

**AAT7301**

ORDERING INFORMATION

DEVICE TYPE	PART NUMBER	PACKAGE	PACKING	TEMP. RANGE	MARKING	MARKING DESCRIPTION
AAT7301	AAT7301-S-T	S:SOP8	T: Tape and Reel	-40 °C to +85 °C	AAT7301 XXXXXX	Device Type Lot no. (6~9 Digits)

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

ABSOLUTE MAXIMUM RATINGS

PARAMETER	SYMBOL	VALUE	UNIT
Supply Voltage (VDD, 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

($V_{DD} = 4V \sim 15V$, $T_C = -40^\circ C$ to $85^\circ C$, Tested at $T_C = 25^\circ C$, $V_{DD} = 12V$, unless otherwise specified.)

General Item

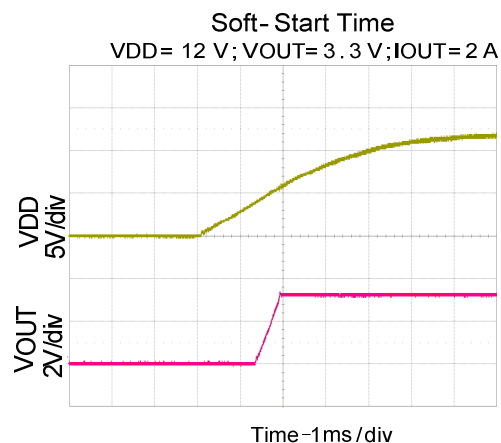
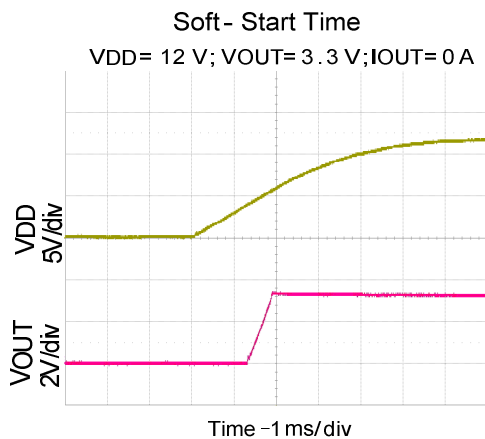
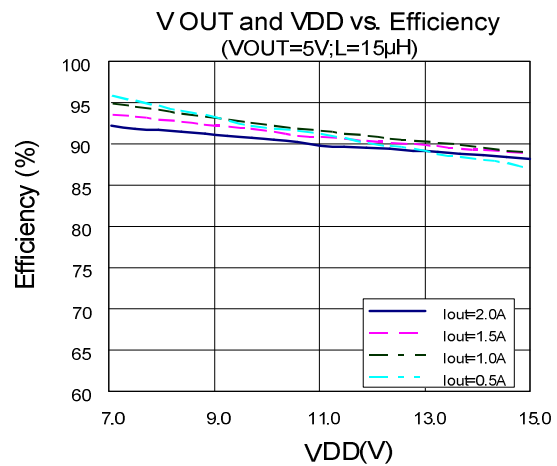
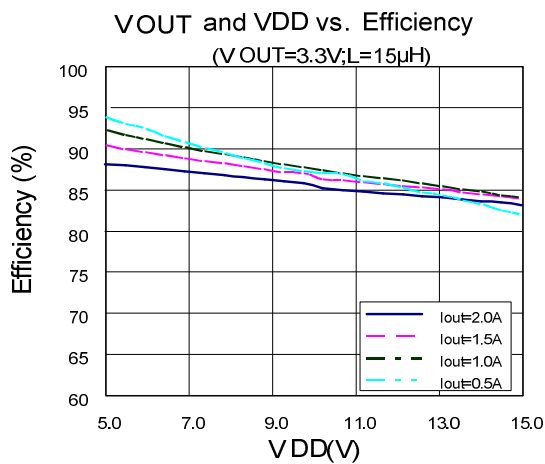
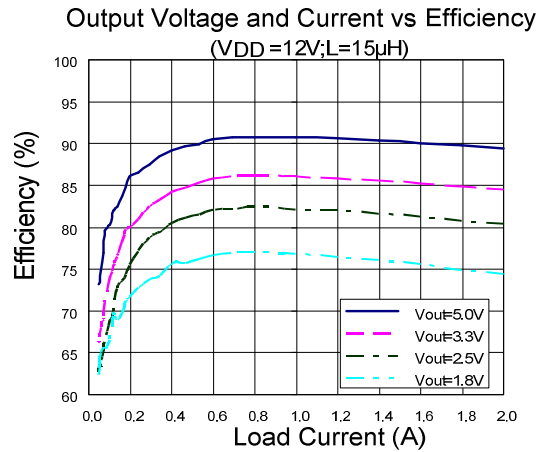
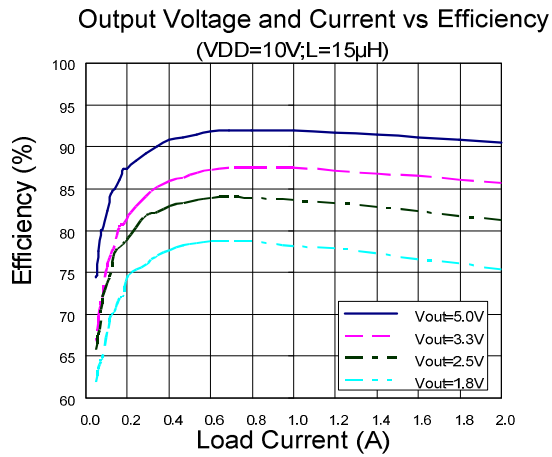
PARAMETER	SYMBOL	TEST CONDITION	MIN	TYP	MAX	UNIT
Input Voltage Range	V_{DD}		4		15	V
Under Voltage Lockout	V_{UVLO}	V_{DD} Falling	3.33	3.48	3.63	V
Under Voltage Lockout Hysteresis	V_{UHYS}			150		mV
Input Current into VDD	I_{DD-OFF}	$V_{IN} = 1.5V$		1		mA
	I_{DD-ON}	$V_{IN} = 0.85V$		5.5		mA
Shutdown Current into VDD	I_{SHDN}			1.70	10.00	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	0.88	0.90	0.92	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	-100.00	0.01	+100.00	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		m Ω
SW Current Limit	I_{LIMIT}		2.5	3.7		A
Soft-Start Time	t_{SS}			700		μs

