

June 2008

## AAT1346A/B/C

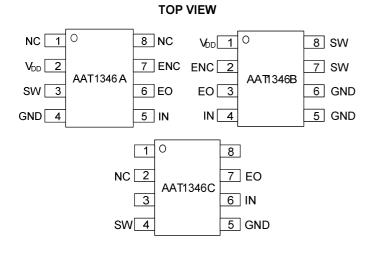
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# 2A 15V Step-Down DC-DC Converter

## FEATURES

- Buck PWM with Internal PMOS
- 4.5V to 15.0V Input Voltage Range
- Max. 2A Output Current
- Under-Voltage Lockout (UVLO) Protection
- Internal Short Circuit and Thermal Protection
- Internal Soft-Start
- Fixed Switching Frequency (380kHz / 47kHz)
- 2µA Shutdown Current
- SOP- 8 Package

# **PIN CONFIGURATION**



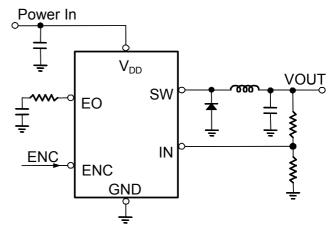
## **GENERAL DESCRIPTION**

The AAT1346A/B/C is a 2A 15V step-down converter, which provides an integrated one-channel PWM solution for the power supply of DC-DC system. It offers system engineers the flexibility to tailor-make the power supply circuitry for specific applications.

The buck PWM contains enable control signal, error amplifier, PWM comparator, output driver, under-voltage protection, oscillator, short circuit protection and voltage reference circuit.

The AAT1346A/B/C contains one buck current mode PWM with internal PMOS. In addition, a digital soft-start is also included to prevent inrush current at startup. AAT1346A/B/C comes with a fixed 380kHz oscillator, however, when the feedback voltage is lower than 0.7V, the switching frequency changes to 47kHz and returns to 380kHz after the short-circuit is released.

# **TYPICAL APPLICATION**



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# **ORDERING INFORMATION**

DEVICE TYPE	PART NUMBER	PACKAGE	PACKING	TEMP. RANGE	MARKING	MARKING DESCRIPTION
AAT1346A	AAT1346A-S-T	S:SOP8	T: Tape and reel	$-40^{\circ}\text{C}$ to +85 $^{\circ}\text{C}$	AAT1346A XXXXXX	Device Type Lot no.(6~9Digits)
AAT1346B	AAT1346B-S-T	S:SOP8	T: Tape and reel	−40 °C to +85 °C	AAT1346B XXXXXX	Device Type Lot no.(6~9Digits)
AAT1346C	AAT1346C-S-T	S:SOP8	T: Tape and reel	−40 °C to +85 °C	AAT1346C XXXXXX	Device Type Lot no.(6~9Digits)

NOTE: All AAT products are lead free and halogen free.

# **ABSOLUTE MAXIMUM RATINGS**

PARAMETER	SYMBOL	VALUE	UNIT
Supply Voltage (V <sub>DD</sub> , SW)	V <sub>DD</sub>	-0.3 to 15.0	V
Pin Voltage (IN, ENC, EO)	VI	–0.3 to(V <sub>DD</sub> +0.3)	V
SW Current	I <sub>SW</sub>	6.5	А
Operating Temperature Range	Т <sub>С</sub>	–40 °C to +85 °C	°C
Storage Temperature Range	T <sub>storage</sub>	–65 °C to +150 °C	°C



# **ELECTRICAL CHARACTERISTICS**

(  $T_C$  =25  $^\circ C$  ,  $~V_{DD}\,$  = 12V, Unless Otherwise Specified)

### **GENERAL ITEM**

PARAMETER	SYMBOL	TEST CONDITION	MIN	ТҮР	МАХ	UNIT
Input Voltage Range	V <sub>DD</sub>		4.50		15.0	V
Under Voltage Lockout	V <sub>UVLO</sub>	V <sub>DD</sub> Falling	3.33	3.48	3.63	V
Under Voltage Lockout Hysteresis	V <sub>UHYS</sub>			150		mV
Input Current into V <sub>DD</sub>	I <sub>DD_OFF</sub>	V <sub>IN</sub> = 1.5V		1		mA
	I <sub>DD_ON</sub>	V <sub>IN</sub> = 1.0V		5.5		mA
Shutdown Current into V <sub>DD</sub>	I <sub>SHDN</sub>			1.70	10.0	μA
	fosc	Normal Operation		380		kHz
OSC Frequency		Short-Circuit		47.5		kHz
Short Detection Voltage	V <sub>SHORT</sub>	V <sub>IN</sub> Falling	0.67	0.70	0.73	V
EN Low Level	V <sub>IL</sub>				0.4	V
EN High Level	V <sub>IH</sub>		1.6			V
Thermal Shutdown	T <sub>SHDN</sub>			160		°C

