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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)**
- **2 µA Shutdown Current**
- **SOP- 8 Package**

PIN CONFIGURATION
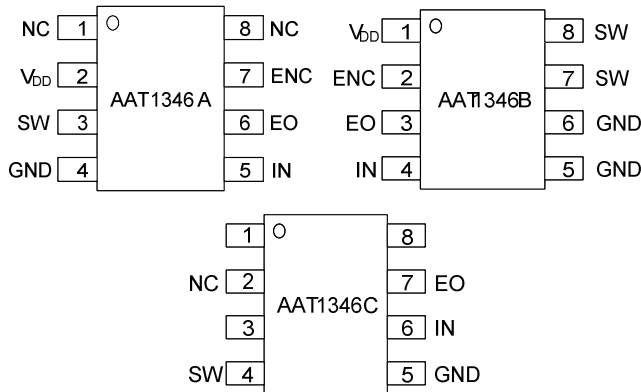
TOP VIEW

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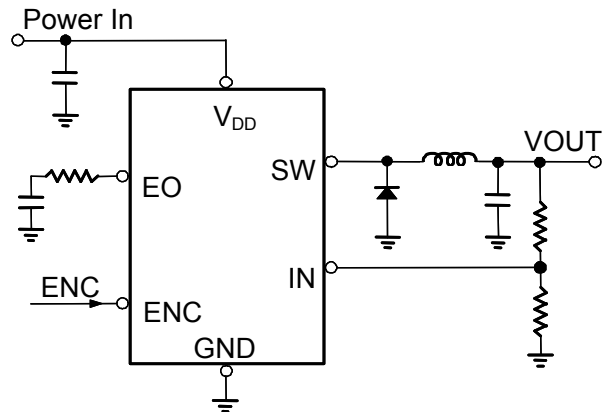
The AAT1346A/B/C contains one buck current mode PWM with internal PMOS. In addition, a digital soft-start is also included to prevent inrush current at startup. AAT1346A/B/C comes with a fixed 380kHz oscillator, however, when the feedback voltage is lower than 0.7V, the switching frequency changes to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

TYPICAL APPLICATION

ORDERING INFORMATION

DEVICE TYPE	PART NUMBER	PACKAGE	PACKING	TEMP. RANGE	MARKING	MARKING DESCRIPTION
AAT1346A	AAT1346A-S-T	S:SOP8	T: Tape and reel	$-40\,°C$ to $+85\,°C$	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_{DD} , SW)	V_{DD}	-0.3 to 15.0	V
Pin Voltage (IN, ENC, EO)	V_I	-0.3 to (V_{DD} +0.3)	V
SW Current	I_{SW}	6.5	A
Operating Temperature Range	T_C	$-40\ °C$ to $+85\ °C$	$°C$
Storage Temperature Range	$T_{storage}$	$-65\ °C$ to $+150\ °C$	$°C$

ELECTRICAL CHARACTERISTICS

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

GENERAL ITEM

PARAMETER	SYMBOL	TEST CONDITION	MIN	TYP	MAX	UNIT
Input Voltage Range	V_{DD}		4.50		15.0	V
Under Voltage Lockout	V_{UVLO}	V_{DD} Falling	3.33	3.48	3.63	V
Under Voltage Lockout Hysteresis	V_{UHYS}			150		mV
Input Current into V_{DD}	I_{DD_OFF}	V_{IN} = 1.5V		1		mA
	I_{DD_ON}	V_{IN} = 1.0V		5.5		mA
Shutdown Current into V_{DD}	I_{SHDN}			1.70	10.0	µA
OSC Frequency	f_{OSC}	Normal Operation		380		kHz
		Short-Circuit		47.5		kHz
Short Detection Voltage	V_{SHORT}	V_{IN} Falling	0.67	0.70	0.73	V
EN Low Level	V_{IL}				0.4	V
EN High Level	V_{IH}		1.6			V
Thermal Shutdown	T_{SHDN}			160		$^\circ$C