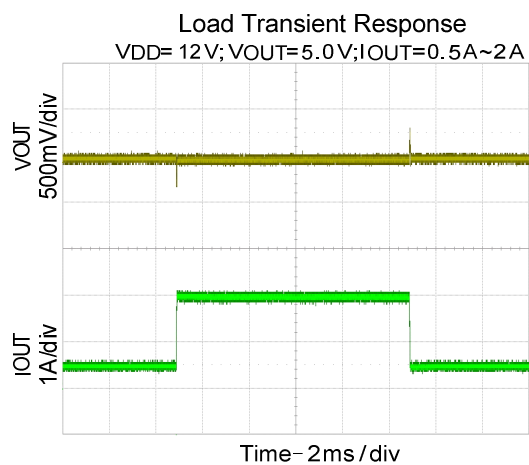
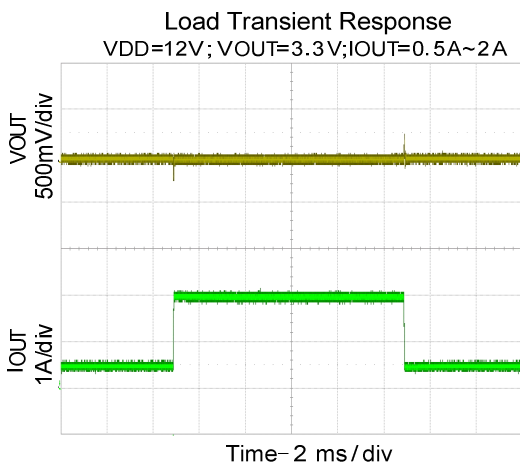
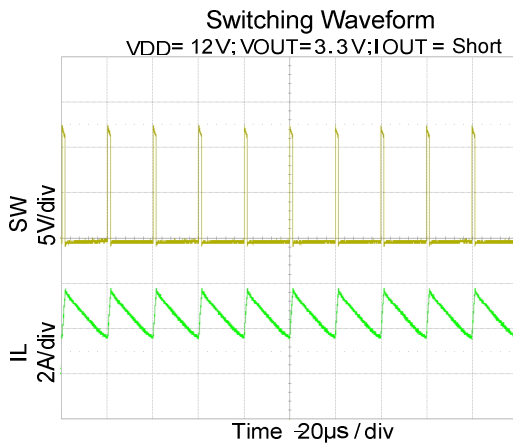
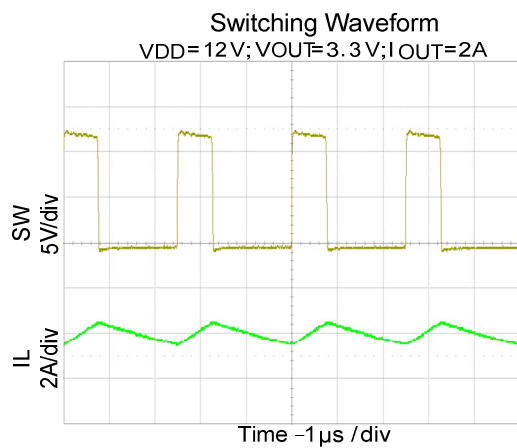
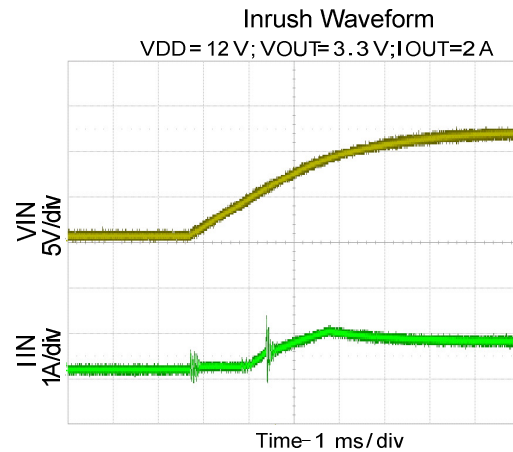
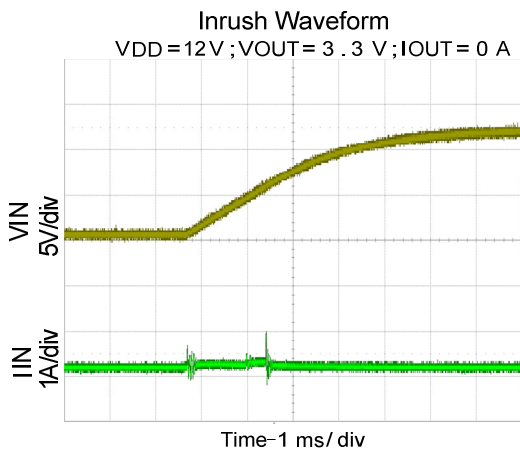


