Description

The AP1507 is a monolithic IC designed for a step-down DC/DC converter and is capable of driving a 3A load without an external transistor. Due to reducing the number of external components, the board space can be saved easily.

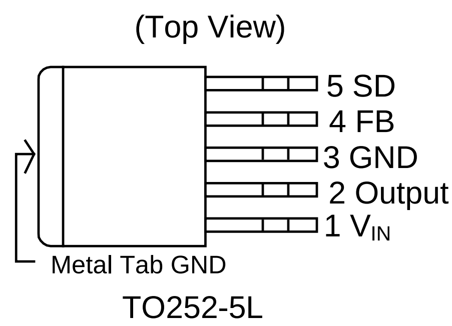
The external shutdown function can be controlled by logic level and then go into standby mode. The internal compensation makes the feedback control have good line and load regulation without an external design. Regarding the protected function, the thermal shutdown prevents overtemperature operation from damaging the device, and current limit protects against overcurrent operation of the output switch. If the current limit function occurs, and V_{FB} is down to 0.5V below, the switching frequency reduces.

The AP1507 series operates at a switching frequency of 150kHz, which allows smaller-sized filter components than the requirements 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 output version included a fixed 3.3V, 5V, 12V, and an adjustable type.

AP1507 is available in a 5-lead TO-252 green 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 up to 22V
- Output Load Current: 3A
- Low Power Standby Mode
- Built-in Switching Transistor On Chip
- **Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)**
- **Halogen and Antimony Free. “Green” Device (Note 3)**

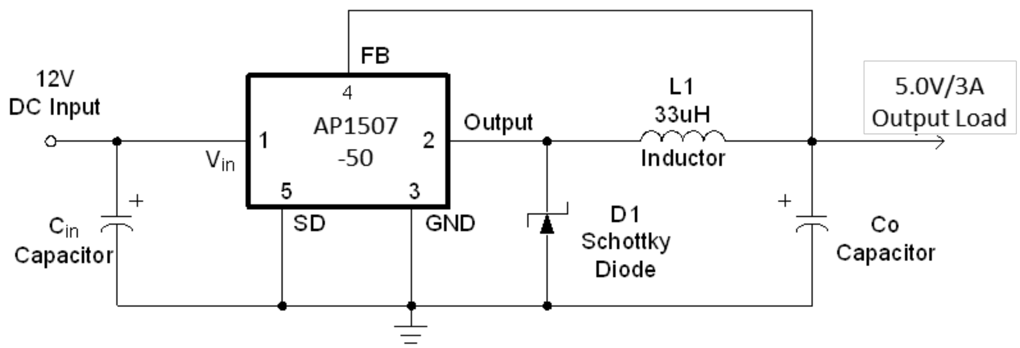
Applications

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

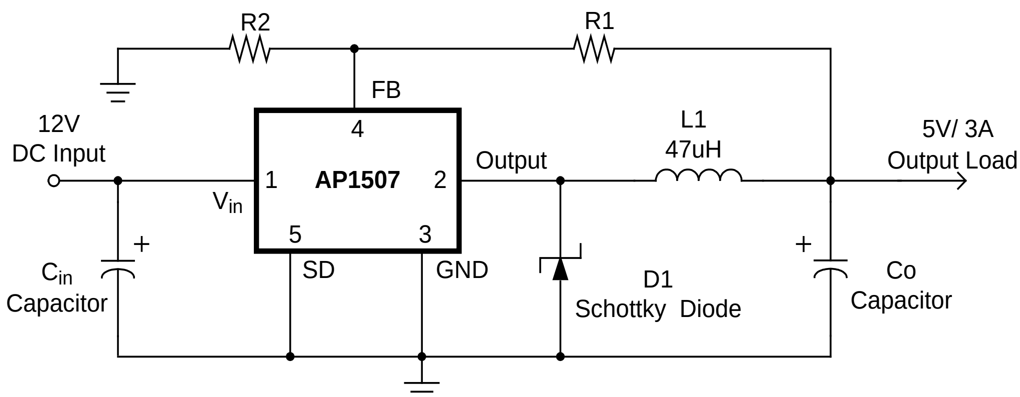
Notes: 1. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS), 2011/65/EU (RoHS 2) & 2015/863/EU (RoHS 3) compliant.
2. See https://www.diodes.com/quality/lead-free/ for more information about Diodes Incorporated’s definitions of Halogen- and Antimony-free, "Green" and Lead-free.
3. Halogen- and Antimony-free "Green" products are defined as those which contain <900ppm bromine, <900ppm chlorine (<1500ppm total Br + Cl) and <1000ppm antimony compounds.