#### **BUCK PWM**

PARAMETER	SYMBOL	TEST CONDITION	MIN	ТҮР	МАХ	UNIT
IN Regulation Voltage	V <sub>IN</sub>	IN=EO	1.209	1.222	1.235	V
IN to EO Transconductance	G <sub>m</sub>	IN=EO	35	80	125	μS
Maximum Duty Cycle				90		%
IN Input Leakage Current	μ	IN=0V to 1.5V	-100	0.01	+100	nA
Current-Sense Amplifier Transresistance	R <sub>CS</sub>			0.2		V/A
SW Leakage Current	I <sub>LSW</sub>	$V_{SW} = 15V$		0.1	5.0	μA
Switch On-Resistance	R <sub>ON</sub>			200		mΩ
SW Current Limit	I <sub>LIMIT</sub>		2.5	3.7		А
Soft-Start Time	t <sub>SS</sub>			700		μs

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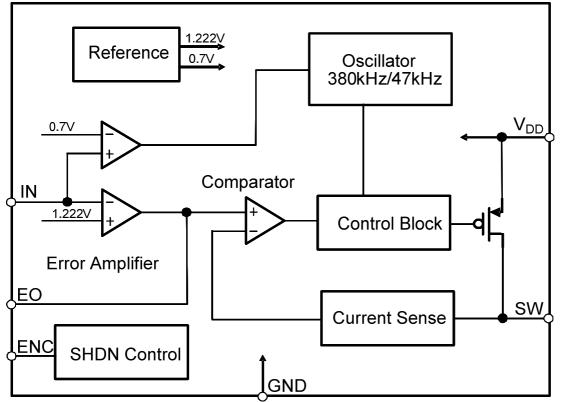
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## **PIN DESCRIPTION**

PIN NO.				FUNCTION		
Α	В	С	NAME	I/O	FUNCITION	
1	-	1, 2	NC	-	Not Connected	
2	1	3	V <sub>DD</sub>	I	Power Input	
3	7, 8	4	SW	I/O	Switching Node	
4	5, 6	5	GND	-	Ground	
5	4	6	IN	I	Feedback Input	
6	3	7	EO	I/O	Error Amplifier Compensation Output	
7	2	8	ENC	I	Enable Control	
8	-	-	NC	-	Not Connected	

# **FUNCTION BLOCK DIAGRAM**

AAT1346A/B/C



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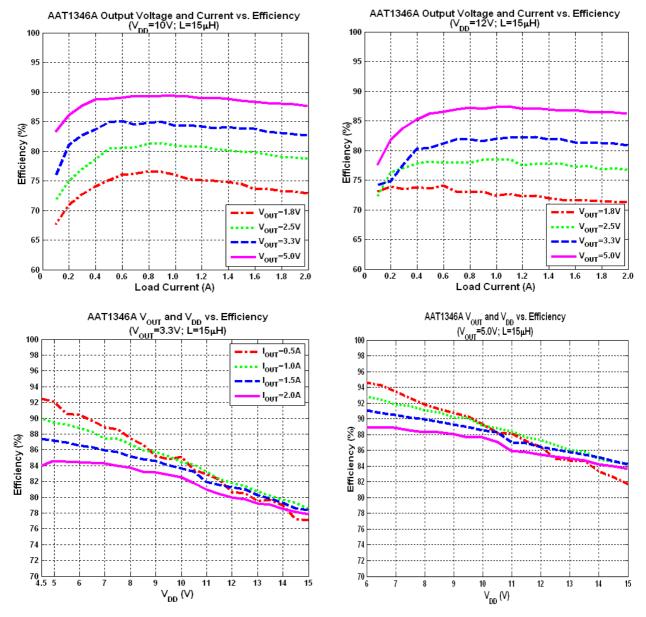
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# **TYPICAL OPERATING CHARACTERISTICS**

( $V_{IN}$ =12V,  $T_{C}$ =25 °C Unless Otherwise Noted)