TYPICAL OPERATING CHARACTERISTICS





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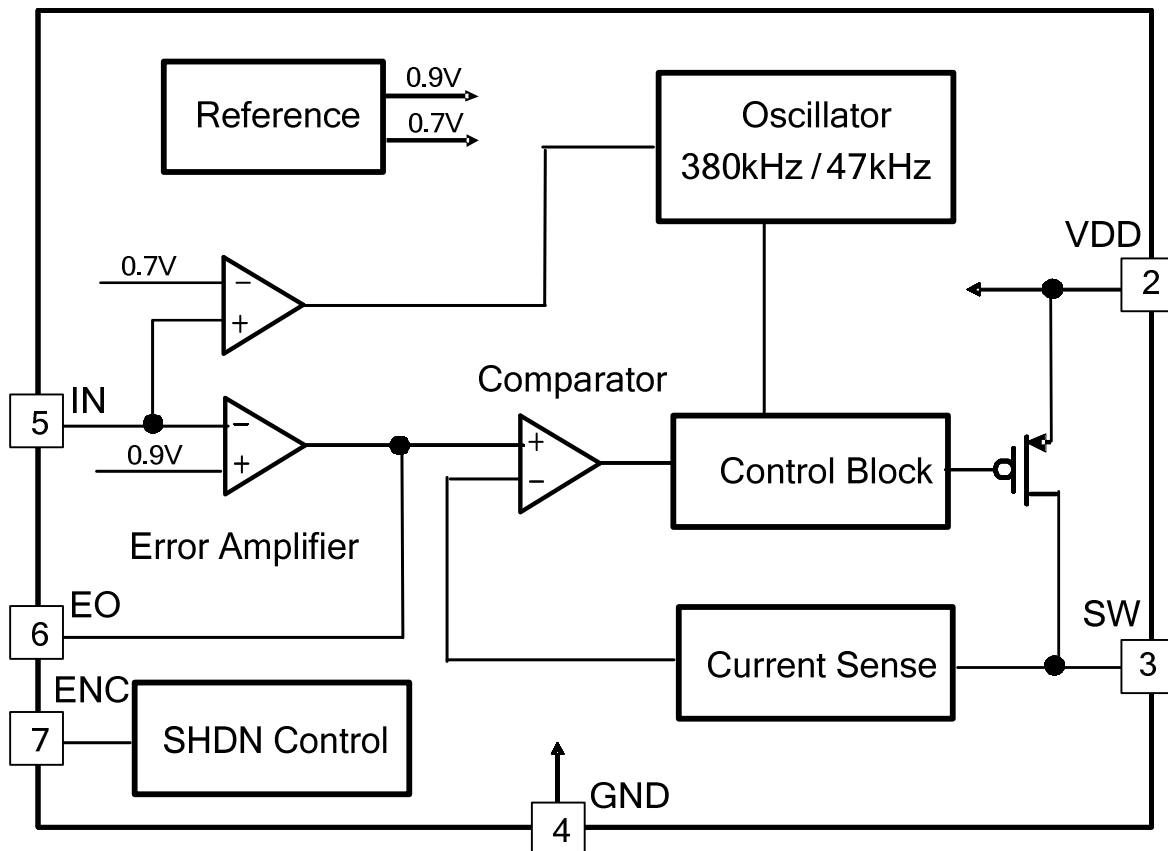


