test

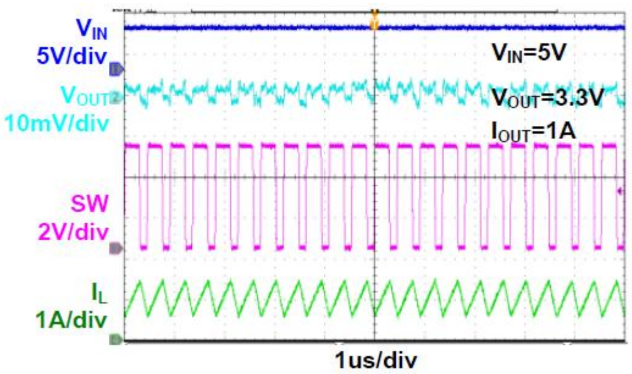


Fig. 5 Steady State Test

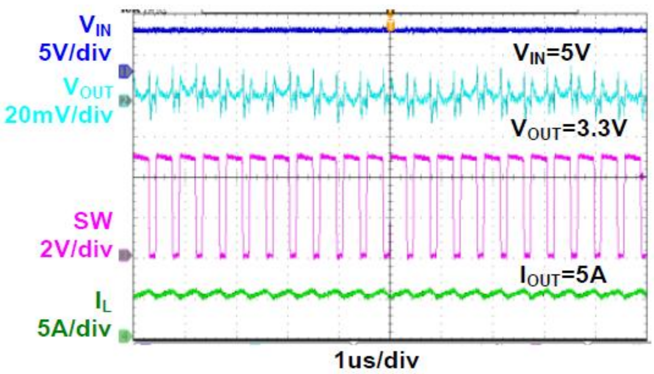


Fig. 6 Steady State Test

■ TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(C_{IN}=10µF+0.1µF,C=22µF, L=0.47µH, T_A =25°C)