### AAT1346A

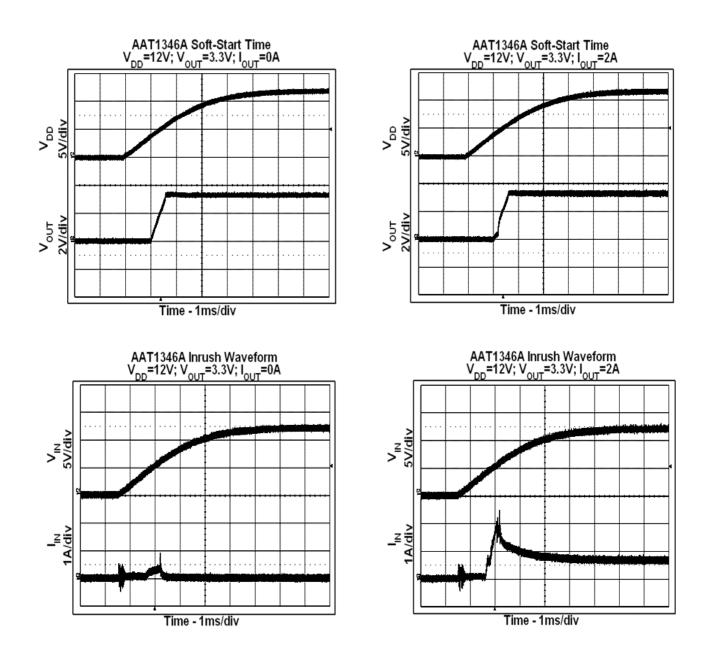


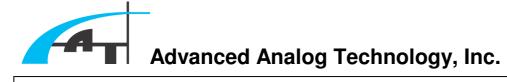
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# **TYPICAL OPERATING CHARACTERISTICS (CONT.)**

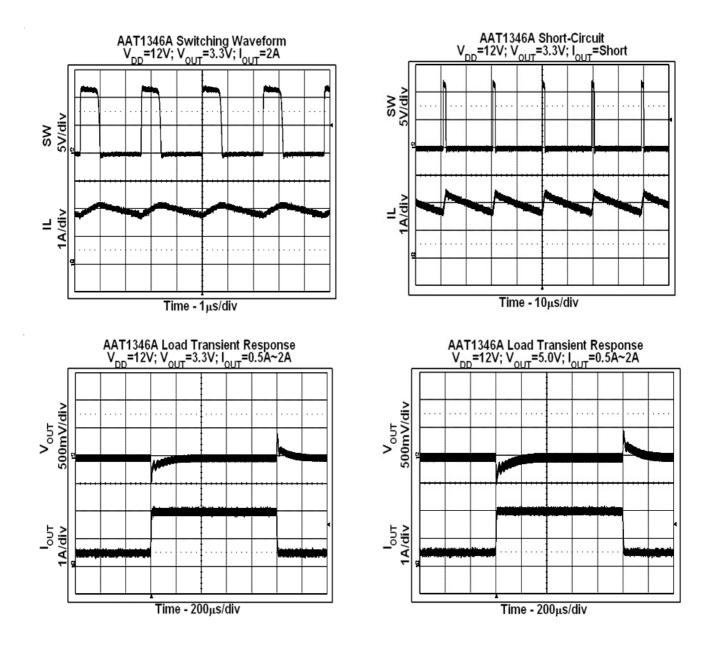
(  $V_{IN}$  =12V, T<sub>C</sub> =25 °C Unless Otherwise Noted)





# **TYPICAL OPERATING CHARACTERISTICS (CONT.)**

(  $V_{IN}$  =12V,  $T_C$  =25 °C Unless Otherwise Noted)



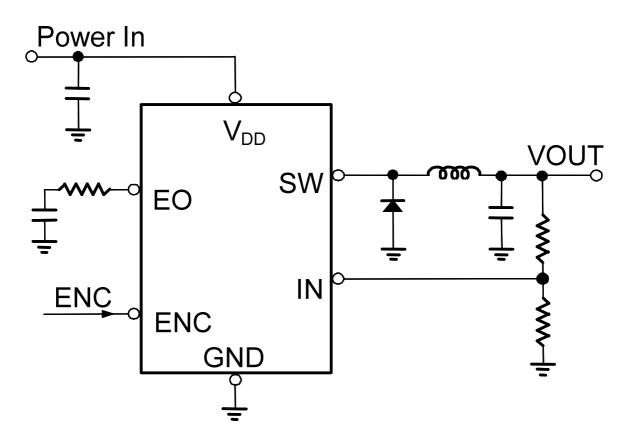


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# **TYPICAL APPLICATION CIRCUIT**

AAT1346A/B/C





### **DETAILED DESCRIPTION**

The AAT1346 is a current-mode buck switch-mode regulator with a fixed switching frequency of 380kHz. It uses an internal P-channel MOSFET switch to step down the input voltage to the regulated output voltage. The converter regulates input voltages from 4.75V to 15V down to an output voltage as low as 1.222V, and is able to supply up to 2A of load current.

