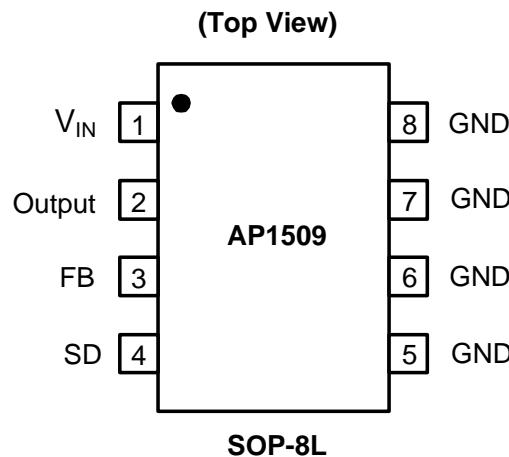

Description

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



Features

- Output Voltage: 3.3V, 5V, 12V and Adjustable Output Version
- Adjustable Version Output Voltage Range, 1.23V to 18V+4%
- 150KHz +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
- SOP-8L: Available in "Green" Molding Compound (No Br, Sb)
- Lead Free Finish/ RoHS Compliant (Note 1)

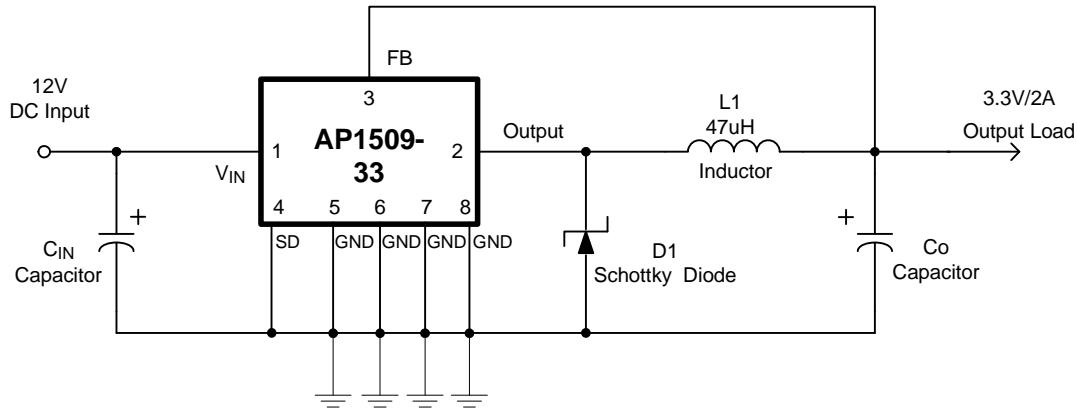
Applications

- Simple High-Efficiency Step-Down Regulator
- On-Card Switching Regulators
- Positive to Negative Converter

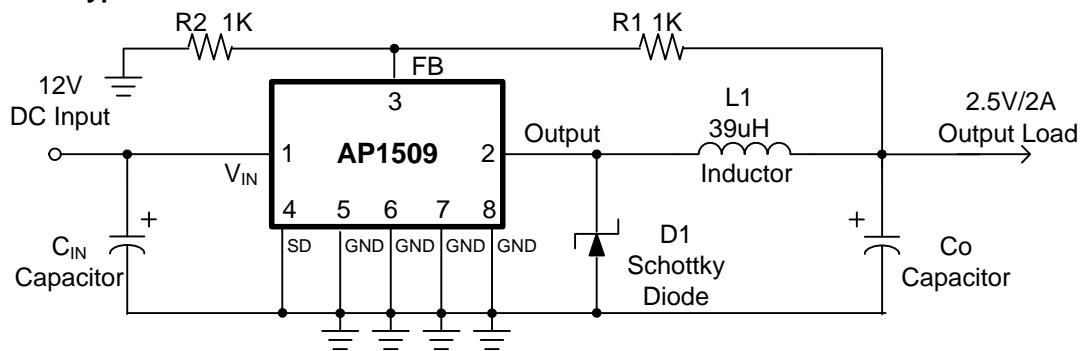
Notes: 1. EU Directive 2002/95/EC (RoHS). All applicable RoHS exemptions applied. Please visit our website at http://www.diodes.com/products/lead_free.html.