BUCK PWM

PARAMETER	SYMBOL	TEST CONDITION	MIN	TYP	MAX	UNIT
IN Regulation Voltage	V_{IN}	IN=EO	1.209	1.222	1.235	V
IN to EO Transconductance	G_m	IN=EO	35	80	125	µS
Maximum Duty Cycle				90		%
IN Input Leakage Current	I_L	IN=0V to 1.5V	−100	0.01	+100	nA
Current-Sense Amplifier Transresistance	R_{CS}			0.2		V/A
SW Leakage Current	I_{LSW}	V_{SW} = 15V		0.1	5.0	µA
Switch On-Resistance	R_{ON}			200		mΩ
SW Current Limit	I_{LIMIT}		2.5	3.7		A
Soft-Start Time	t_{SS}			700		µs

PIN DESCRIPTION

PIN NO.			NAME	I/O	FUNCITION
A	B	C			
1	-	1, 2	NC	-	Not Connected
2	1	3	V_{DD}	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
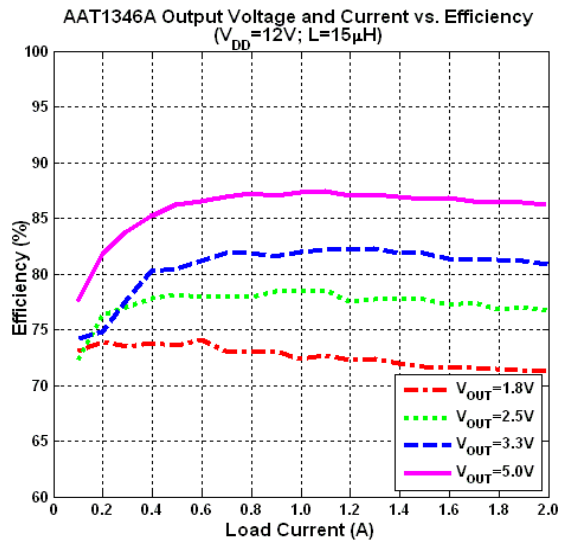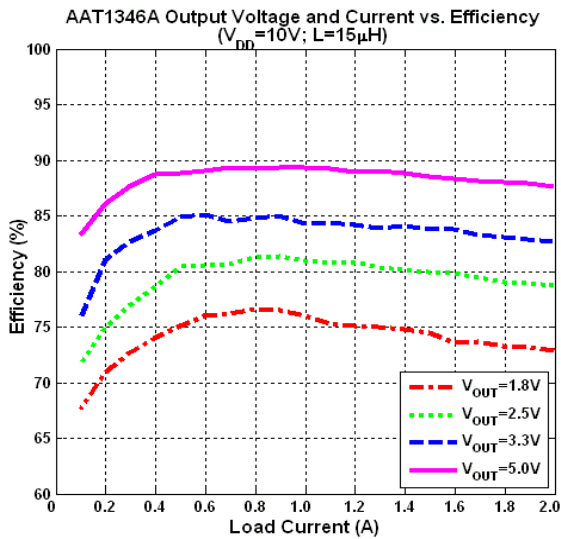
AAT1346A/B/C
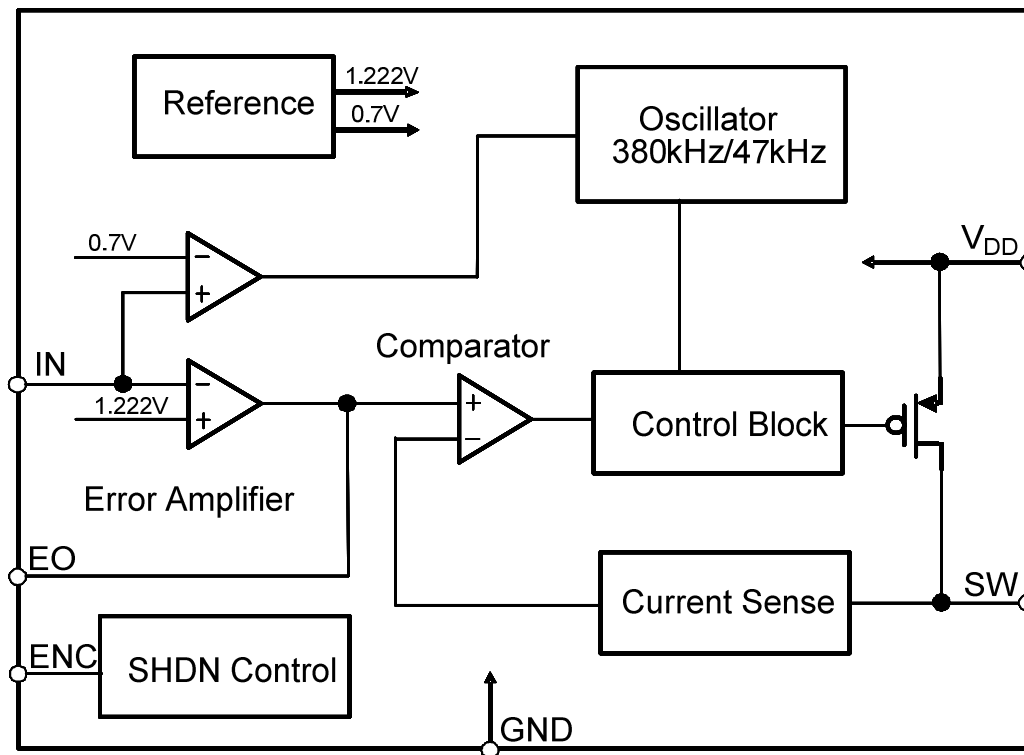
TYPICAL OPERATING CHARACTERISTICS
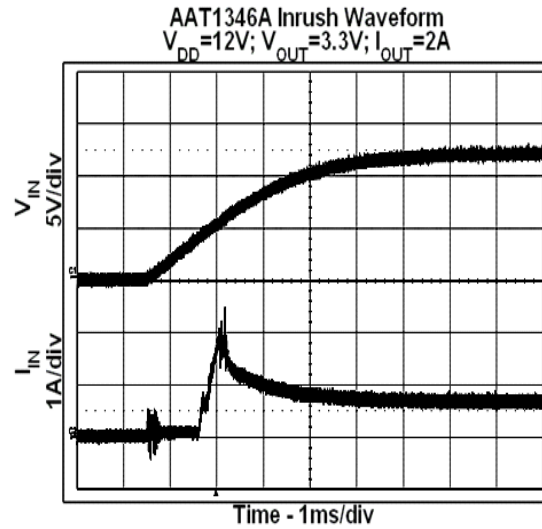
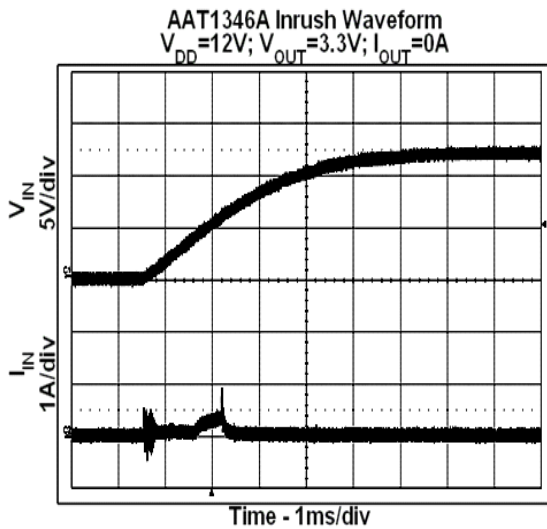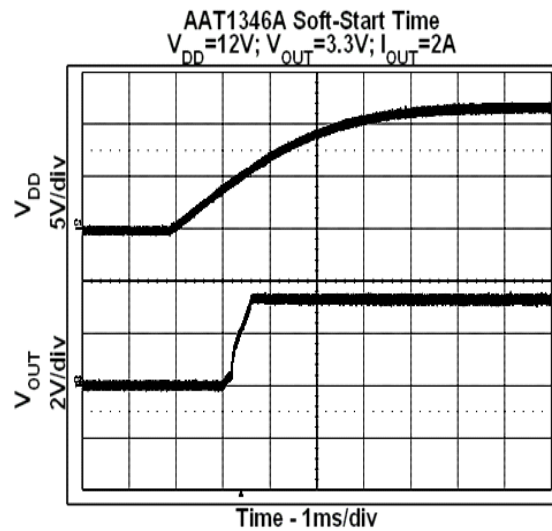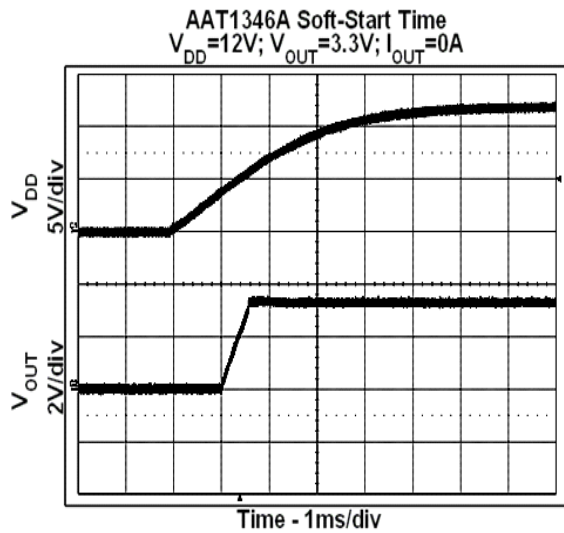(V_{IN} =12V, T_C =25 $^\circ$C Unless Otherwise Noted)
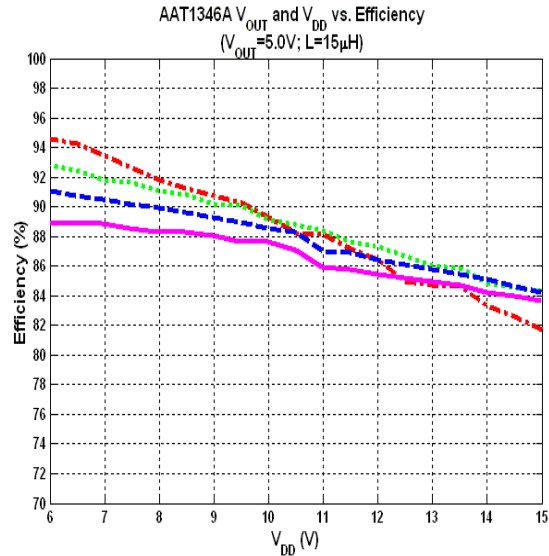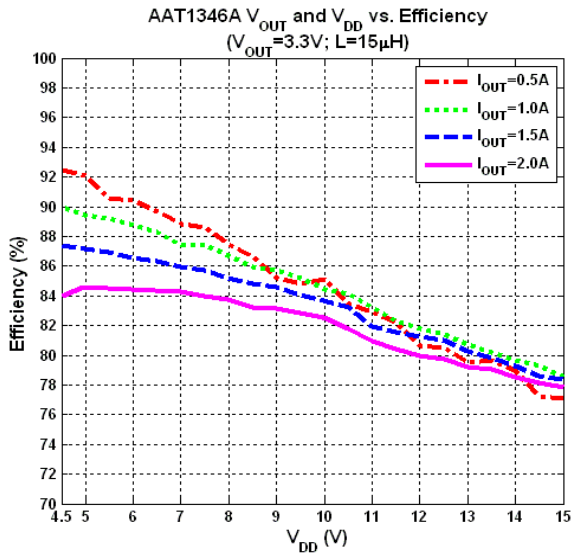
AAT1346A