#### **ENC Control Input**

The AAT1346 contains built-in pull high logic. The IC is enabled when ENC becomes floating (ENC pin voltage  $>\,$  1.6V). When the voltage is lower than 0.4V, the IC is disabled.

### Soft-Start

The AAT1346 has built-in 700  $\mu s$  soft-start time. Upon power turn-on, if ENC pin is not pulled low; and V\_{DD} is above V\_{UVLO} (typ. 3.48V), IN pin will climb from 0V to 1.222V during 700  $\mu s$  soft-start time to reduce inrush current.

### **Short Ciecuit Protection**

When short circuit happens, and the feedback voltage (IN) is less than 0.7V, the switching frequency will change to 47kHz to reduce the power supply from input to output to protect the system. The frequency will switch back to 380kHz after the short circuit is released.

### **Thermal Shutdown**

The AAT1346 includes a thermal-limit circuit that shuts down the IC at approximately +160 °C. The part turns on after the IC cools by approximately 20 °C.

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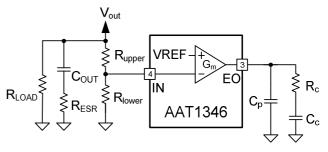
### **DESIGN PROCEDURE**

### Programming the Output Voltage

The output voltage for the AAT1346 is programmed using a resistor divider from the output connected to the feedback pins (Figure 1). When setting the output voltage, connect a resistive voltage divider from the output to IN pin and then to GND. Choose the lower-side (IN-to-GND) resistor, then calculate the upper-side (output-to-IN) resistor as follows:

$$R_{upper} = R_{lower} \left( \frac{V_{out}}{V_{IN}} - 1 \right)$$

Where  $V_{IN}$  is the feedback regulation voltage, 1.222V (typ). Typical values for  $R_{Iower}$  are in the range of  $10k\Omega$  to  $100k\Omega$ .



#### Figure 1. Feedback Network

#### **Inductor Selection**

A good rule of thumb when choosing the inductance is to allow the peak inductor current in the inductor to be approximately 115% of the maximum load current. Also, make sure that the peak inductor current is below the 2.5A minimum current limit.

The inductance value can be calculated by the equation:

$$L \approx \frac{V_{out} \cdot (1 - \frac{V_{out}}{V_i})}{0.3 \cdot I_{out} \cdot f_{SW}}$$

Where  $V_{out}$  is the output voltage,  $V_i$  is the input voltage,  $f_{SW}$  is the switching frequency (380kHz), and

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Iout is the maximum load current.

When the inductance value is determined, then the peak inductor current can be calculated by the equation:

• •

$$I_{L(peak)} = I_{out} + \frac{V_{out} \cdot (1 - \frac{V_{out}}{V_i})}{2 \cdot f_{SW} \cdot L_{setting}}$$

Where  $I_{out}$  is the maximum load current,  $V_{out}$  is the output voltage,  $V_i$  is the input voltage,  $f_{SW}$  is the switching frequency (380kHz), and  $L_{setting}$  is the inductance value. Choose an inductor that does not saturate under the peak inductor current.

### **Schottky Diode Selection**

Choose a Schottky diode whose maximum reverse voltage rating is greater than the maximum input voltage, and whose current rating is greater than the peak inductor current.

#### **Input Capacitor**

The input capacitor in a DC-to-DC converter reduces current peaks drawn from the input power source and reduces switching noise in the controller. The impedance of the input capacitor at the switching frequency should be less than that of the input source so high-frequency switching currents do not pass through the input source. Ceramic capacitors are preferred, but tantalum or low-ESR electrolytic capacitors may also satisfy. For insuring stable operation the IC must be bypassed with a 0.22  $\mu$ F ceramic capacitor placed close to the V<sub>DD</sub>.

#### **Output Capacitor**

The output capacitor keeps output ripple small and ensures control-loop stability. The output capacitor must also have low impedance at the switching frequency. Ceramic, polymer, and tantalum or low-ESR electrolytic capacitors are suitable.

Output ripple with a ceramic output capacitor is

approximately as follows:

$$V_{\text{ripple}} \approx \frac{V_{\text{out}} \cdot (1 - \frac{V_{\text{out}}}{V_{\text{i}}})}{8 \cdot L_{\text{setting}} \cdot C_{\text{out}} \cdot f_{\text{SW}}^{2}}$$

Where  $V_{out}$  is the output voltage,  $V_i$  is the input voltage,  $f_{SW}$  is the switching frequency (380kHz),  $C_{out}$  is the output capacitance, and  $L_{setting}$  is the inductance value.

