

150KHz, 2A PWM Buck DC/DC Converter

■ Features

- Output voltage: 3.3V, 5V, 12V and adjustable output version
- Adjustable version output voltage range, 1.23V to 18V+4%
- 150KHz $\pm 15\%$ fixed switching frequency
- Voltage mode non-synchronous PWM control
- Thermal-shutdown and current-limit protection
- ON/OFF shutdown control input
- Operating voltage can be up to 22V
- Output load current: 2A
- SOP-8L packages
- Low power standby mode
- Built-in switching transistor on chip

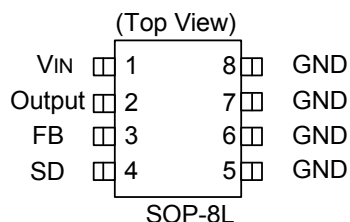
■ Applications

- Simple High-efficiency step-down regulator
- On-card switching regulators
- Positive to negative converter

■ General Description

The AP1509 series are monolithic IC designed for a step-down DC/DC converter, and own the ability of driving a 2A load without additional transistor. It saves board space. The external shutdown function can be controlled by logic level and then come into standby mode. The internal compensation makes feedback control having good line and load regulation without external design. Regarding protected function, thermal shutdown is to prevent over temperature operating from damage, and current limit is against over current operating of the output switch. If current limit function occurs and V_{FB} is down below 0.5V, the switching frequency will be reduced. The AP1509 series operates at a switching frequency of 150KHz thus allow smaller sized filter components than what would be needed with lower frequency switching regulators. Other features include a guaranteed $\pm 4\%$ tolerance on output voltage under specified input voltage and output load conditions, and $\pm 15\%$ on the oscillator frequency. The output version included fixed 3.3V, 5V, 12V, and an adjustable type. The chips are available in a standard 8-lead SOP-8 package.