Typical Application Circuit

(1) Fixed Type Circuit



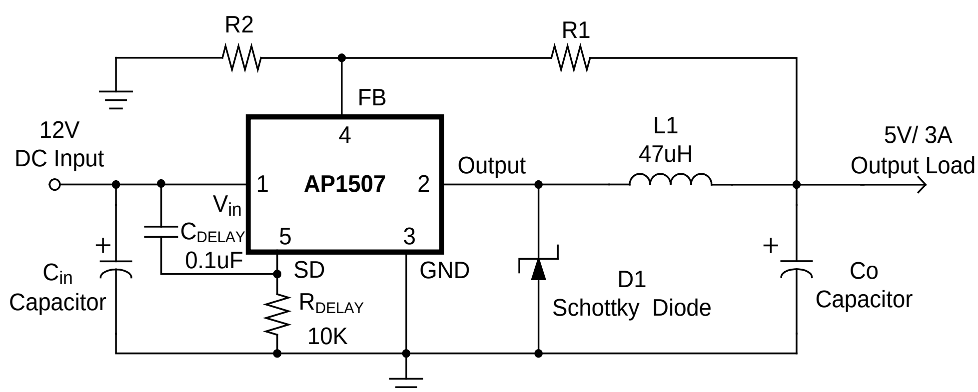
(2) Adjustable Type Circuit



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

V_{FB} = 1.23V, R2 = 1K ~ 3K

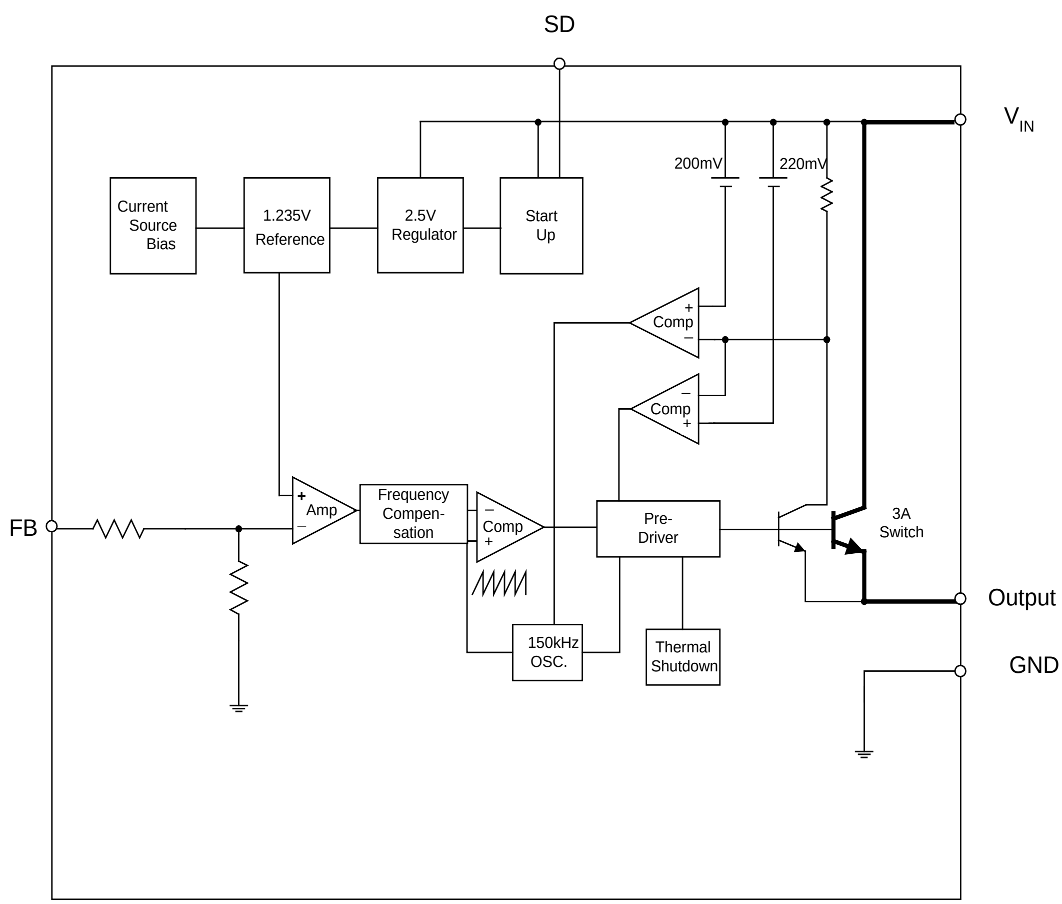
(3) Delay Start Circuit



Pin Descriptions

Pin Number	Pin Name	Description
1	V_{IN}	Operating Voltage Input
2	Output	Switching Output
3	GND	Ground
4	FB	Output Voltage Feedback Control
5	SD	ON / $\overline{\text{OFF}}$ Shutdown

Functional Block Diagram



Absolute Maximum Ratings ($T_A = 25°C$) (Note 4)

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

Note: 4. Stresses greater than the *Absolute Maximum Ratings* specified above, may cause permanent damage to the device. These are stress ratings only; functional operation of the device at these or any other conditions exceeding those indicated in this specification is not implied. Device reliability may be affected by exposure to absolute maximum rating conditions for extended periods of time.

Recommended Operating Conditions ($T_A = 25°C$)

Symbol	Parameter	Min	Max	Unit
I_{OUT}	Output Current	0	3	A
V_{OP}	Operating Voltage	4.5	22	V
T_A	Operating Ambient Temperature	-20	+85	°C

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