Typical Application Circuit

(1) Fixed Type Circuit



(2) Adjustable Type Circuit

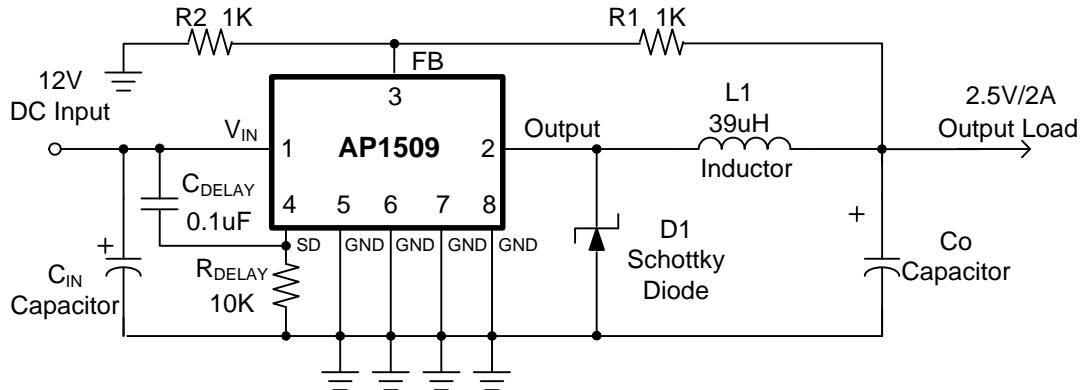


$$V_{OUT} = V_{FB} \times \left(1 + \frac{R1}{R2}\right)$$

$$V_{FB} = 1.23V$$

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

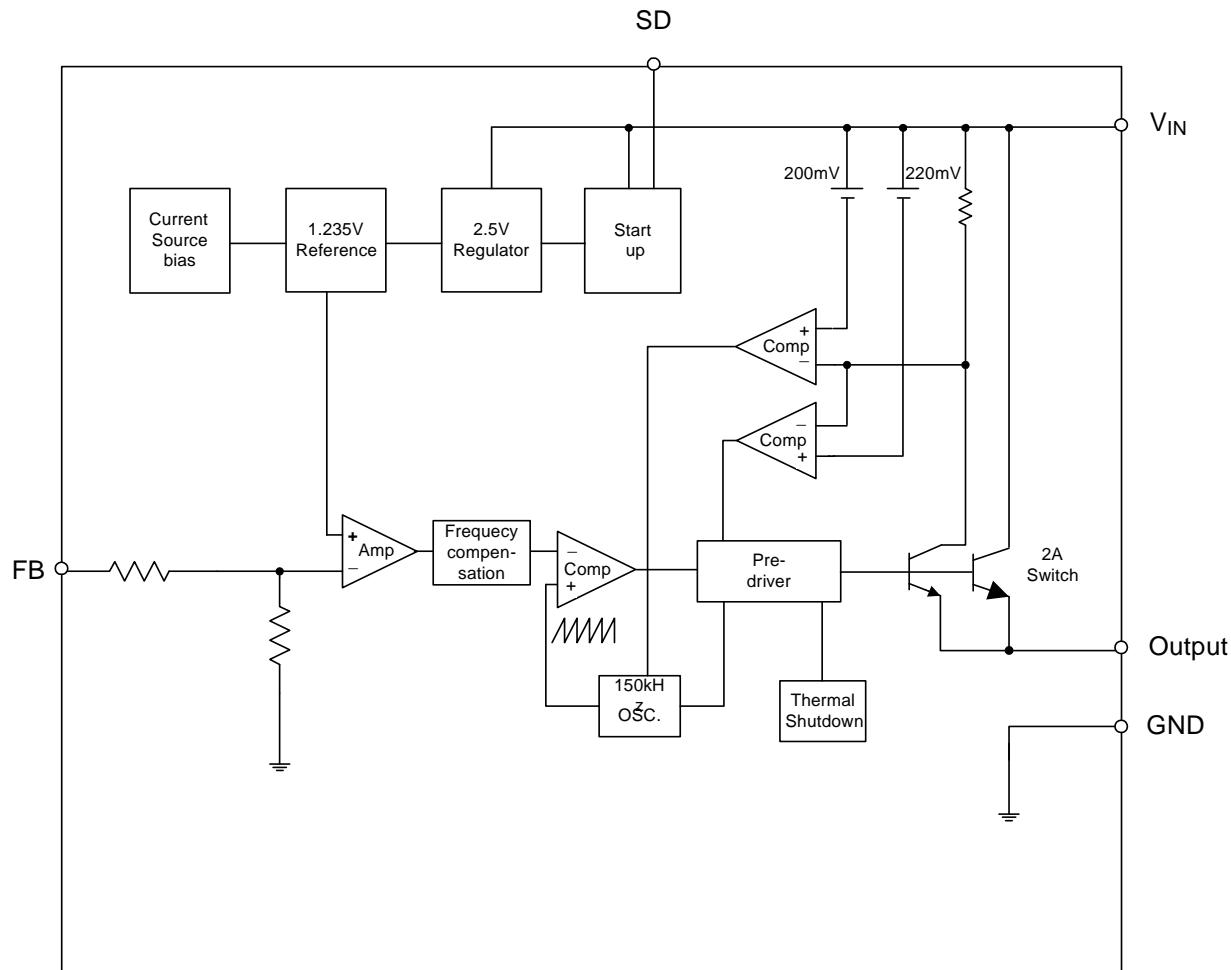
(3) Delay Start Circuit



Pin Descriptions

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

Functional Block Diagram



Absolute Maximum Ratings

Symbol	Parameter	Rating	Unit
ESD HBM	Human Body Model ESD Protection	2	KV
ESD MM	Machine Model ESD Protection	200	V
V_{IN}	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_J	Operating Junction Temperature	-40 to +125	°C

Recommended Operating Conditions

Symbol	Parameter	Min	Max	Unit
I_{OUT}	Output Current	0	2	A
V_{OP}	Operating Voltage	4.5	22	V
T_A	Operating Ambient Temperature	-20	85	°C

Electrical Characteristics

Unless otherwise specified, $V_{IN} = 12V$ for 3.3V, 5V, adjustable version and $V_{IN} = 18V$ for the 12V version. $I_{LOAD} = 0.5A$. Specifications with **boldface type** are for full operating temperature range, the other type are for $T_J = 25^{\circ}C$.

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	150	173	KHz
				110		173	