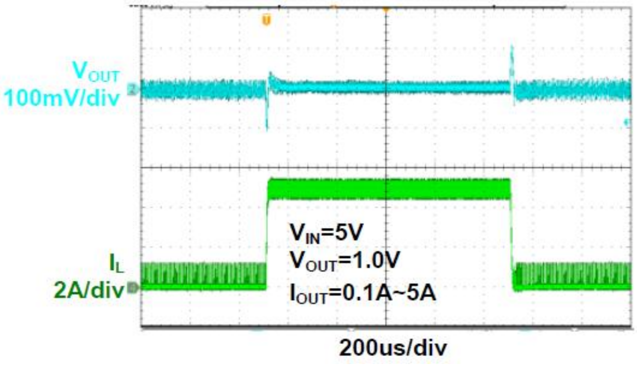


Fig. 7 Load Transient Response

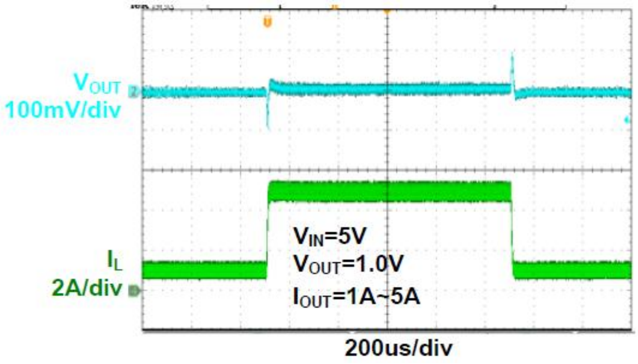


Fig. 8 Load Transient Response

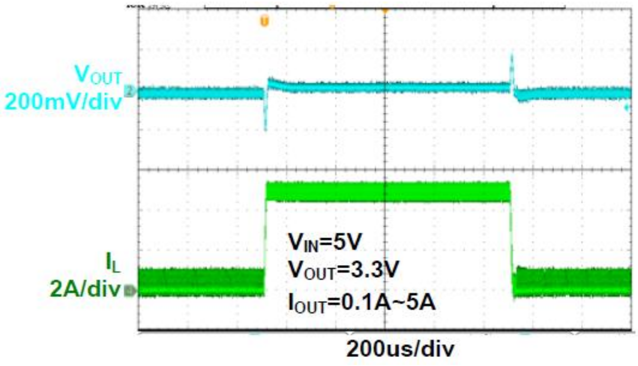


Fig. 9 Load Transient Response

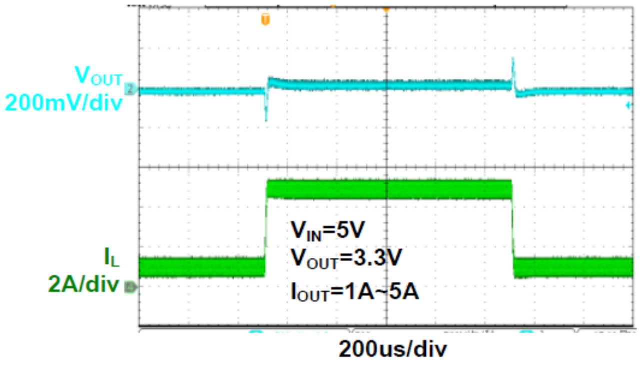


Fig. 10 Load Transient Response

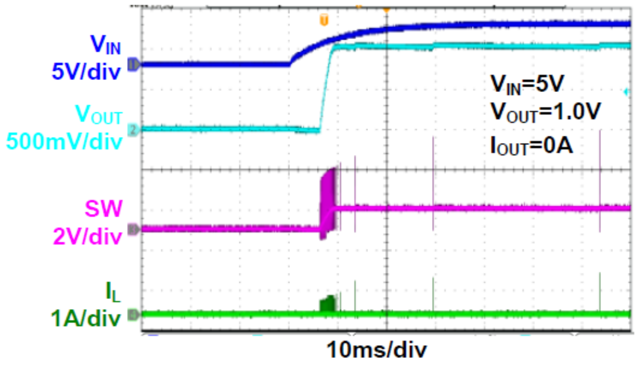


Fig. 11 V_{IN} Power On

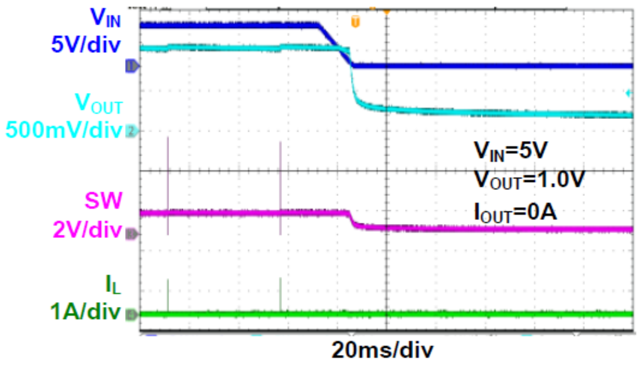


Fig. 12 V_{IN} Power Off

■ TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(C_{IN}=10μF+0.1μF,C=22μF, L=0.47μH, T_A =25°C)