TYPICAL OPERATING CHARACTERISTICS (CONT.)
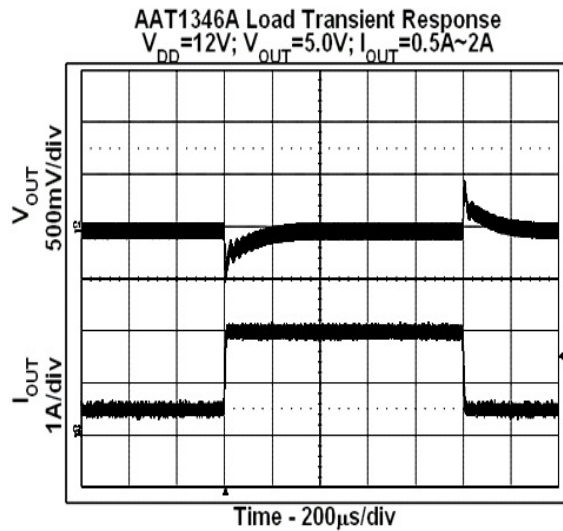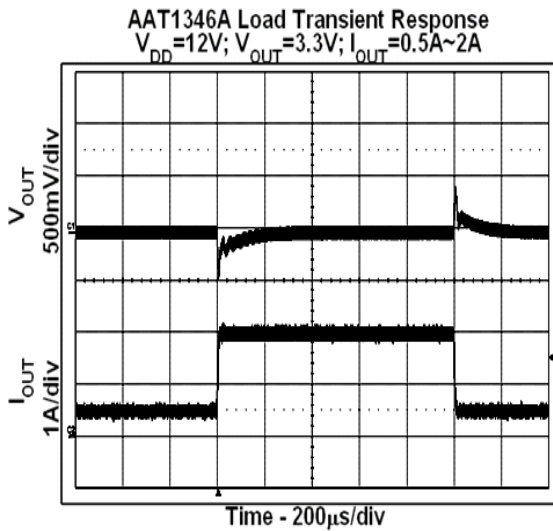
(V_{IN} =12V, T_C =25 °C Unless Otherwise Noted)