F_{SCP}	Oscillator Frequency of Short Circuit Protect	When current limit occurred and $V_{FB} < 0.5V$, $T_a = 25^{\circ}C$		10	30	50	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	No outside circuit $V_{FB} = 12V$ force driver off			-200	uA
	Output = -1	Current	$V_{IN} = 22V$		-5		mA
I_Q	Quiescent Current	$V_{FB} = 12V$ force driver off			5	10	mA
I_{STBY}	Standby Quiescent Current	$V_{IN} = 22V$			70	150 200	uA
						0.6	
V_{IL}	ON/OFF Pin Logic Input Threshold Voltage	Low (regulator ON)		-	1.3	0.6	V
V_{IH}		High (regulator OFF)		2.0		-	
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_{JA}	Thermal Resistance	SOP-8L	Junction to case		15		°C/W
θ_{JC}	Thermal Resistance with a copper area of approximately 3 in ²	SOP-8L	Junction to ambient		70		°C/W

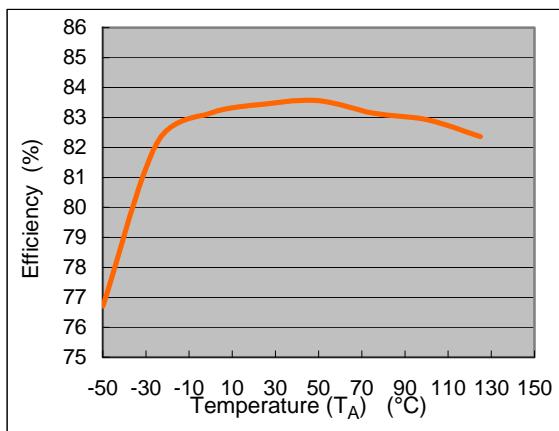
Electrical Characteristics (Continued)

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

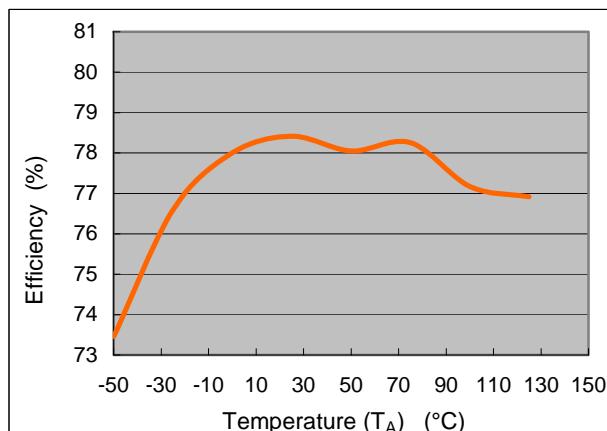
	Symbol	Parameter	Conditions	V_{Min}	Typ.	V_{Max}	Unit
AP1509-ADJ	V_{FB}	Output Feedback	$4.5V \leq V_{\text{IN}} \leq 22V$ $0.2A \leq I_{\text{LOAD}} \leq 2A$ V_{OUT} programmed for 3V	1.193 1.18	1.23	1.267 1.28	V
	η	Efficiency	$V_{\text{IN}} = 12V$, $I_{\text{LOAD}} = 2A$	76	76		%
AP1509-3.3V	V_{OUT}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