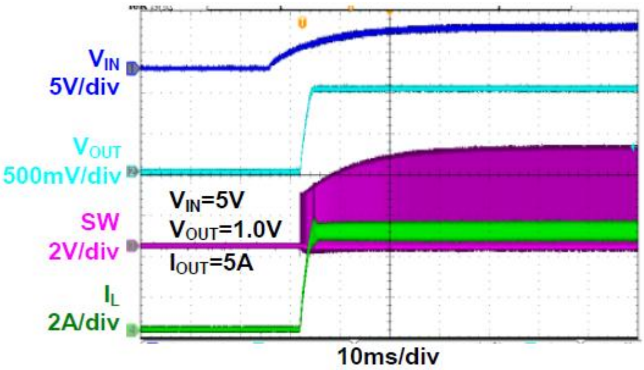


Fig. 13 V_{IN} Power On

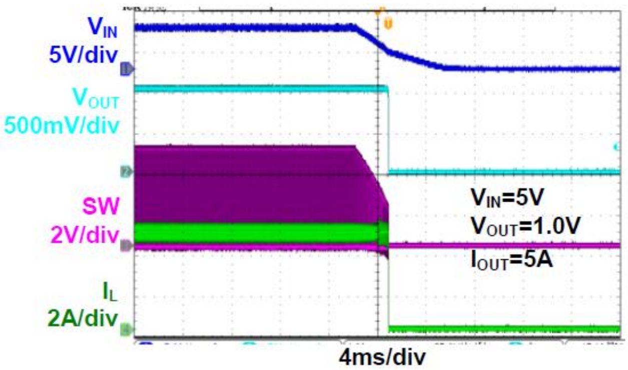


Fig. 14 V_{IN} Power Off

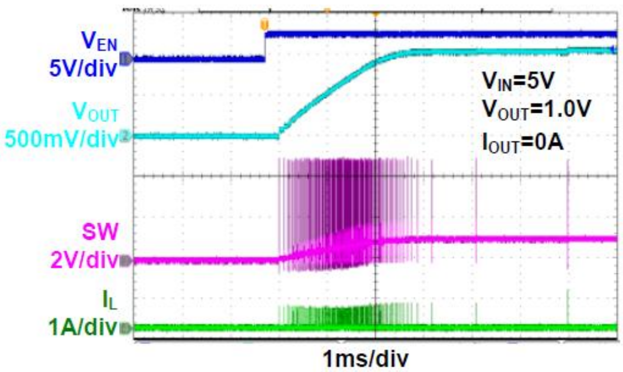


Fig. 15 EN On

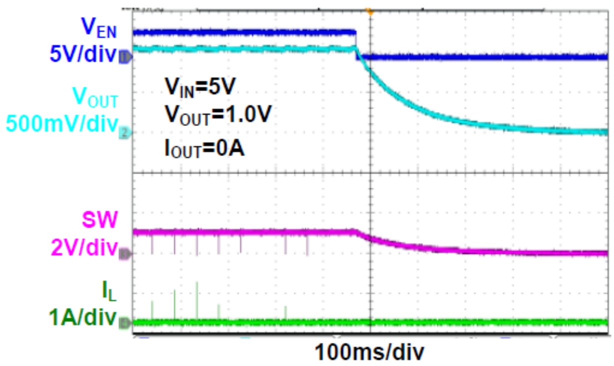


Fig. 16 EN Off

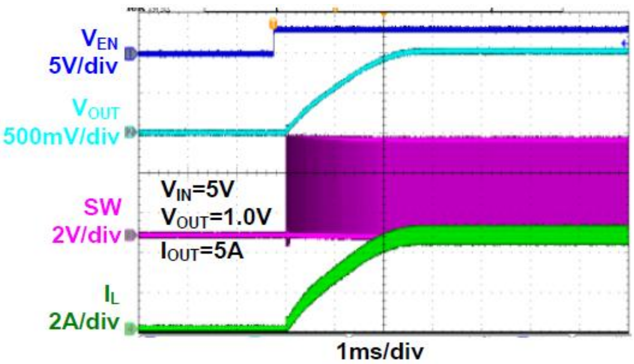


Fig. 17 EN On

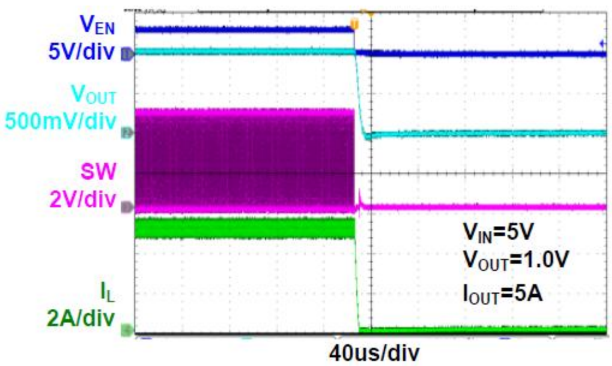


Fig. 18 EN Off

■ TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

(C_{IN}=10μF+0.1μF,C=22μF, L=0.47μH, T_A =25°C)