AAT1346A Soft-Start Time
V_{DD}=12V; V_{OUT}=3.3V; I_{OUT}=0A

AAT1346A Soft-Start Time
V_{DD}=12V; V_{OUT}=3.3V; I_{OUT}=2A

AAT1346A Inrush Waveform
V_{DD}=12V; V_{OUT}=3.3V; I_{OUT}=0A

AAT1346A Inrush Waveform
V_{DD}=12V; V_{OUT}=3.3V; I_{OUT}=2A

TYPICAL OPERATING CHARACTERISTICS (CONT.)

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

AAT1346A Switching Waveform
V_{DD}=12V; V_{OUT}=3.3V; I_{OUT}=2A

AAT1346A Short-Circuit
V_{DD}=12V; V_{OUT}=3.3V; I_{OUT}=Short

AAT1346A Load Transient Response
V_{DD}=12V; V_{OUT}=3.3V; I_{OUT}=0.5A~2A

AAT1346A Load Transient Response
V_{DD}=12V; V_{OUT}=5.0V; I_{OUT}=0.5A~2A
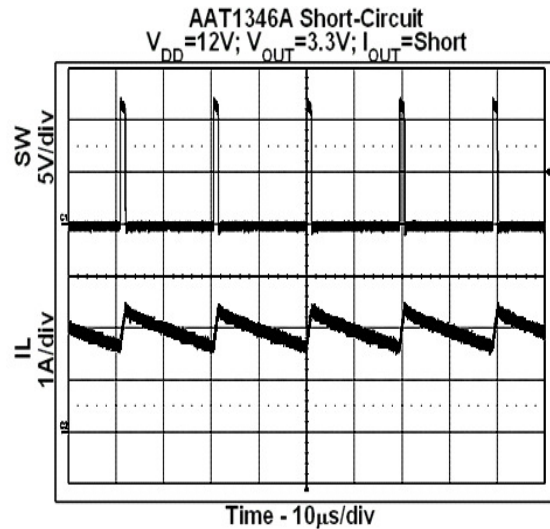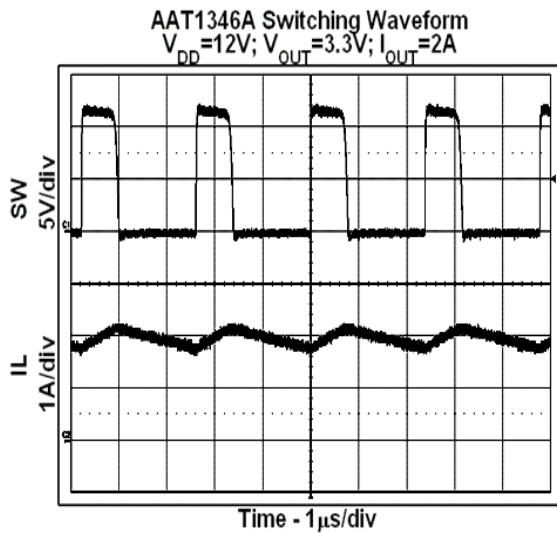
TYPICAL APPLICATION CIRCUIT