Typical Performance Characteristics

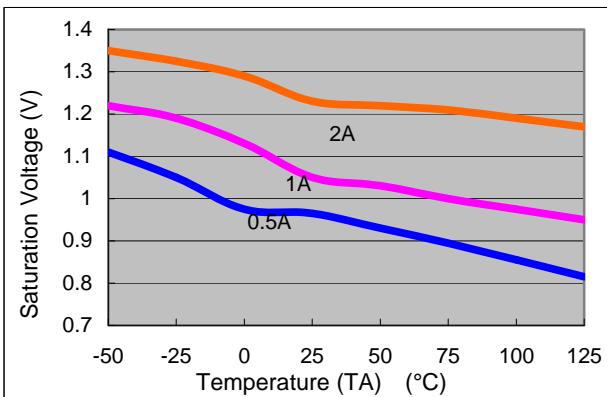
AP1509 Efficiency vs. Temperature
($V_{IN}=12V$, $V_{OUT}=5V$, $I_o=2A$)



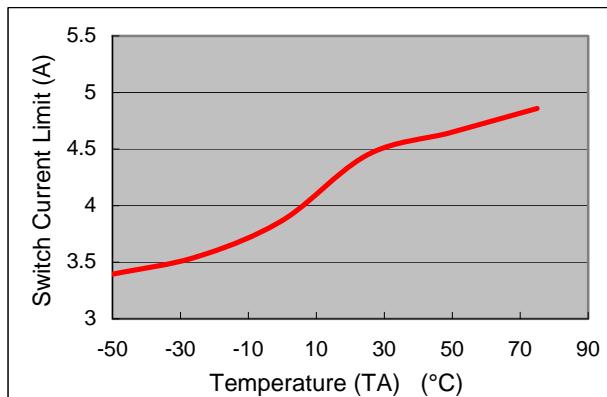
AP1509 Efficiency vs. Temperature
($V_{IN}=12V$, $V_{OUT}=3.3V$, $I_o=2A$)



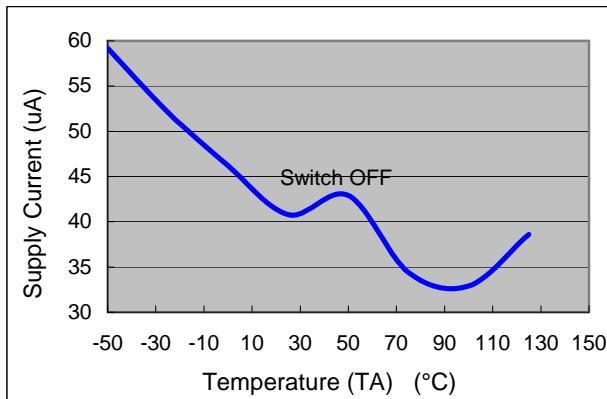
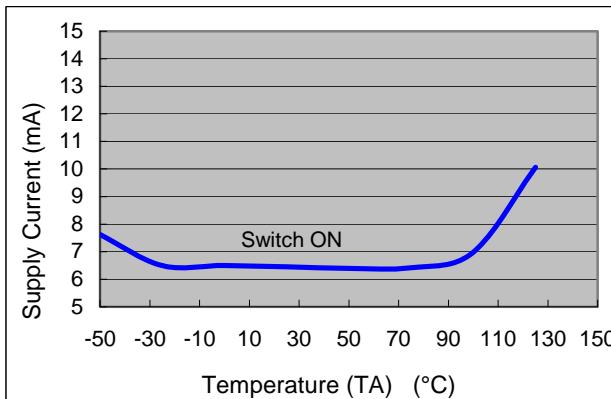
AP1509 Saturation Voltage vs. Temperature
($V_{IN} = 12V$, $V_{FB}=0V$, $V_{SD}=0$)



AP1509 Switch Current Limit vs. Temperature
($V_{IN}=12V$, $V_{FB}=0V$)