Specifications with **boldface type** are for full operating temperature range, the other type are for T_J = 25°C.

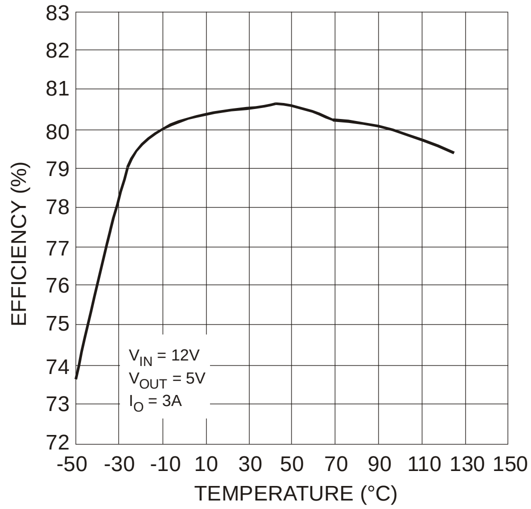
Symbol	Parameter	Conditions	Min	Typ	Max	Unit
I_{FB}	Feedback Bias Current	V_{FB} = 1.3V (Adjustable Version Only)	—	-10	-50 **-100**	nA
F_{OSC}	Oscillator Frequency	—	127 **110**	150 **—**	173 **173**	kHz
F_{SCP}	Oscillator Frequency of Short-Circuit Protect	When Current Limit Occurred and V_{FB} < 0.5V, T_A = 25°C	10	30	50	kHz
V_{SAT}	Saturation Voltage	I_{OUT} = 3A No Outside Circuit V_{FB} = 0V Force Driver On	—	1.4	1.6 **1.7**	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	3.6	4.5	5.5 6.5	A
I_{LEAK}	Output Leakage Current: Output = 0V	No Outside Circuit V_{FB} =12V Force Driver Off	—	—	-200	µA
	Output Leakage Current: Output = -1V	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**	µA
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	µA
I_L	ON/OFF Pin Input Current	V_{LOGIC} = 0.5V (ON)	—	-0.1	-1	
$θ_{JA}$	Thermal Resistance	TO252-5, Junction to Case	—	10	—	°C/W
$θ_{JC}$	Thermal Resistance (Copper Area of Approximately 2cm × 2cm)	TO252-5, Junction to Ambient	—	50	—	°C/W

Electrical Characteristics (All Output Voltage Versions)