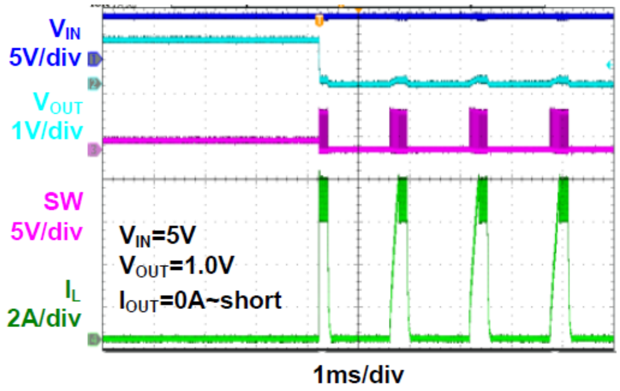


Fig. 19 Short Circuit Entry

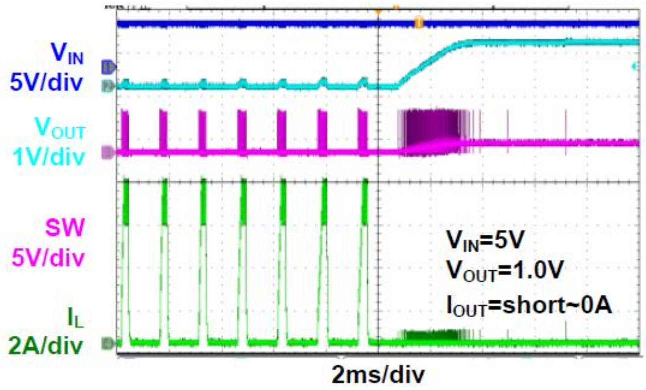


Fig. 20 Short Circuit Recovery

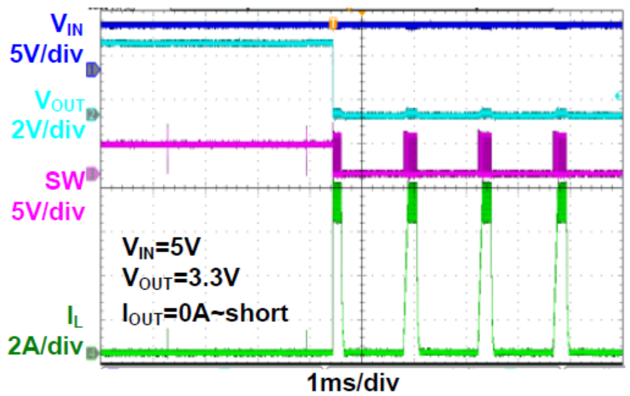


Fig. 21 Short Circuit Entry

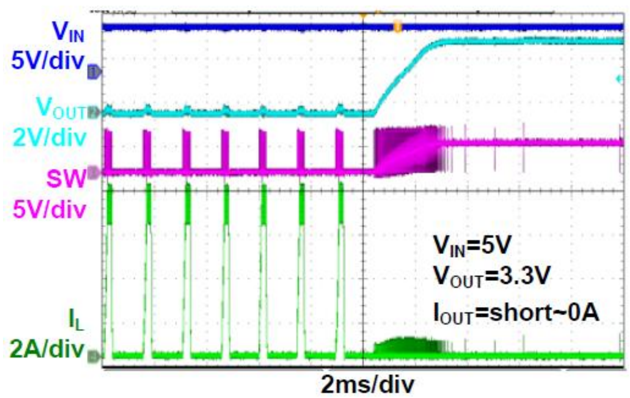


Fig. 22 Short Circuit Recovery

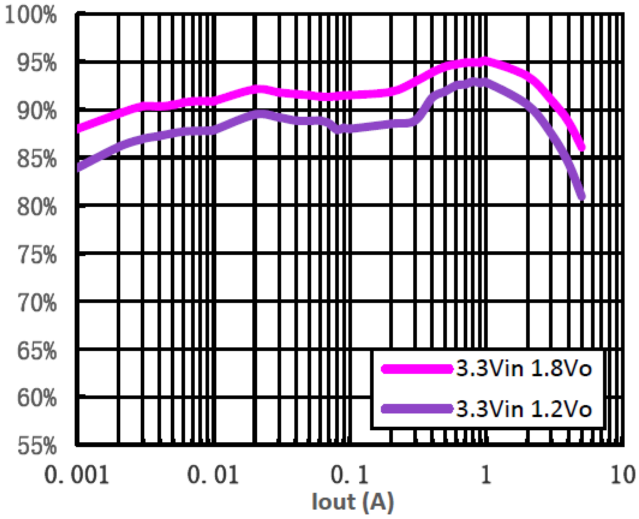


Fig. 23 Efficiency

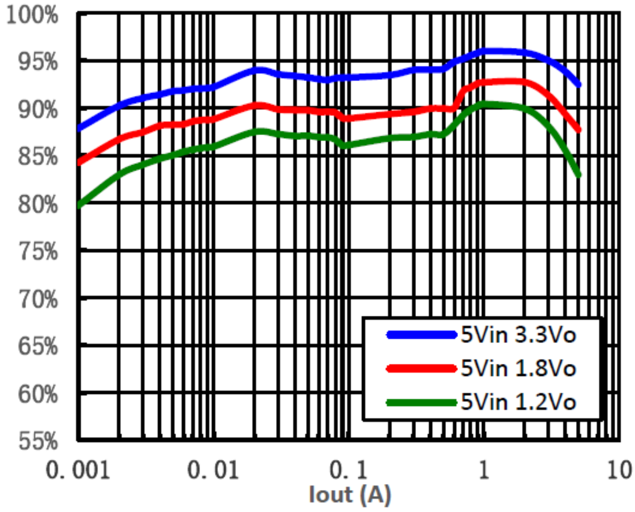
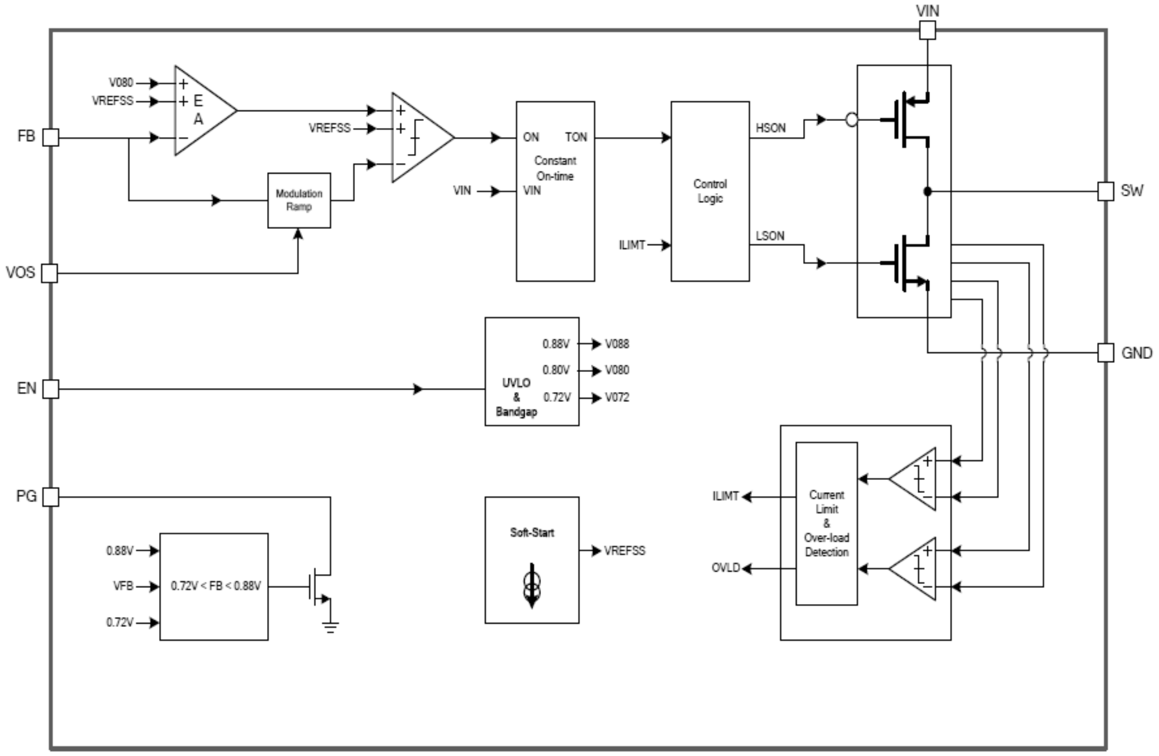


Fig. 24 Efficiency

BLOCK DIAGRAM



Functional Block Diagram of AIC2265B

PIN DESCRIPTIONS

Pin No.	Pin Name	Pin Function
1	EN	Enable input integrated a 1MΩ pull down resistor. Enable Control Input with accurate 1.21V enable threshold which can be used to build precision R-C turn-on delay and input under-voltage lockout. EN pin has an internal 1MΩ pull-down resistor to AGND. Drive EN above 1.21V to turn on the converter. Drive EN below 1.11V to turn off the converter and discharge output (Optional).
2	PG	Power Good Open-drain Output. Connect a 100kΩ pull-up resistor to V_{IN} or V_{OUT}.
3	FB	Feedback voltage input connects to external feedback resistors.
4	VOS	Output voltage sense pin. This pin must be directly connected to the output capacitor.
5	GND	Analog ground and LS switch Power ground.
6	SW	Switching pin, connect to the external inductor.
7	VIN	Analog input supply voltage and HS Switch input Supply voltage.

APPLICATION INFORMATION

Operation

AIC2265B is a constant on-time controlled synchronous step-down converter that offers excellent transient response over a wide range of input voltage. It achieves superior light-load efficiency with extremely low quiescent current.