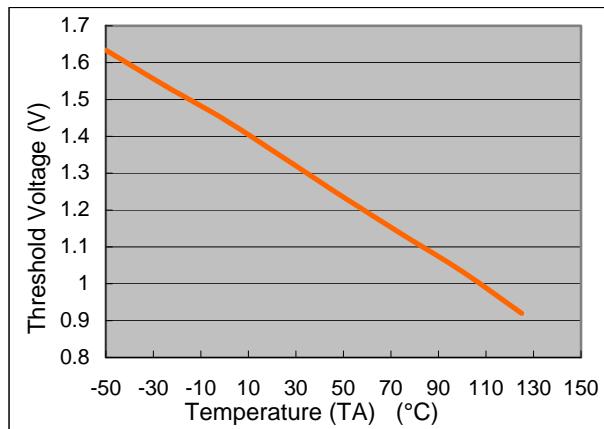


AP1509 Supply Current vs. Temperature
($V_{IN}=12V$, No Load, Von/off =0V(Switch ON) ,Von/off =5V(Switch OFF))

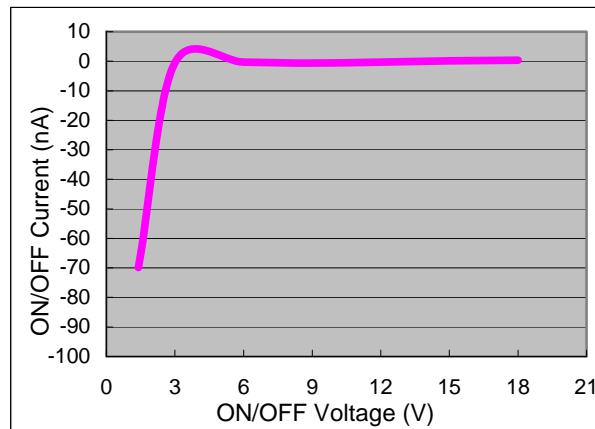


Typical Performance Characteristics (Continued)

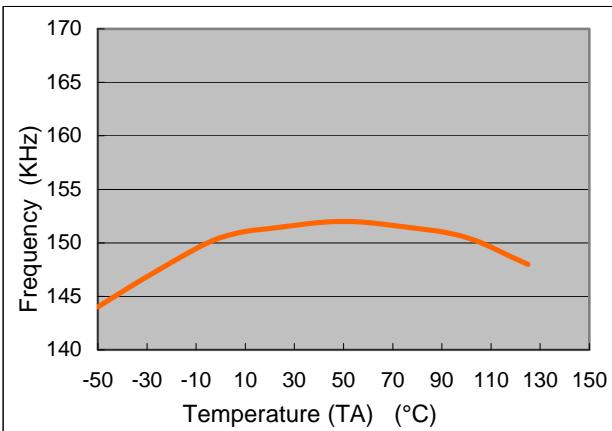
AP1509 Threshold Voltage vs. Temperature
($V_{IN}=12V$, $I_o=100mA$)



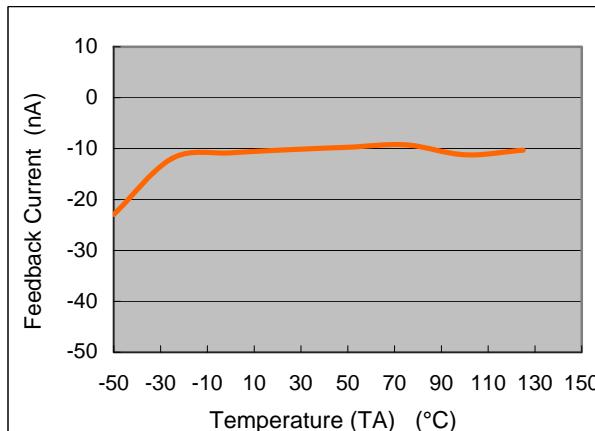
AP1509 ON/OFF Current vs. ON/OFF Voltage
($V_{IN}=12V$)



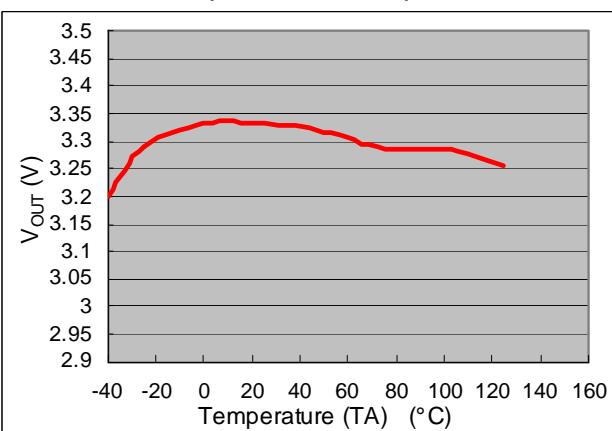
AP1509 Frequency vs. Temperature
($V_{IN}=12V$, $I_o=500mA$, $V_{OUT}=5V$)