PIN DESCRIPTION

PIN NO.	NAME	I/O	FUNCTION
1	NC	-	Not Connected
2	VDD	I	Power Input
3	SW	I/O	Switching Node
4	GND	-	Ground
5	IN	I	Feedback Input
6	EO	I/O	Error Amplifier Compensation Output
7	ENC	I	Enable Control
8	NC	-	Not Connected

FUNCTION BLOCK DIAGRAM

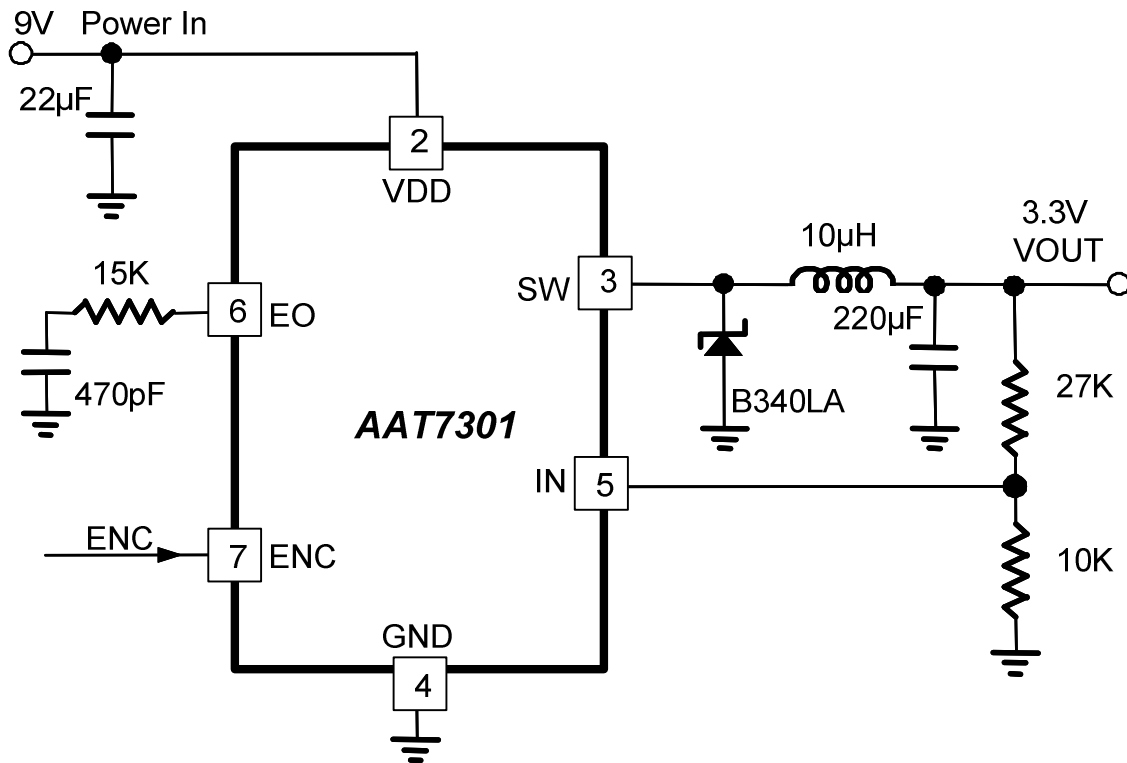
AAT7301





TYPICAL APPLICATION CIRCUIT

AAT7301





DETAILED DESCRIPTION

The AAT7301 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 4V to 15V down to an output voltage as low as 0.9V, and is able to supply up to 2A of load current.

ENC Control Input

The AAT7301 contains built-in pull high logic. The IC is enabled even ENC left floating (ENC pin voltage > 1.6V). When the voltage is lower than 0.4V, the IC is disabled.

Soft-Start

The AAT7301 has built-in 700μs 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 0.9V during 700μs soft-start time to reduce inrush current.