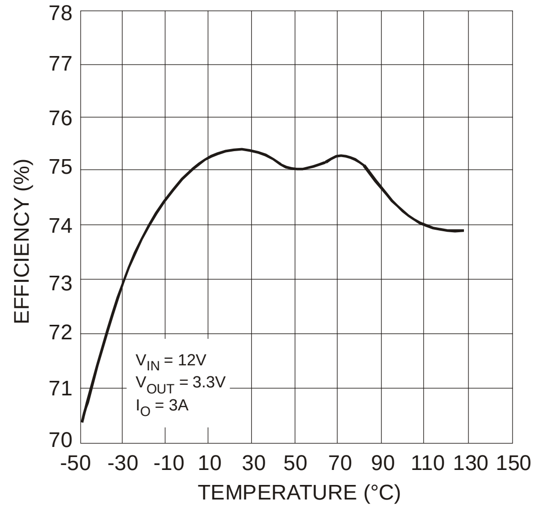
Specifications with **boldface type** are for full operating temperature range, the other type are for $T_J = 25ºC$.

—	Symbol	Parameter	Conditions	V_{MIN}	Typ.	V_{MAX}	Unit
AP1507-ADJ	V_{FB}	Output Feedback	$5V \leq V_{IN} \leq 22V$ $0.2A \leq I_{LOAD} \leq 3A$ V_{OUT} Programmed for 3V	1.193 **1.18**	1.23	1.267 **1.28**	V
	η	Efficiency	$V_{IN} = 12V$, $I_{LOAD} = 3A$	—	74	—	%
AP1507-3.3V	V_{OUT}	Output Voltage	$5.5V \leq V_{IN} \leq 22V$ $0.2A \leq I_{LOAD} \leq 3A$	3.168 **3.135**	3.3	3.432 **3.465**	V
	η	Efficiency	$V_{IN} = 12V$, $I_{LOAD} = 3A$	—	75	—	%
AP1507-5V	V_{OUT}	Output Voltage	$8V \leq V_{IN} \leq 22V$ $0.2A \leq I_{LOAD} \leq 3A$	4.8 **4.75**	5	5.2 **5.25**	V
	η	Efficiency	$V_{IN} = 12V$, $I_{LOAD} = 3A$	—	80	—	%
AP1507-12V	V_{OUT}	Output Voltage	$15V \leq V_{IN} \leq 22V$ $0.2A \leq I_{LOAD} \leq 3A$	11.52 **11.4**	12	12.48 **12.6**	V
	η	Efficiency	$V_{IN} = 16V$, $I_{LOAD} = 3A$		89		%