AP1509 Feedback Current vs. Temperature
($V_{IN}=12V$, $V_{OUT}=5V$, $V_{fb}=1.3V$)

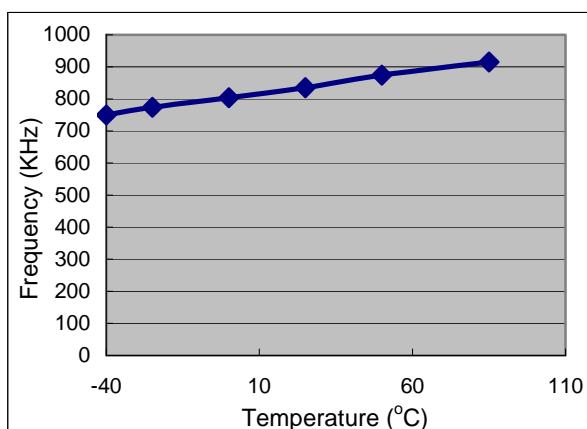


AP1509 Output Voltage vs. Temperature
($V_{IN}=12V$, $I_o=2A$)

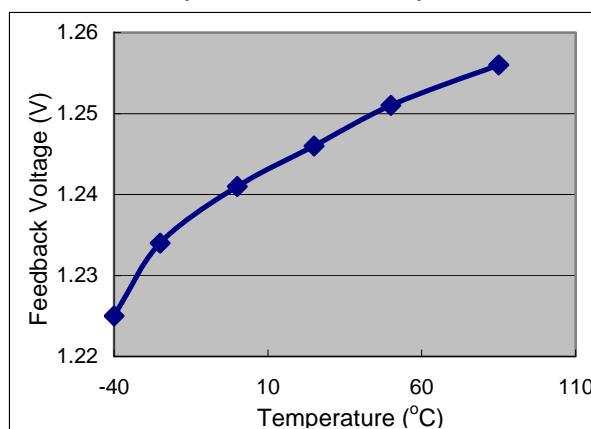


Typical Performance Characteristics (Continued)

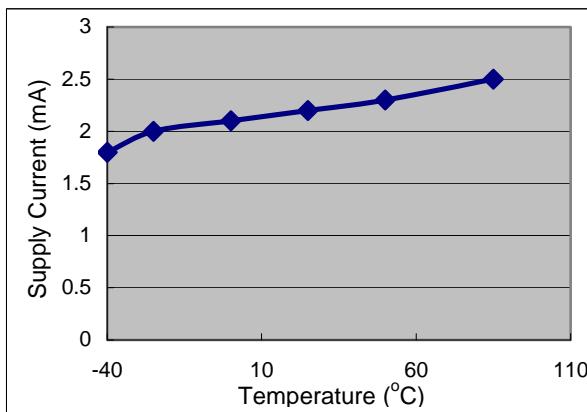
Header Frequency vs. Temperature



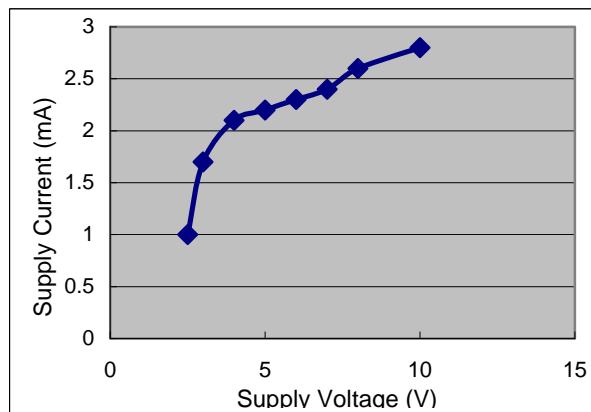
**Feedback Voltage vs. Temperature
($V_{IN}=15V$, $V_{OUT}=5V$)**