Short Circuit 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 AAT7301 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 AAT7301 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:

$$R_{\text{UPPER}} = R_{\text{LOWER}} \left(\frac{V_{\text{OUT}}}{V_{\text{IN}}} - 1 \right)$$

Where V_{IN} is the feedback regulation voltage, 0.9V (typ). Typical values for R_{LOWER} are in the range of 10kΩ to 100kΩ.

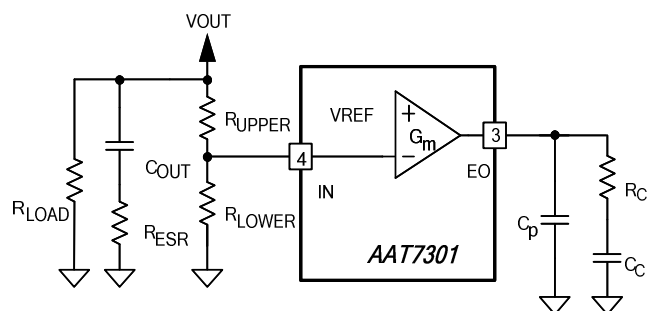


Figure 1. Feedback Network



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:

$$L \approx \frac{V_{OUT} \cdot \left(1 - \frac{V_{OUT}}{V_I}\right)}{0.3 \cdot I_{OUT} \cdot f_{SW}}$$

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:

$$I_{L(\text{peak})} = I_{OUT} + \frac{V_{OUT} \cdot \left(1 - \frac{V_{OUT}}{V_I}\right)}{2 \cdot f_{SW} \cdot L_{\text{setting}}}$$

Where I_{OUT} is 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:

$$V_{\text{ripple}} \approx \frac{V_{OUT} \cdot \left(1 - \frac{V_{OUT}}{V_I}\right)}{8 \cdot L_{\text{setting}} \cdot C_{OUT} \cdot f_{SW}^2}$$

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:

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

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

**Compensation**

The AAT7301 employs current-mode control, thereby simplifying the control-loop compensation. When the AAT7301 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 μ S) and V_{IN} is the feedback threshold voltage (0.9V).

If the value calculated for R_C is greater than 100k Ω , recommend 100k Ω .

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.

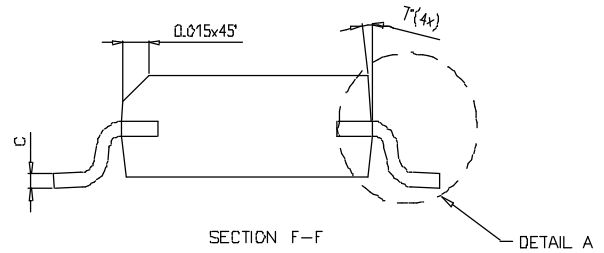
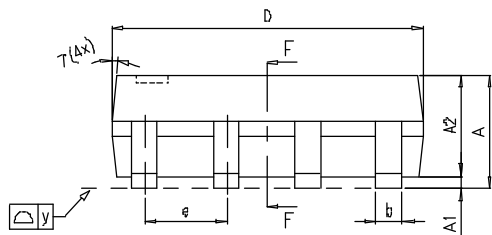
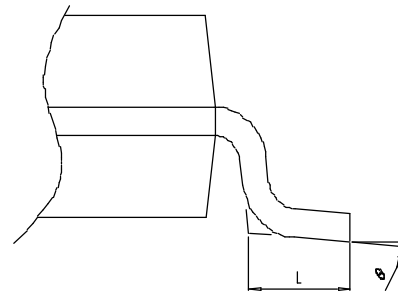
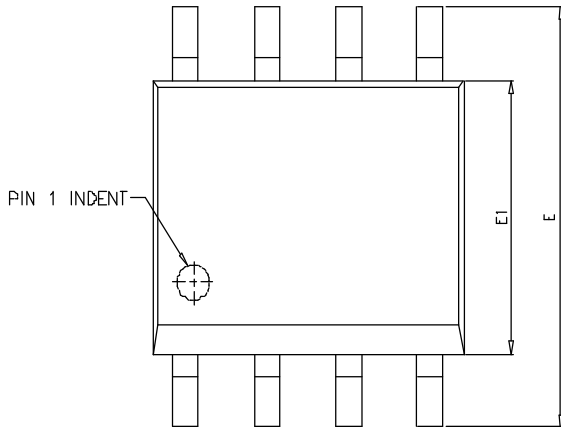
LAYOUT CONSIDERATIONS

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 μ 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



Symbol	Dimensions In Millimeters		
	MIN	TYP	MAX
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°