■ Pin Assignments



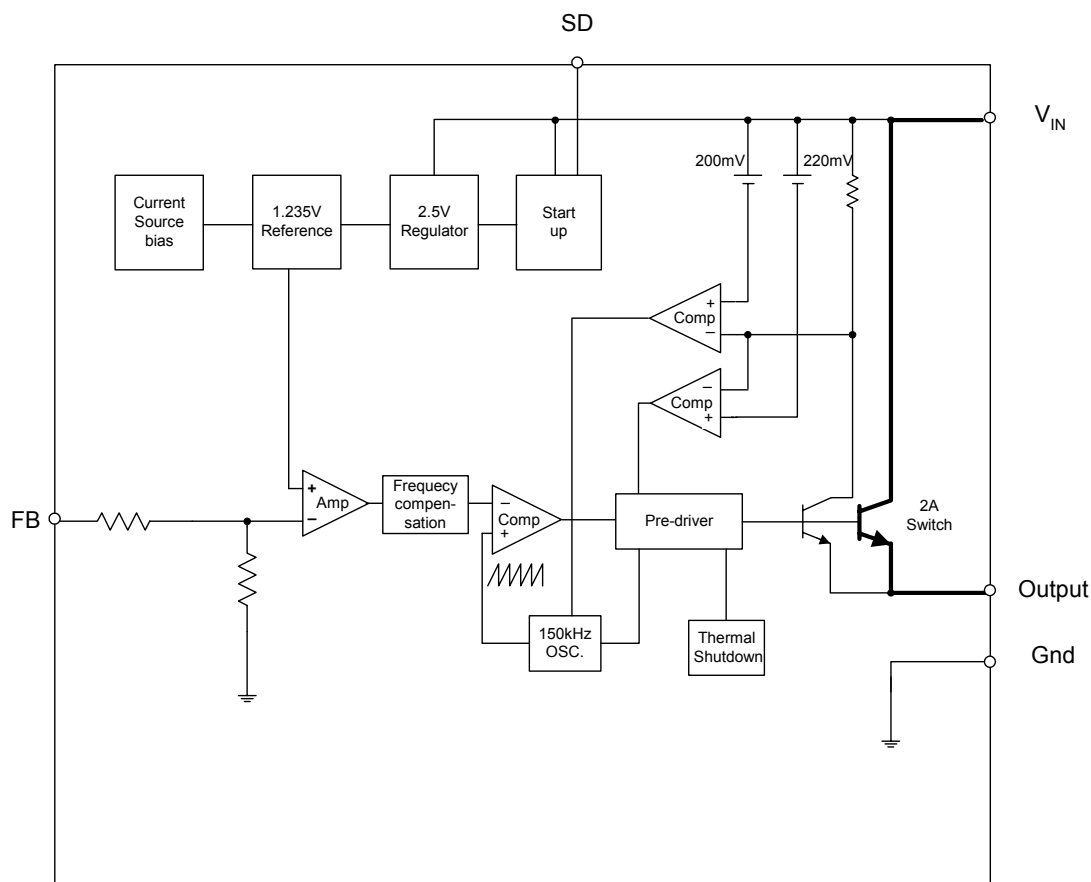
■ Pin Descriptions

Name	Description
V_{IN}	Operating voltage input
Output	Switching output
GND	Ground
FB	Output voltage feedback control
SD	ON/OFF Shutdown

■ Ordering Information

AP1509 XX X X X			
Output version	Package	Lead Free	Packing
Blank : Adjustable	S: SOP-8L	Blank : Normal	Blank : Tube
-33 : 3.3V		L : Lead Free Package	A : Taping
-50 : 5.0V			
-12 : 12V			

■ Block Diagram



■ Absolute Maximum Ratings

Symbol	Parameter	Rating	Unit
V_{CC}	Supply Voltage	+24	V
V_{SD}	ON/OFF Pin input voltage	-0.3 to +18	V
V_{FB}	Feedback Pin voltage	-0.3 to +18	V
V_{OUT}	Output voltage to Ground	-1	V
P_D	Power dissipation	Internally limited	W
T_{ST}	Storage temperature	-65 to +150	°C
T_{OP}	Operating temperature	-40 to +125	°C
V_{OP}	Operating voltage	+4.5 to +22	V

■ Electrical Characteristics (All Output Voltage Versions)

Unless otherwise specified, $V_{IN}=12V$ for 3.3V, 5V, adjustable version and $V_{IN}=18V$ for the 12V version. $I_{LOAD} = 0.5A$

Unless otherwise specified, $V_{IN}=12V$ for 0.5V, 0V, adjustable version and $V_{IN}=10V$ for the 12V version; $I_{LOAD}=0.5A$

Symbol	Parameter		Conditions	Min.	Typ.	Max.	Unit
I_{FB}	Feedback bias current		$V_{FB}=1.3V$ (Adjustable version only)		-10	-50 -100	nA
F_{OSC}	Oscillator frequency			127 110	150	173 173	KHz
F_{SCP}	Oscillator frequency of short circuit protect		When current limit occurred and $V_{FB} < 0.5V$, $T_a=25^{\circ}C$	5	15	25	KHz
V_{SAT}	Saturation voltage		$I_{OUT}=2A$ No outside circuit $V_{FB}=0V$ force driver on		1.25	1.4 1.5	V
DC	Max. Duty Cycle (ON)		$V_{FB}=0V$ force driver on		100		%
	Min. Duty Cycle (OFF)		$V_{FB}=12V$ force driver off		0		
I_{CL}	Current limit		Peak current No outside circuit $V_{FB}=0V$ force driver on	3			A
I_L	Output = 0	Output leakage current	No outside circuit $V_{FB}=12V$ force driver off			-200	uA
	Output = -1		$V_{IN}=22V$		-5		mA
I_Q	Quiescent Current		$V_{FB}=12V$ force driver off		5	10	mA
I_{STBY}	Standby Quiescent Current		ON/OFF pin=5V $V_{IN}=22V$		70	150 200	uA
	V_{IL}	ON/OFF pin logic input threshold voltage		Low (regulator ON)	-	0.6	V
V_{IH}			High (regulator OFF)	2.0	1.3	-	
I_H	ON/OFF pin logic input current		$V_{LOGIC}=2.5V$ (OFF)			-0.01	uA
I_L	ON/OFF pin input current		$V_{LOGIC}=0.5V$ (ON)		-0.1	-1	
Θ_{JC}	Thermal Resistance		SOP-8L	Junction to case	15		$^{\circ}C/W$
Θ_{JA}	Thermal Resistance With copper area of approximately 3 in ²		SOP-8L	Junction to ambient	70		$^{\circ}C/W$