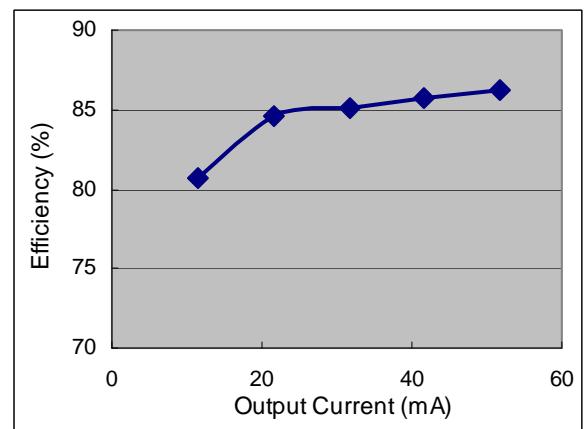
**Supply Current vs. Temperature
($V_{IN}=15V$, $V_{OUT}=5V$, $I_{OUT}=0A$)**



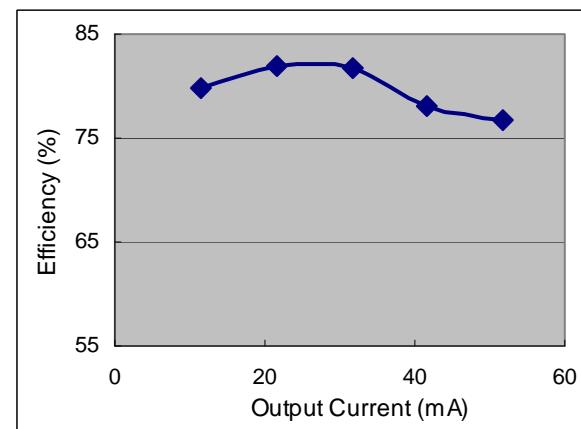
**Supply Current vs. Supply Voltage
($V_{IN}=15V$, $V_{OUT}=5V$, $I_{OUT}=0A$)**



**Efficiency vs. Output Current
($V_{IN}=15V$, $V_{OUT}=5V$)**



**Efficiency vs. Output Current
($V_{IN}=15V$, $V_{OUT}=3.3V$)**



Functions 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

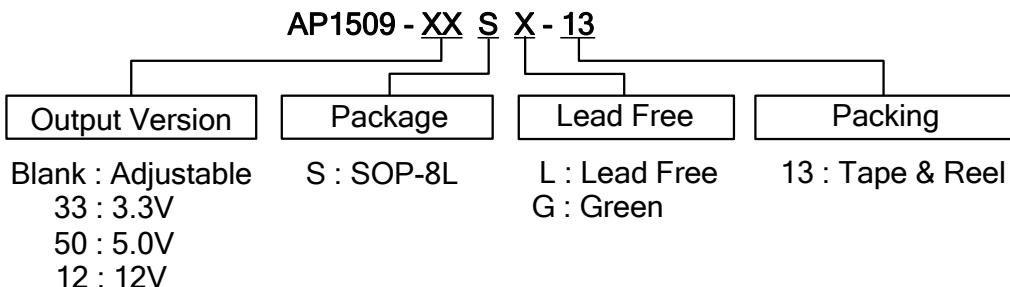
The SOP-8L package needs a heat sink under most conditions. The size of the heat sink depends on the input voltage, the output voltage, the load current and the ambient temperature. The AP1509 junction temperature rises above ambient temperature for a 2A load and different input and output voltages.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

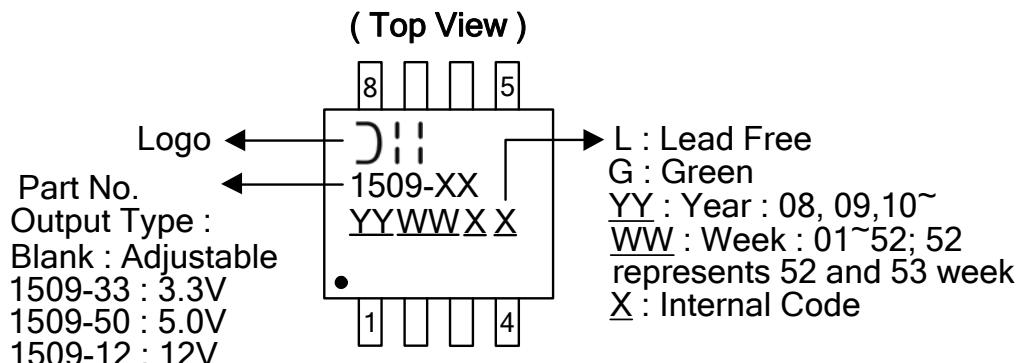
Ordering Information



Device	Package Code	Packaging (Note 2)	13" Tape and Reel	
			Quantity	Part Number Suffix
AP1509-XXSL-13	S	SOP-8L	2500/Tape & Reel	-13
AP1509-XXSG-13	S	SOP-8L	2500/Tape & Reel	-13