AAT1346A/B/C

Power In

V$_{DD}$

VOUT

SW

EO

IN

ENC

ENC

GND
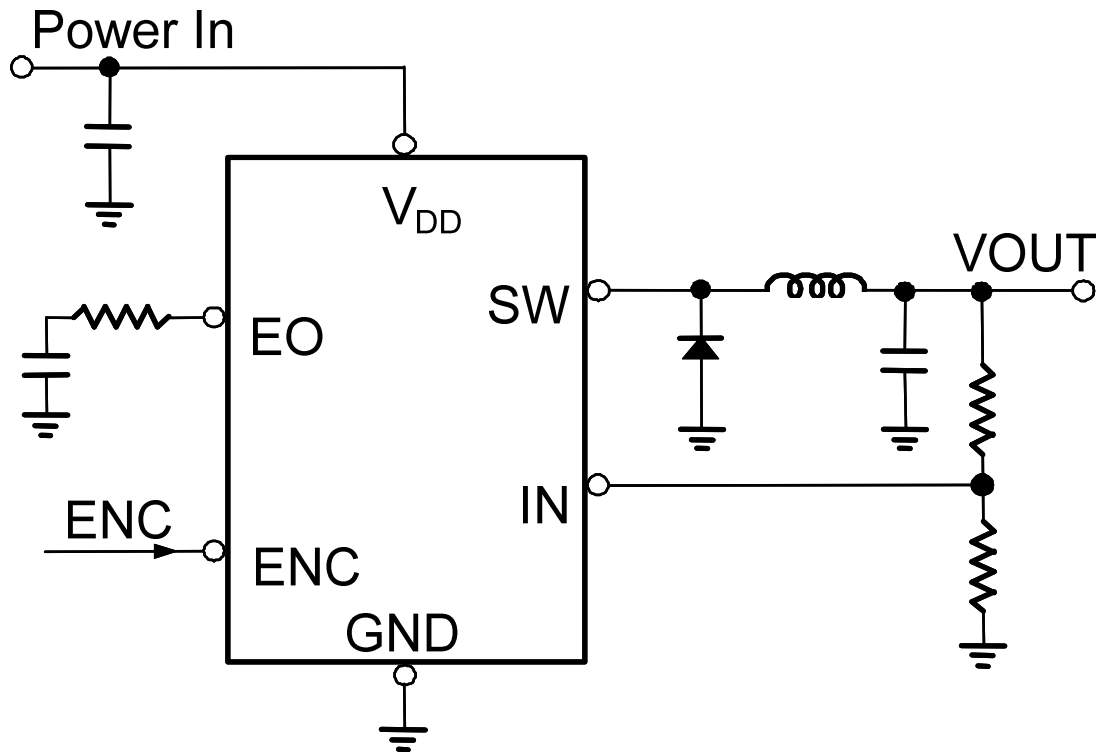
DETAILED DESCRIPTION

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.

