## General Description

The AP1509 is a monolithic IC designed for a step-down DC/DC converter, and own the ability of driving a 3A 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.
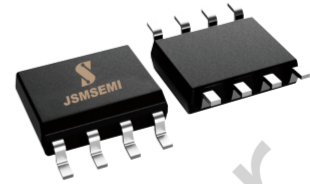
The AP1509 operates at a switching frequency of 150KHz thus allow smaller sized filter components than what would be needed with lower frequency switching regulators. Other features include a guaranteed ±4% tolerance on output voltage under specified input voltage and output load conditions, and ±15% on the oscillator frequency.

The chips are available in a standard 8-lead SOP8 package.

Features

- 3.3V, 5V, 12V and Adjustable Output Version
- Output Adjustable Voltage From 1.23V to 37V
- Fixed 150KHz Switching Frequency
- Voltage Mode Non-synchronous PWM Control
- ON/OFF Shutdown Control Input
- Wide 4.5V to 40V Input Voltage Range
- Output Load Current: 3A
- Low Power Standby Mode
- Built-in Switching Transistor on Chip

Application

- Simple High-Efficiency Step-down Regulator
- On-card Switching Regulators
- Positive to Negative Converter

Pin Configuration

(Top View)

VIN 1   8 GND
Output 2   7 GND
FB 3   6 GND
EN 4   5 GND
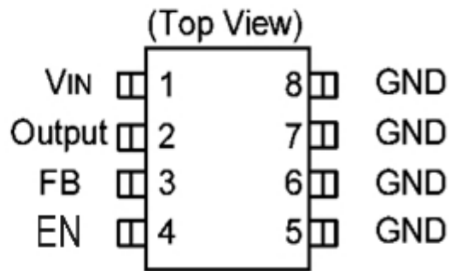
SOP8

Pin Descriptions

Name	Description
V_{IN}	Supply Voltage Input
Output	Power Switching Output
GND	Ground
FB	Output Voltage Feedback Control
EN	ON/OFF Shutdown