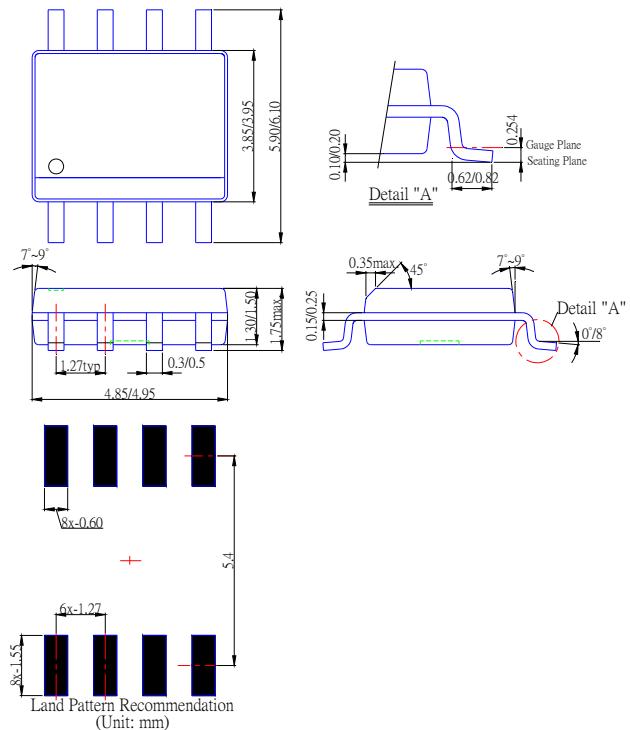
Notes: 2. Pad layout as shown on Diodes Inc. suggested pad layout document AP02001, which can be found on our website at <http://www.diodes.com/datasheets/ap02001.pdf>.

Marking Information

(1) SOP-8L


Package Outline Dimensions (All Dimensions in mm)

(1) Package Type: SOP-8L



IMPORTANT NOTICE

DIODES INCORPORATED MAKES NO WARRANTY OF ANY KIND, EXPRESS OR IMPLIED, WITH REGARDS TO THIS DOCUMENT, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE (AND THEIR EQUIVALENTS UNDER THE LAWS OF ANY JURISDICTION).

Diodes Incorporated and its subsidiaries reserve the right to make modifications, enhancements, improvements, corrections or other changes without further notice to this document and any product described herein. Diodes Incorporated does not assume any liability arising out of the application or use of this document or any product described herein; neither does Diodes Incorporated convey any license under its patent or trademark rights, nor the rights of others. Any Customer or user of this document or products described herein in such applications shall assume all risks of such use and will agree to hold Diodes Incorporated and all the companies whose products are represented on Diodes Incorporated website, harmless against all damages.

Diodes Incorporated does not warrant or accept any liability whatsoever in respect of any products purchased through unauthorized sales channel.

Should Customers purchase or use Diodes Incorporated products for any unintended or unauthorized application, Customers shall indemnify and hold Diodes Incorporated and its representatives harmless against all claims, damages, expenses, and attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized application.

Products described herein may be covered by one or more United States, international or foreign patents pending. Product names and markings noted herein may also be covered by one or more United States, international or foreign trademarks.

LIFE SUPPORT

Diodes Incorporated products are specifically not authorized for use as critical components in life support devices or systems without the express written approval of the Chief Executive Officer of Diodes Incorporated. As used herein:

- A. Life support devices or systems are devices or systems which:
 1. are intended to implant into the body, or
 2. support or sustain life and whose failure to perform when properly used in accordance with instructions for use provided in the labeling can be reasonably expected to result in significant injury to the user.
- B. A critical component is any component in a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or to affect its safety or effectiveness.

Customers represent that they have all necessary expertise in the safety and regulatory ramifications of their life support devices or systems, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of Diodes Incorporated products in such safety-critical, life support devices or systems, notwithstanding any devices- or systems-related information or support that may be provided by Diodes Incorporated. Further, Customers must fully indemnify Diodes Incorporated and its representatives against any damages arising out of the use of Diodes Incorporated products in such safety-critical, life support devices or systems.

Copyright © 2010, Diodes Incorporated

www.diodes.com