Fast-PWM Constant On-Time Control

AIC2265B employs advanced constant on-time control (Fast-PWM) to achieve superior transient response. The Fast-PWM constant on-time control turns on HS immediately when FB droops below reference. The HS is turned on for a pre-determined period (on-time) to ramp up the inductor current, and then the LS will be turned on to ramp down the inductor current. The cycle repeats itself if FB droops below reference again. AIC2265B uses adaptive on-time based on input and output voltage level to achieve a relatively constant switching frequency. The on-time can be estimated as:

$$T_{ON} = \frac{V_{OUT}}{V_{IN}} \cdot 0.4\mu$$

Due to its immediate response on FB voltage droop and simplified loop compensation, Fast-PWM constant on-time offers a superior transient response compare to traditional fixed frequency PWM control step-down converters.

Light Load Operation

In light load condition where the switcher operates in discontinuous mode, AIC2265B cuts down its quiescent current to as low as 17µA, thus achieve excellent light load efficiency.

Enable

When input voltage is above the under voltage lock-out threshold, AIC2265B can be enabled by pulling the EN pin to above 1V. AIC2265B will be disabled if the EN pin is kept below 0.5V.

Internal Soft Start

AIC2265B has built-in 2.5ms soft-start timer. During the soft start period, output voltage is ramped up linearly to the regulation voltage, independent of the load current level and output capacitor value.

Current Limit and Hiccup Mode

AIC2265B has cycle-by-cycle HS current limit protection to prevent inductor current from running away. Once HS current limit is triggered, AIC2265B will turn on LS and wait for the inductor to drop down to a pre-determined level before the HS can be turned on again. If this current limit condition is repeated for a sustained long period of time, AIC2265B will consider it as over-load or short circuit. Either way, AIC2265B will enter hiccup mode, where it stop switching for a pre-determined period of time before automatically re-try to start up again. It always starts up with soft-start to limit inrush current and avoid output overshoot.

Power Good Indication

AIC2265B has open drain PG indicator with internal 1MΩ pull-up resistor to input voltage. PG will be pulled up if output voltage is within +/-10% of regulation, otherwise PG is pulled down by the internal NMOS.

Setting the Output Voltage

External feedback resistors are used to set the output voltage. Refer to typical application circuit on page 1, the bottom feedback resistor R2 has some impact on the loop stability, so its recommended range is below 100kΩ. For any chosen R2, the top feedback resistor R1 can be calculated as:

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

$$R_1 = R_2 \cdot \left(\frac{V_{OUT}}{0.8} - 1 \right)$$

Inductor Selection

The recommended inductor value for AIC2265B is between 0.47µH to 4.7µH. Usually the inductor value is chosen to satisfy a desired ripple current:

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

Where ΔI is the inductor ripple current.

With the chosen ΔI , the peak inductor current will be:

$$I_{PK} = I_{LOAD} + \frac{1}{2} \cdot \Delta I$$

Input Bypass Capacitor Selection

The input current to the step-down converter is discontinuous with very sharp edges, therefore an input bypass capacitor is required. For best performance, it's recommended to use low ESR ceramic capacitors and place them as close to the input pin as possible. For lowest temperature variations, use X5R or X7R dielectric ceramic capacitors. The RMS current of the input capacitor is approximately:

$$I_{CIN\_RMS} = I_{OUT} \sqrt{D(1 - D)}$$

From the equation, it can be seen that the highest RMS current occurs when D is 0.5:

$$I_{CIN\_RMS} = \frac{1}{2} I_{OUT}$$

Choose the capacitor with RMS current rating higher than 1/2 I_{OUT}. The power dissipation on the input capacitor can be estimated with the RMS current and the ESR resistor.

Electrolytic or tantalum capacitors can also be used, but due to their significantly higher ESR, a small size ceramic capacitor should be placed as close to the IC as possible.

The voltage ripple on the input capacitor, neglecting the ESR impact, can be calculated as:

$$\Delta V_{CIN} = \frac{I_{LOAD}}{f_{SW} \cdot C_{IN}} \cdot \frac{V_{OUT}}{V_{IN}} \cdot \left(1 - \frac{V_{OUT}}{V_{IN}} \right)$$

Output Capacitor Selection

An output capacitor is required to obtain a stable output voltage. To minimize the output voltage ripple, ceramic capacitors should be used, and the ripple voltage can be estimated as:

$$\Delta V_{OUT} = \frac{1}{8} \cdot \left(1 - \frac{V_{OUT}}{V_{IN}} \right) \cdot \frac{V_{OUT}}{L} \cdot \frac{1}{(f_{SW})^2 \cdot C_{OUT}}$$

If electrolytic or tantalum capacitors are used, the ESR will dominate the output voltage ripple:

$$\Delta V_{OUT} = \left(1 - \frac{V_{OUT}}{V_{IN}} \right) \cdot \frac{V_{OUT}}{f_{SW} \cdot L} \cdot R_{ESR}$$

PCB Layout Recommendation

Proper layout and component placement are very important, and sometimes critical for the step-down converters. The PCB can radiate excessive noise and contribute to converter instability with improper layout.