Block Diagram
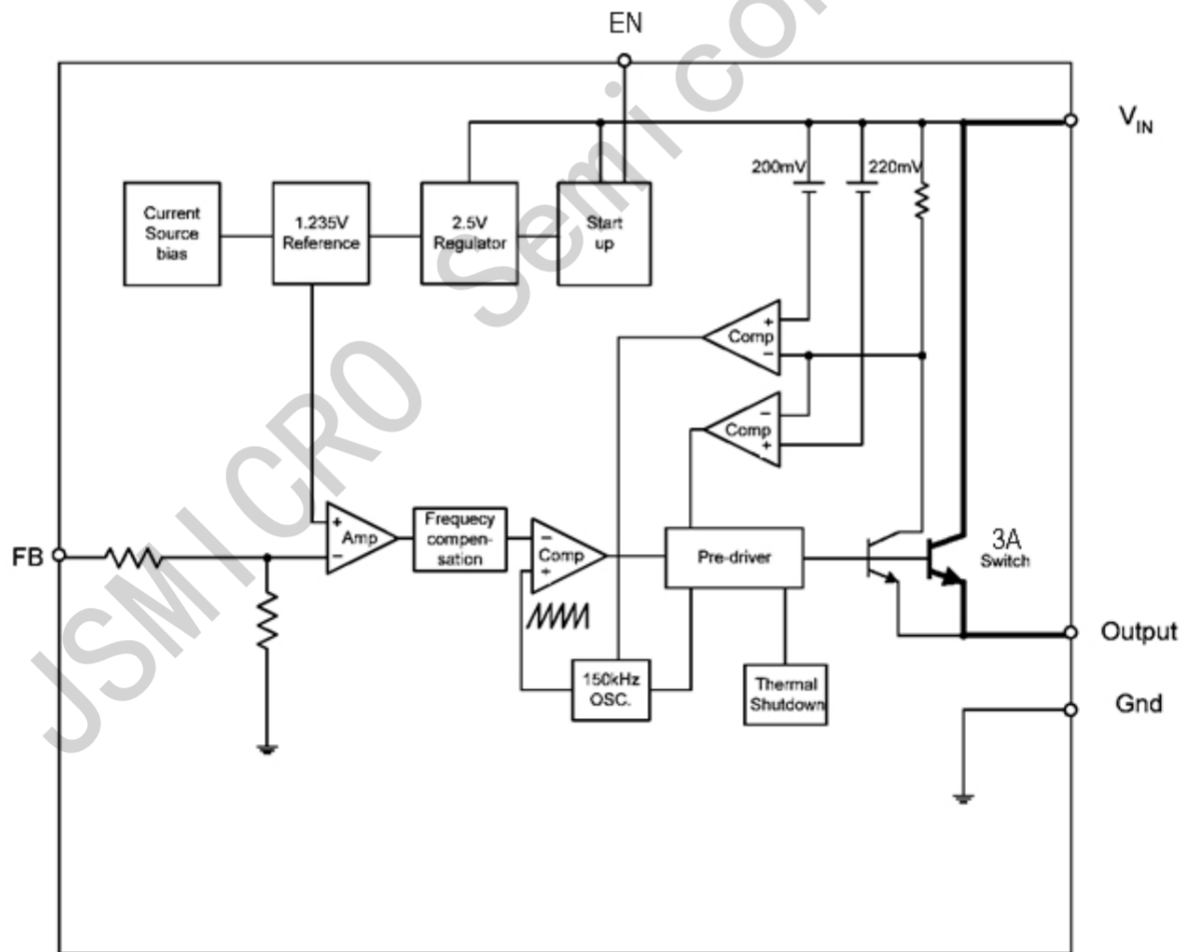
Absolute Maximum Ratings

Characteristics	Symbol	Value	Unit
Supply Voltage	V_{IN}	+40	V
ON/OFF pin input voltage	V_{SD}	$-0.3 \sim V_{IN}$	V
Feedback pin voltage	V_{FB}	$-0.3 \sim V_{IN}$	V
Output voltage to ground	V_{OUT}	-1	V
Power dissipation	PD	Internally limited	W
Storage temperature	Tstg	$-65 \sim +150$	°C
Operating temperature	Topr	$-40 \sim +125$	°C
Operating voltage	V_{OP}	$+4.5 \sim +40$	V

Electrical Characteristics

(Refer to the test circuit, V_{IN}=12V for 3.3V, 5V, adjustable version and V_{IN}=24V for the 12V version, I_{LOAD}=0.5A)

Characteristics	Symbol	Test Conditions	Min	Typ	Max	Unit
Feedback Bias Current	I_{FB}	V_{FB}=1.3V (Adjustable version only)		50	100	nA
Oscillator Frequency	Fosc		127	150	173	kHz
Saturation Voltage	V_{SAT}	I_{OUT}=2A, No outside circuit V_{FB}=0V force driver on		1.2	1.5	V
Max. Duty Cycle(ON)	DC	V_{FB}=0V force driver on	93	98		%
Min. Duty Cycle(OFF)		V_{FB}=12V force driver off		0		
Current Limit	I_{CL}	Peak current, No outside circuit V_{FB}=0V force driver on	3.0	4.0		A
Output Leakage Current (Output=0)	I_L	No outside circuit V_{FB}=12V force driver off			2	mA
Output Leakage Current (Output=-1)		V_{IN}=40V		5	20	mA
Quiescent Current	I_Q	V_{FB}=12V force driver off		5	10	mA
Standby Quiescent Current	I_{STBY}	ON/OFF pin=5V V_{IN}=40V		50	200	μA
ON/OFF pin Logic Input Threshold Voltage	V_{IL}	Low(regulator ON)			0.6	V
	V_{IH}	High(regulator OFF)	2.0			
ON/OFF pin Logic Input Current	I_H	V_{LOGIC}=5.0V(OFF)		12	30	μA
ON/OFF pin Input Current	I_L	V_{LOGIC}=0.5V(ON)		0	10	
Thermal Resistance	Θ_{JC}	Junction to case		15		°C/W
Thermal Resistance with Copper Area of Aapproximately 3 in²	Θ_{JA}	Junction to ambient		70		°C/W

Continue:

Characteristics	Symbol	Test Conditions	Min	Typ	Max	Unit
AP1509-SG-13						
Output Feedback	V_{FB}	4.5V≤V_{IN}≤40V 0.2A≤I_{LOAD}≤3A V_{OUT} programmed for 3V	1.193	1.230	1.267	V
Efficiency	η	V_{IN}=12V, I_{LOAD}=3A		74		%
AP1509-33SG-13						
Output Voltage	V_{OUT}	4.75V≤V_{IN}≤40V 0.2A≤I_{LOAD}≤3A	3.168	3.300	3.432	V
Efficiency	η	V_{IN}=12V, I_{LOAD}=3A		76		%
AP1509-50SG-13						
Output Voltage	V_{OUT}	7V<V_{IN}<40V 0.2A≤I_{LOAD}≤3A	4.80	5.00	5.20	V
Efficiency	η	V_{IN}=12V, I_{LOAD}=3A		83		%
AP1509-12SG-13						
Output Voltage	V_{OUT}	15V≤V_{IN}≤40V 0.2A≤I_{LOAD}≤3A	11.52	12.00	12.48	V
Efficiency	η	V_{IN}=25V, I_{LOAD}=3A		90		%

Function Description

Pin Function +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.

EN

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 shuts the regulator down. If this shutdown feature is not needed, the EN pin can be wired to the ground pin.

Thermal Considerations

The SOP8 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 3A load and different input and output voltages. The data for these curves was taken with the AP1509 (SOP8 package) operating as a buck-switching regulator in an ambient temperature of 25ºC (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.
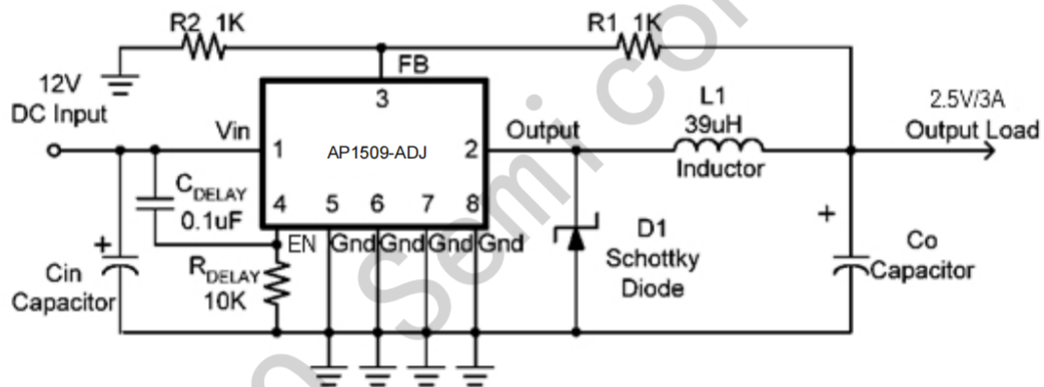
Application Circuit

Fixed Type Circuit
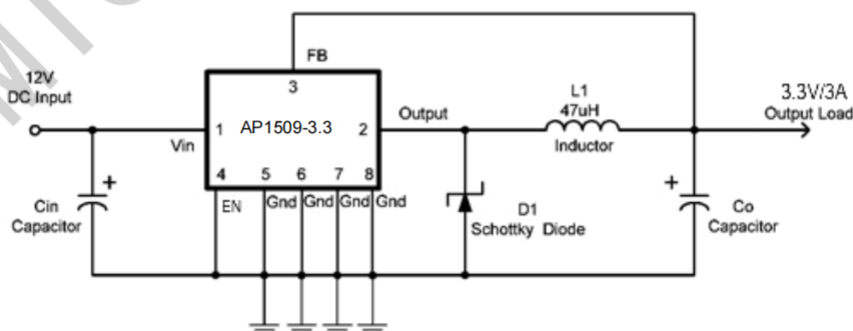
Adjustable Type Circuit