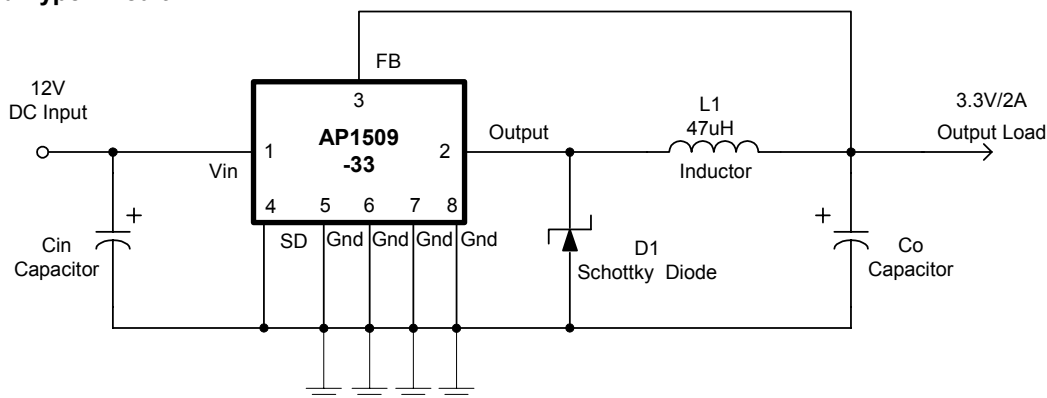
■ Electrical Characteristics (Continued)

	Symbol	Parameter	Conditions	Typ.	Limit	Unit
AP1509-ADJ	V_{FB}	Output Feedback	$4.5V \leq V_{IN} \leq 22V$ $0.2A \leq I_{LOAD} \leq 2A$ V_{OUT} programmed for 3V	1.23	1.193/ 1.18 1.267/ 1.28	V V_{MIN} V_{MAX}
	η	Efficiency	$V_{IN} = 12V, I_{LOAD}=2A$	76		%
AP1509-3.3V	V_{OUT}	Output voltage	$4.75V \leq V_{IN} \leq 22V$ $0.2A \leq I_{LOAD} \leq 2A$	3.3	3.168/ 3.135 3.432/ 3.465	V V_{MIN} V_{MAX}
	η	Efficiency	$V_{IN} = 12V, I_{LOAD}=2A$	78		%
AP1509-5V	V_{OUT}	Output voltage	$7V \leq V_{IN} \leq 22V$ $0.2A \leq I_{LOAD} \leq 2A$	5	4.8/ 4.75 5.2/ 5.25	V V_{MIN} V_{MAX}
	η	Efficiency	$V_{IN} = 12V, I_{LOAD}=2A$	83		%
AP1509-12V	V_{OUT}	Output voltage	$15V \leq V_{IN} \leq 22V$ $0.2A \leq I_{LOAD} \leq 2A$	12	11.52/ 11.4 12.48/ 12.6	V V_{MIN} V_{MAX}
	η	Efficiency	$V_{IN} = 15V, I_{LOAD} = 2A$	90		%

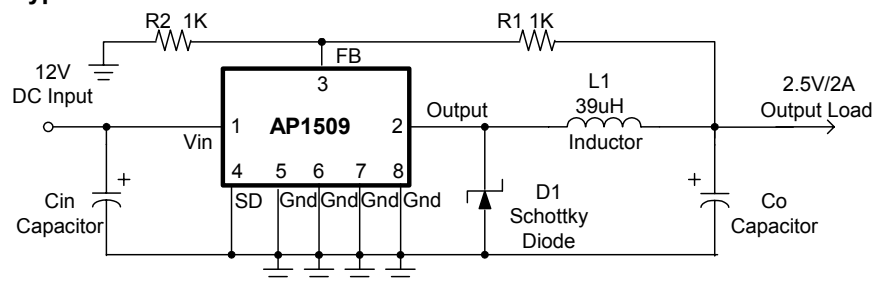
Specifications with **boldface type** are for full operating temperature range, the other type are for $T_J=25^{\circ}C$.