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_{lower} are in the range of 10kΩ to 100kΩ.
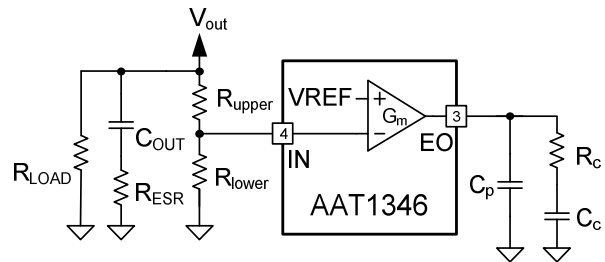

Figure 1. Feedback Network

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

I_{out} 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 μF ceramic capacitor placed close to the V_{DD}.

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:

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

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 μS) and V_{IN} is the feedback

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 $0.22\,\mu F$ ceramic capacitor placed close to the V_{DD}. 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

PIN 1 INDENT

DETAIL A

DETAIL A

SECTION F-F

0.015x45°
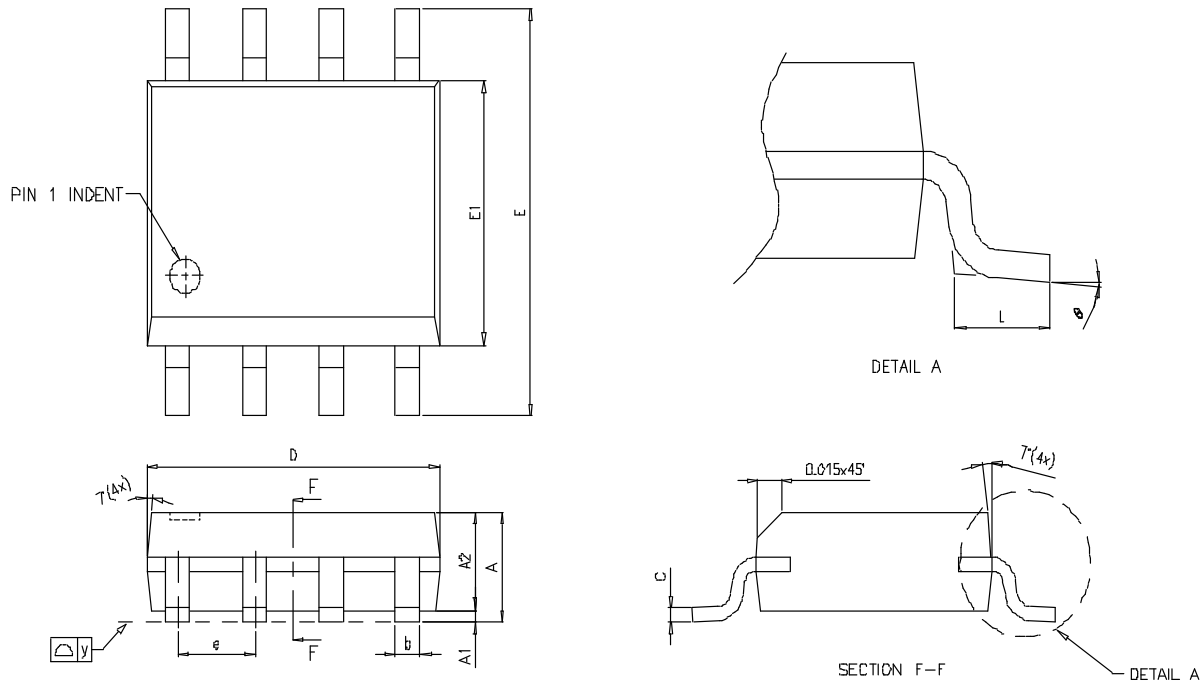
Symbol	Dimensions In Millimeters		
	MIN	**TYP**	**MIN**
A	1.35	1.60	1.73
A1	0.05	------	0.15
A2	------	1.45	------
b	0.33	0.41	0.51
C	0.19	0.20	0.25
D	4.80	4.85	4.95
E	5.79	5.99	6.20
E1	3.81	3.91	3.99
e	1.27 BSC		
L	0.406	0.710	1.270
y	------	------	0.076
θ	0°	------	8°