$$\text{Vout} = V_{FB} \times (1 + \frac{R1}{R2})$$

$V_{FB} = 1.23V$

$R2 = 1K \sim 3K$
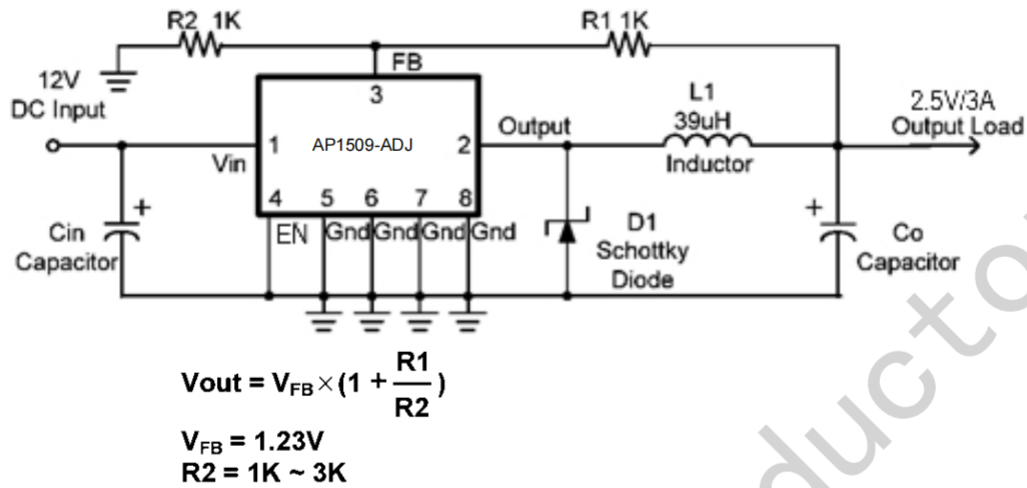
Delay Start Circuit

Schottky Diode Selection Table

Current	Surface Mount	Through Hole	VR (The same as system maximum input voltage)				
			20V	30V	40V	50V	60V
1A		√	1N5817	1N5818	1N5819		
3A		√	1N5820	1N5821	1N5822		
		√	MBR320	MBR330	MBR340	MBR350	MBR360
	√		SK32	SK33	SK34	SK35	SK36
	√			30WQ03	30WQ04	30WQ05	
		√		31DQ03	31DQ04	31DQ05	
		√	SR302	SR303	SR304	SR305	SR306

AP1509 Series Buck Regulator Design Procedure (Fixed Output)

Conditions			Inductor (L1)	Output Capacitor (COUT)			
				Through Hole Electrolytic		Surface Mount Tantalum	
Output Voltage (V)	Load Current (A)	Max Input Voltage (V)	Inductance (uh)	Panasonic HFQ Series (uf/V)	Nichicon PL Series (uf/V)	AVX TPS Series (uf/V)	Sprague 595D Series (uf/V)
3.3	3	6	22	470/25	470/35	330/6.3	390/6.3
		10	33	330/35	330/35	330/6.3	390/6.3
		40	47	330/35	270/50	220/10	330/10
5	3	9	22	470/25	560/16	220/10	330/10
		20	68	180/35	180/35	100/10	270/10
		40	68	180/35	180/35	100/10	270/10
12	3	15	33	330/25	330/25	100/16	180/16
		20	68	180/25	180/25	100/16	120/20
		40	150	82/25	82/25	68/20	68/25

AP1509 Series Buck Regulator Design Procedure (Adjustable Output)

Output Voltage (V)	Through Hole Output Electrolytic			Surface Mount Output Capacitor		
	Panasonic HFQ Series (uf/V)	Nichicon PL Series (uf/V)	Feedforward Capacitor	AVX TPS Series (uf/V)	Sprague 595D Series (uf/V)	Feedforward Capacitor
2	820/35	820/35	33nf	330/6.3	470/4	33nf
4	560/35	470/35	10nf	330/6.3	390/6.3	10nf
6	470/25	470/35	3.3nf	220/10	330/10	3.3nf
9	330/25	330/25	1.5nf	100/16	180/16	1.5nf
12	330/25	330/25	1nf	100/16	180/16	1nf
15	220/25	220/35	680pf	68/20	120/20	680pf
24	220/35	150/35	560pf	33/25	33/25	220pf
28	100/50	100/50	390pf	10/35	15/50	220pf