■ Typical Application Circuit

(1) Fixed Type Circuit



(2) Adjustable Type Circuit

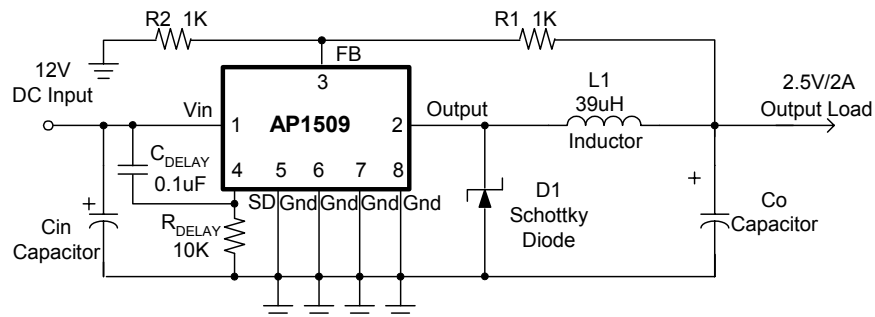


$$V_{out} = V_{FB} \times \left(1 + \frac{R1}{R2}\right)$$

$$V_{FB} = 1.23V$$

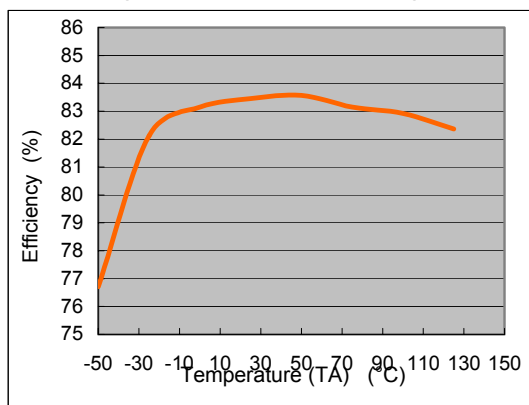
$$R2 = 1K \sim 3K$$

(3) Delay Start Circuit

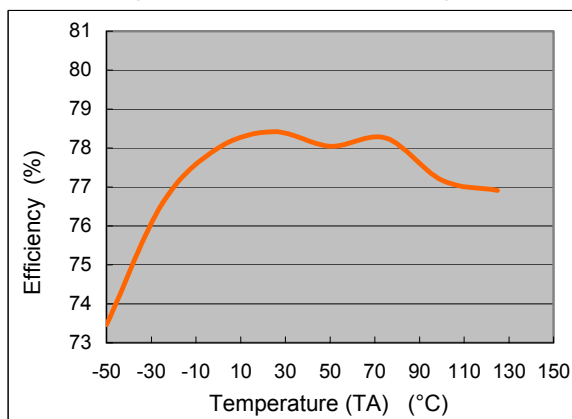


■ Typical Performance Characteristics

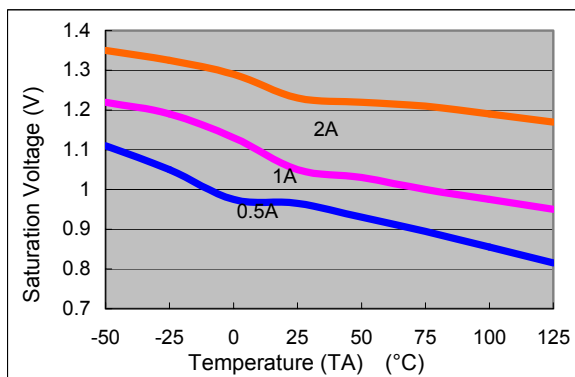
AP1509 Efficiency v.s. Temperature
($V_{in}=12V, V_{out}=5V, I_o=2A$)



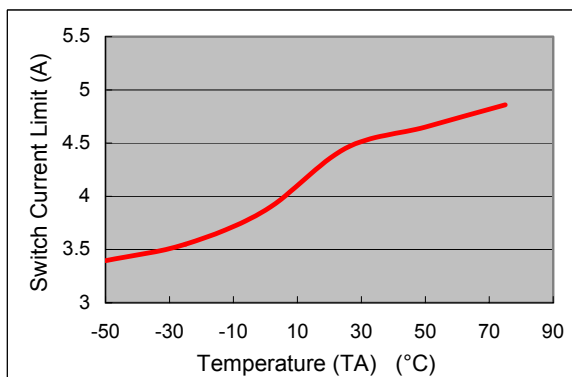
AP1509 Efficiency v.s. Temperature
($V_{in}=12V, V_{out}=3.3V, I_o=2A$)