If the capacitor has significant ESR, the output ripple component due to capacitor ESR is as follows:

$$V_{ripple} \approx 2 \cdot (I_{L(peak)} - I_{out}) \times R_{ESR}$$

Where  $I_{L(peak)}$  is the peak inductor current,  $I_{out}$  is the maximum load current, and  $R_{ESR}$  is the capacitor's ESR.

#### Compensation

The AAT1346 employs current-mode control, thereby simplifying the control-loop compensation. When the AAT1346 operates with continuous inductor current (typically the case), a  $R_{LOAD}$   $C_{OUT}$  pole appears in the loop-gain frequency response. To ensure stability, set the compensation  $R_C C_C$  to zero to compensate for the  $R_{LOAD} C_{OUT}$  pole. Set the loop crossover below the lower of 1/10 the switching frequency (380kHz). The compensation resistor and capacitor are then chosen to optimize control-loop stability.

Choose the compensation resistor  $R_C$  to set the desired crossover frequency  $f_C$ . Determine the value by the following equation:

$$R_{C} = \frac{2\pi \times C_{OUT} \times V_{OUT} \times R_{CS} \times f_{c}}{G_{m} \times V_{IN}}$$

Where  $C_{out}$  is the output capacitance,  $V_{out}$  is the output voltage,  $R_{CS}$  is the current-sense amplifier transresistance (0.2V/A),  $G_m$  is the error amplifier transconductance (80  $\mu S$ ) and  $V_{IN}$  is the feedback

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threshold voltage (1.222V).

If the value calculated for  $\,R_C^{}\,$  is greater than  $100\,k\Omega\,,$   $100\,k\Omega\,$  is recommend.

Choose the compensation capacitor  $C_C$  to set the zero to 1/4 of the crossover frequency.

$$C_{C} < \frac{C_{OUT} \times V_{OUT}}{4 \times R_{C}}$$

If the output filter capacitor  $C_{out}$  has significant ESR, a zero occurs at the following:

$$Z_{ESR} = \frac{1}{2\pi \times C_{OUT} \times R_{ESR}}$$

If  $Z_{ESR} > f_C/4$ , it can be ignored, as is typically the case with ceramic output capacitors. If  $Z_{ESR} < f_C/4$ , it should be cancelled with a pole set by capacitor  $C_p$  connected from EO to GND:

$$C_{P} = \frac{C_{OUT} \times R_{ESR}}{R_{C}}$$

If  $C_p$  is calculated to be <10pF, it can be omitted.

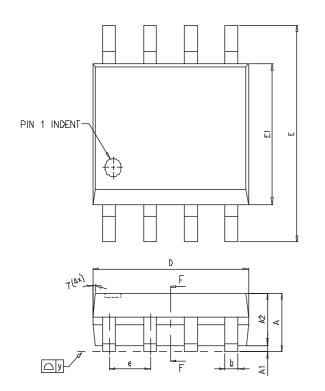
# LAYOUT CONSIDERATIONS

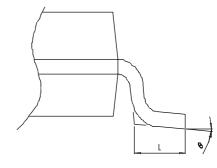
Conductors carrying discontinuous currents and any high-current path should be made as short and wide as possible. The compensation network should be very close to the EO pin and avoid through VIA. The IC must be bypassed with a  $0.22\,\mu\text{F}$  ceramic capacitor placed close to the V<sub>DD</sub>. Tie the feedback resistor divider to be very close to output capacitor and far away from the inductor or Schottky diode. Keep the feedback network IN close to the IC. Switching nodes (SW) should be kept as small as possible and should be routed away from high-impedance nodes such as IN.



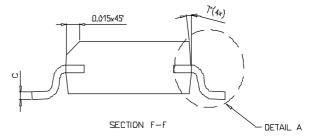
## **PACKAGE DIMENSION**

SOP-8









Symbol	Dimensions In Millimeters						
Symbol	MIN	TYP	MIN				
A	1.35	1.60	1.73				
A1	0.05		0.15				
A2		1.45					
b	0.33	0.41	0.51				
С	0.19	0.20	0.25				
D	4.80	4.85	4.95				
E	5.79	5.99	6.20				
E1	3.81	3.91	3.99				
е	1.27 BSC						
L	0.406	0.710	1.270				
у			0.076				
θ	0°		8°				

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