Certain points must be considered before starting a layout using the AIC2265B.

1. Use wide trace for the high current paths, the traces of the high current paths as short and wide as possible.
2. Place the input capacitor C_{IN} close to PVIN and PGND, so the total PCM trace from the pins to C_{IN} capacitor is minimized.
3. SW pin and the trace will be the most noisy signal on the board, so proper isolation between SW from FB is essential, SW node encounters high frequency voltage swings so it should be kept in a small area.
4. Ensure all feedback network connections are short and direct. Place the feedback network as close to the chip as possible.
5. Components away from the SW node to prevent

stray capacitive noise pick-up.

6. The GND pin and Exposed Pad should be connected to a strong ground plane for heat sinking and noise protection.
7. An example of PCB layout guide is shown in below Figure for reference.

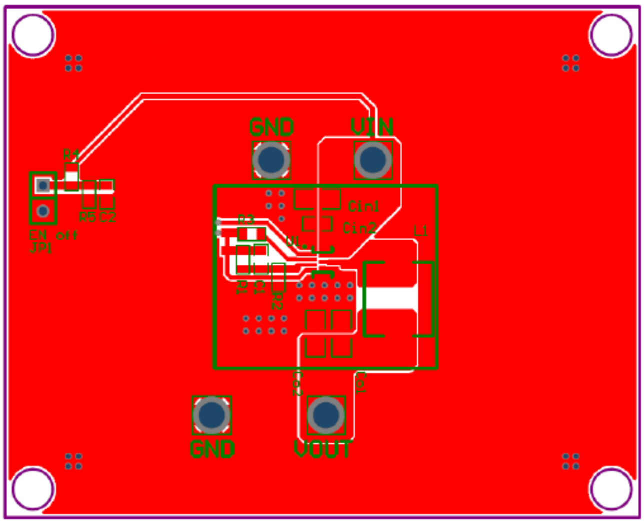


Fig. 25 Top Layer

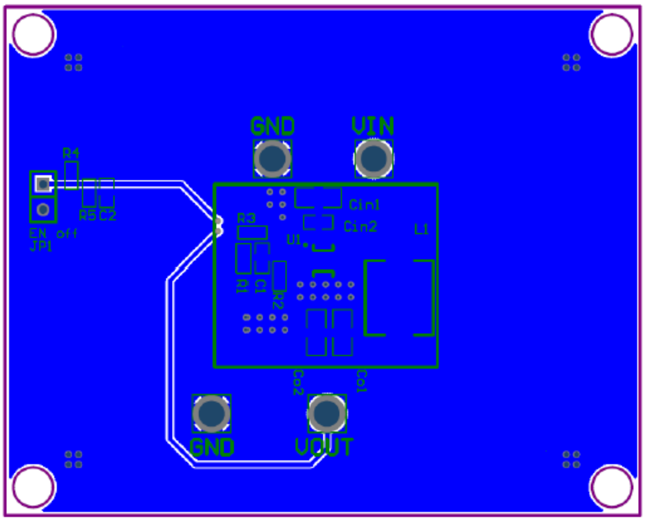


Fig. 26 Bottom Layer

APPLICATION EXAMPLES

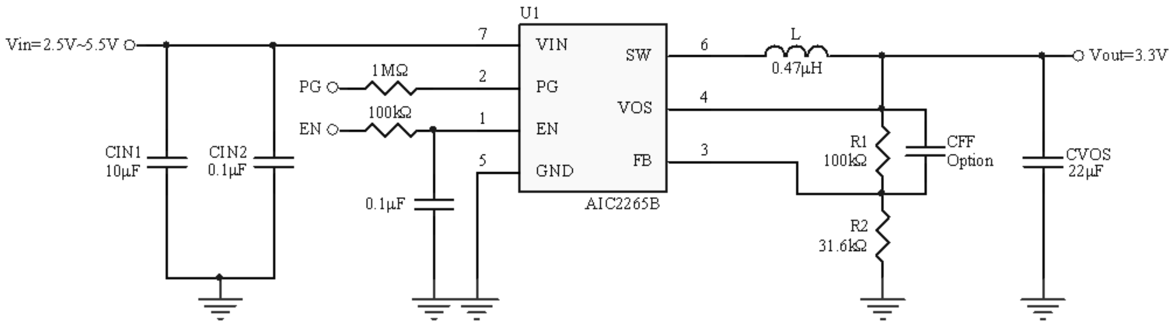