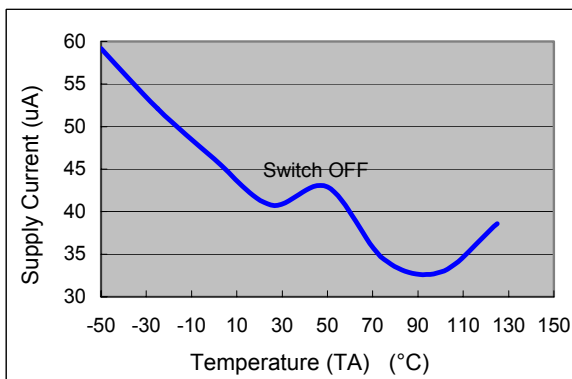
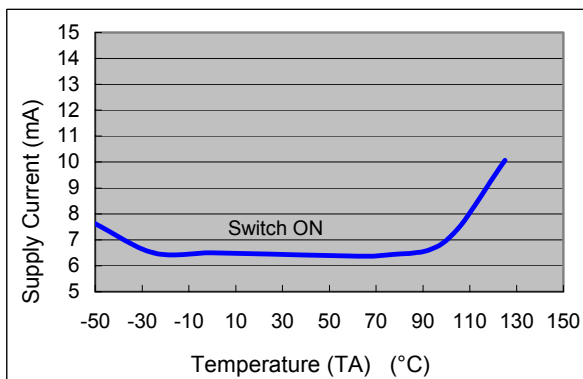
AP1509 Saturation Voltage v.s. Temperature
($V_{cc}=12V, V_{fb}=0V, V_{SD}=0$)



AP1509 Switch Current Limit v.s. Temperature
($V_{cc}=12V, V_{fb}=0V$)

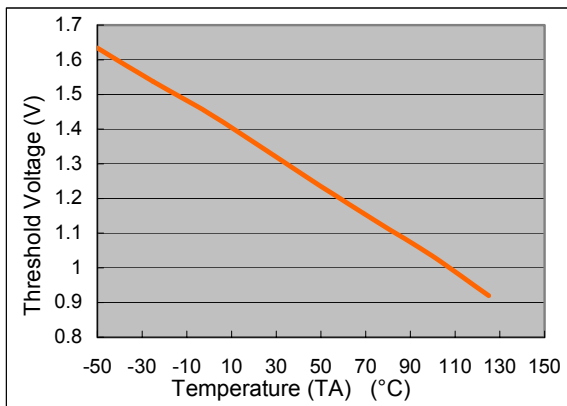


AP1509 Supply Current v.s. Temperature
($V_{cc}=12V$, No Load, $V_{on/off}=0V$ (Switch ON), $V_{on/off}=5V$ (Switch OFF))

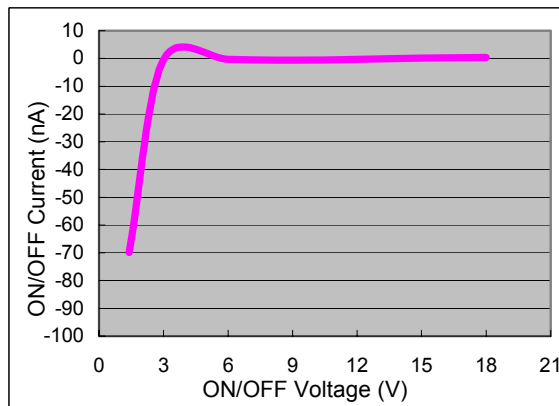


■ Typical Performance Characteristics (Continued)