Outline Drawing

SOIC-8 Package Outlines

SECTION B-B
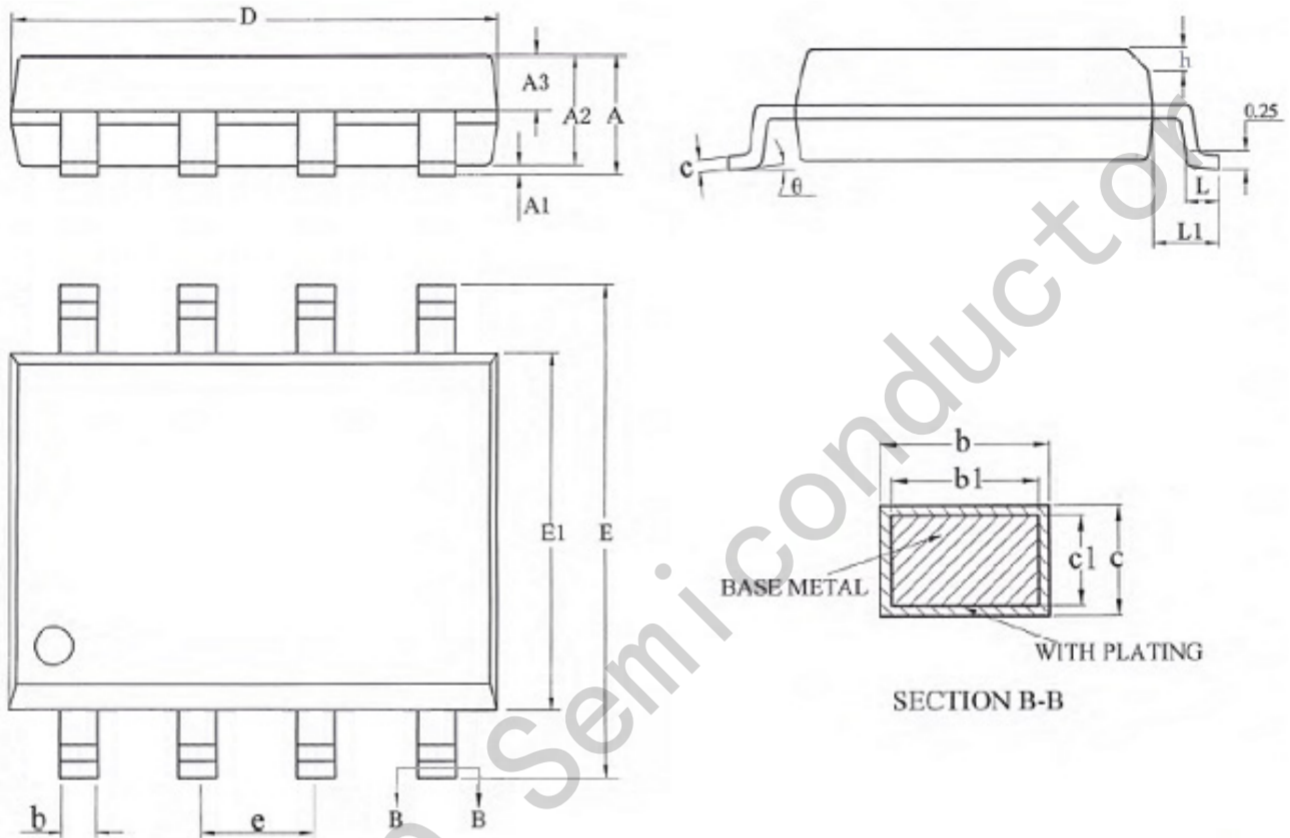
SOIC-8 Package Dimensions

Size Symbol	MIN(mm)	TYP(mm)	MAX(mm)	Size Symbol	MIN(mm)	TYP(mm)	MAX(mm)
A	-	-	1.75	D	4.70	4.90	5.10
A1	0.10	-	0.225	E	5.80	6.00	6.20
A2	1.30	1.40	1.50	E1	3.70	3.90	4.10
A3	0.60	0.65	0.70	e		1.27BSC	
b	0.39	-	0.48	h	0.25	-	0.50
b1	0.38	0.41	0.43	L		0.50	
c	0.21	-	0.26	L1	1.05BSC		
c1	0.19	0.20	0.21	θ	0	-	8°

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