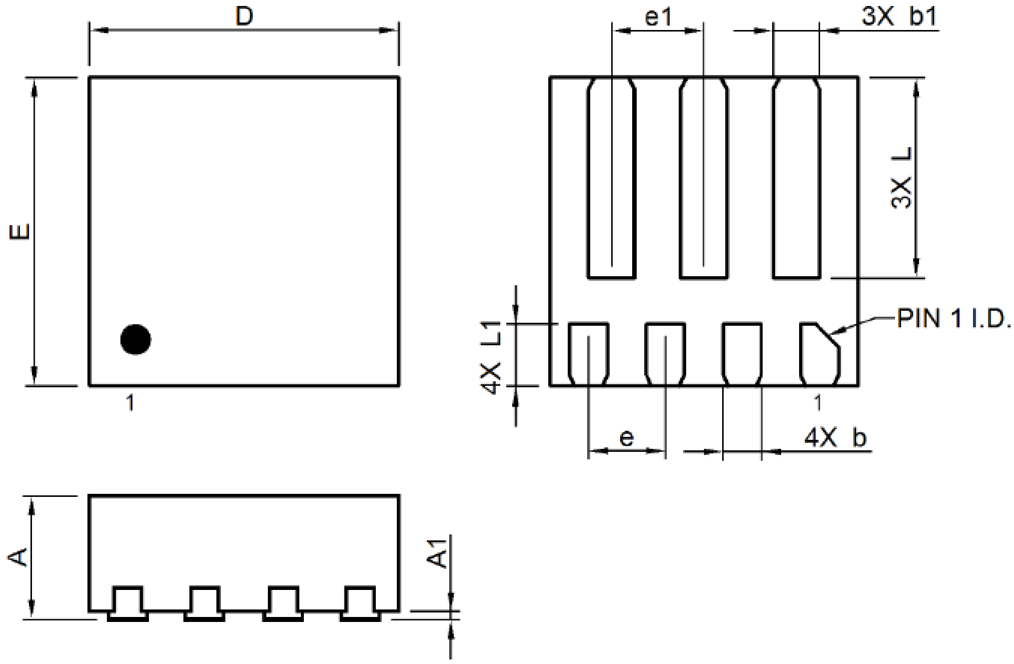
Fig. 27 AIC2265B Application Circuit

Table 1 BOM List

Ref	Value		Description	Package	Qty
C_{IN1}	10µF		Ceramic Capacitor, 10V, X5R	0805	1
C_{IN2}	0.1µF		Ceramic Capacitor, 10V, X5R	0603	1
C_{VOS}	22µF		Ceramic Capacitor, 10V, X5R	0805	1
R_{pg}	1MΩ		Resistor, ±1%	0603	1
L	0.47µH		Inductor:MPCA-0630-R47-M, 4.13mohm	SMD	1
R1	V_{OUT}=3.3V	100kΩ	Resistor, ±1%	0603	1
	V_{OUT}=1.8V	37.4kΩ	Resistor, ±1%	0603	
	V_{OUT}=1.2V	15kΩ	Resistor, ±1%	0603	
	V_{OUT}=1.0V	7.5kΩ	Resistor, ±1%	0603	
R2	V_{OUT}=3.3V	31.6kΩ	Resistor, ±1%	0603	1
	V_{OUT}=1.8V	30kΩ	Resistor, ±1%	0603	
	V_{OUT}=1.2V	30kΩ	Resistor, ±1%	0603	
	V_{OUT}=1.0V	30kΩ	Resistor, ±1%	0603	
U1	AIC2265B		Step-Down DC/DC Converter	DFN-7 (2mmx2mm)	1

PHYSICAL DIMENSIONS

- **DFN-7 (2mmx2mm)**



SYMBOLS	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A	0.70	0.80	0.028	0.031
A1	0.00	0.05	0.000	0.002
b	0.25	0.35	0.010	0.014
b1	0.20	0.30	0.008	0.012
D	1.90	2.10	0.075	0.083
E	1.90	2.10	0.075	0.083
L	1.25	1.35	0.049	0.053
L1	0.35	0.45	0.014	0.018
e	0.50 BSC		0.020 BSC	
e1	0.60 BSC		0.024 BSC	