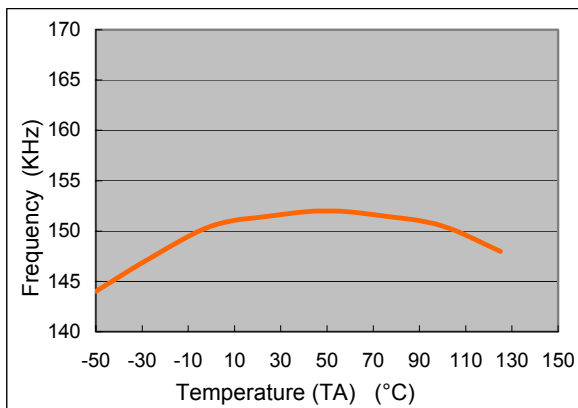
AP1509 Threshold Voltage v.s. Temperature
($V_{cc}=12V$, $I_o=100mA$)



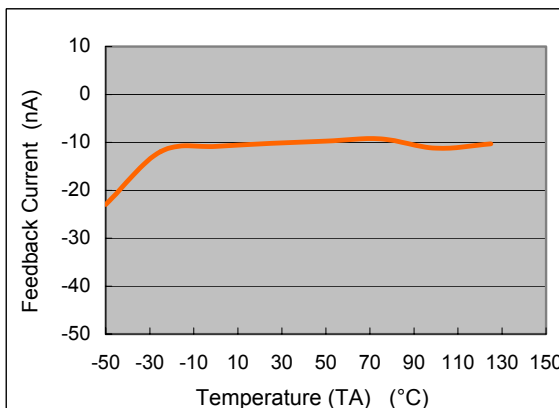
AP1509 ON/OFF Current v.s. ON/OFF Voltage
($V_{in}=12V$)



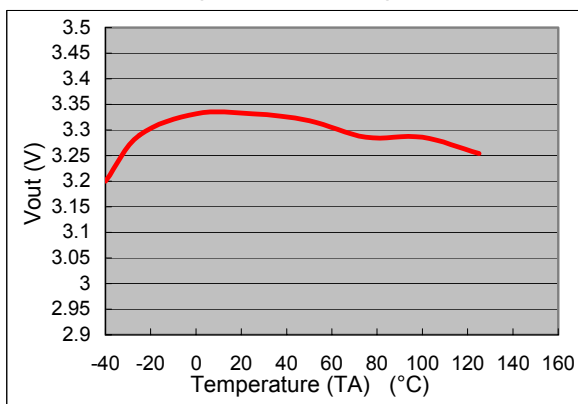
AP1509 Frequency v.s. Temperature
($V_{cc}=12V$, $I_o=500mA$, $V_{out}=5V$)



AP1509 Feedback Current v.s. Temperature
($V_{cc}=12V$, $V_{out}=5V$, $V_{fb}=1.3V$)



AP1509 Output Voltage v.s. Temperature
($V_{in}=12V$, $I_o=2A$)



■ Function Description

Pin Functions

+V_{IN}

This is the positive input supply for the IC switching regulator. A suitable input bypass capacitor must be presented at this pin to minimize voltage transients and to supply the switching currents needed by the regulator.

Ground

Circuit ground.

Output

Internal switch. The voltage at this pin switches between $(+V_{IN} - V_{SAT})$ and approximately $-0.5V$, with a duty cycle of approximately V_{OUT} / V_{IN} . To minimize coupling to sensitive circuitry, the PC board copper area connected to this pin should be minimized.

Feedback

Senses the regulated output voltage to complete the feedback loop.

SD

Allows the switching regulator circuit to be shutdown using logic level signals thus dropping the total input supply current to approximately 150uA. Pulling this pin below a threshold voltage of approximately 1.3V turns the regulator on, and pulling this pin above 1.3V (up to a maximum of 18V) shuts the regulator down. If this shutdown feature is not needed, the SD pin can be wired to the ground pin.

Thermal Considerations

The SOP-8 package needs a heat sink under most conditions. The size of the heatsink depends on the input voltage, the output voltage, the load current and the ambient temperature. The AP1509 junction temperature rises above ambient temperature for a 2A load and different input and output voltages. The data for these curves was taken with the AP1509 (SOP-8 package) operating as a buck-switching regulator in an ambient temperature of 25°C (still air). These temperature increments are all approximate and are affected by many factors. Higher ambient temperatures requires more heat sinker.

For the best thermal performance, wide copper traces and generous amounts of printed circuit board copper should be used in the board layout. (One exception is the output (switch) pin, which should not have large areas of copper.) Large areas of copper provide the best transfer of heat (lower thermal resistance) to the surrounding air, and moving air lowers the thermal resistance even further.

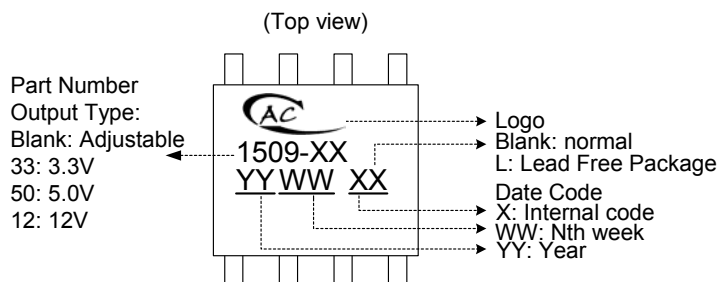
Package thermal resistance and junction temperature increments are all approximate. The increments are affected by a lot of factors. Some of these factors include board size, shape, thickness, position, location, and even board temperature. Other factors are, trace width, total printed circuit copper area, copper thickness, single or double-sided, multi-layer board and the amount of solder on the board.

The effectiveness of the PC board to dissipate heat also depends on the size, quantity and spacing of other components on the board, as well as whether the surrounding air is still or moving. Furthermore, some of these components such as the catch diode will add heat to the PC board and the heat can vary as the input voltage changes. For the inductor, depending on the physical size, type of core material and the DC resistance, it could either act as a heat sink taking heat away from the board, or it could add heat to the board.

150KHz, 2A PWM Buck DC/DC Converter

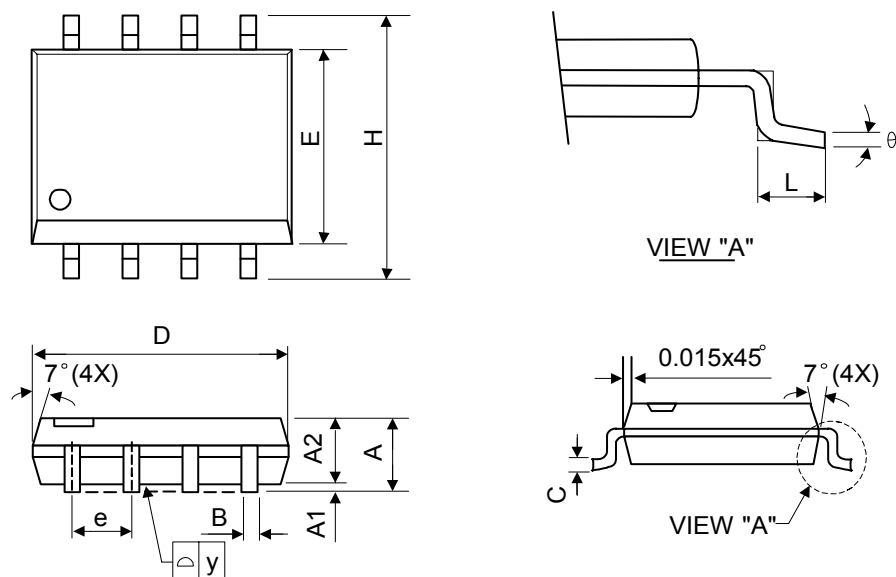
■ Marking Information

SOP-8L



■ Package Information

Package Type: SOP-8L



Symbol	Dimensions In Millimeters			Dimensions In Inches		
	Min.	Nom.	Max.	Min.	Nom.	Max.
A	1.40	1.60	1.75	0.055	0.063	0.069
A1	0.10	-	0.25	0.040	-	0.100
A2	1.30	1.45	1.50	0.051	0.057	0.059
B	0.33	0.41	0.51	0.013	0.016	0.020
C	0.19	0.20	0.25	0.0075	0.008	0.010
D	4.80	5.05	5.30	0.189	0.199	0.209
E	3.70	3.90	4.10	0.146	0.154	0.161
e	-	1.27	-	-	0.050	-
H	5.79	5.99	6.20	0.228	0.236	0.244
L	0.38	0.71	1.27	0.015	0.028	0.050
y	-	-	0.10	-	-	0.004
θ	0°	-	8°	0°	-	8°