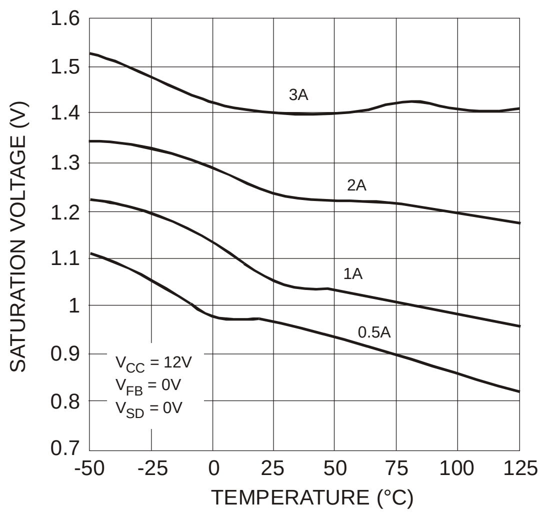
Typical Characteristics



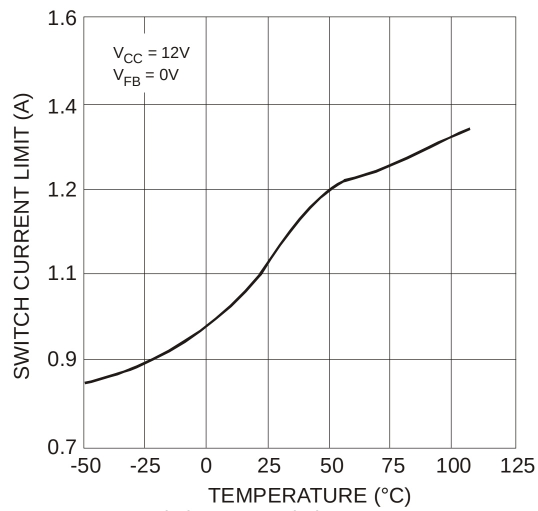
Efficiency vs. Temperature



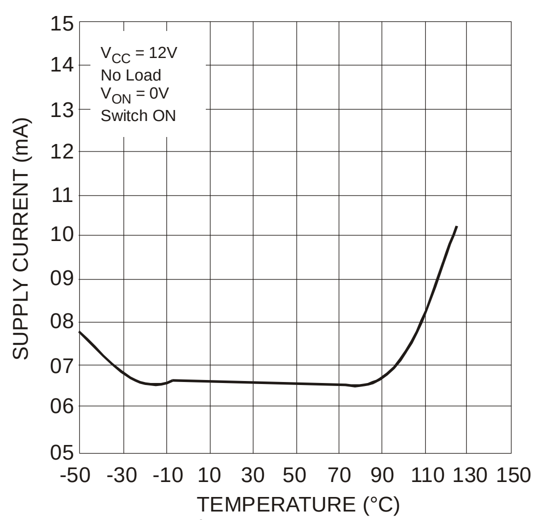
Efficiency vs. Temperature



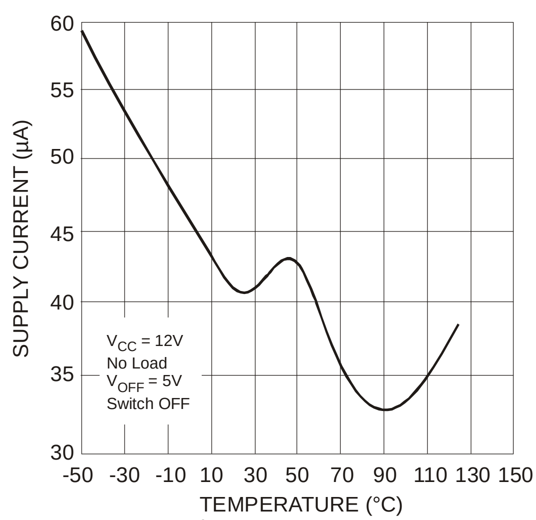
Saturation Voltage vs. Temperature



Switch Current Limit vs. Temperature

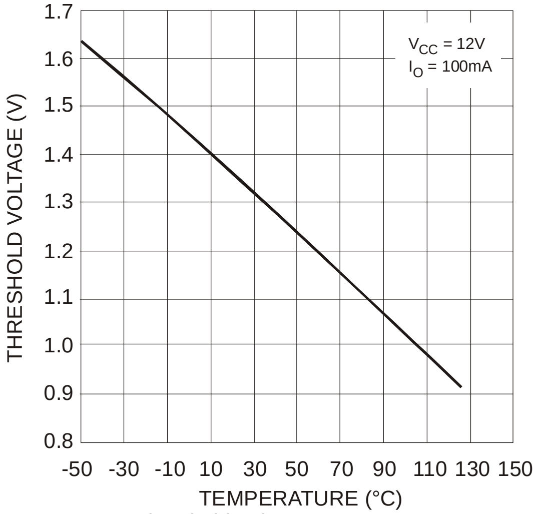


Supply Current vs. Temperature

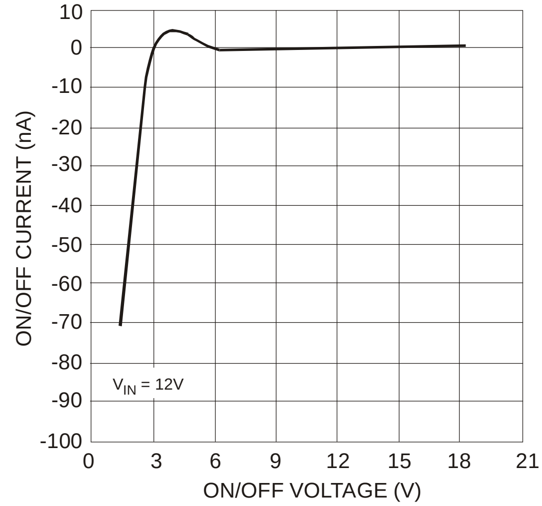


Supply Current vs. Temperature

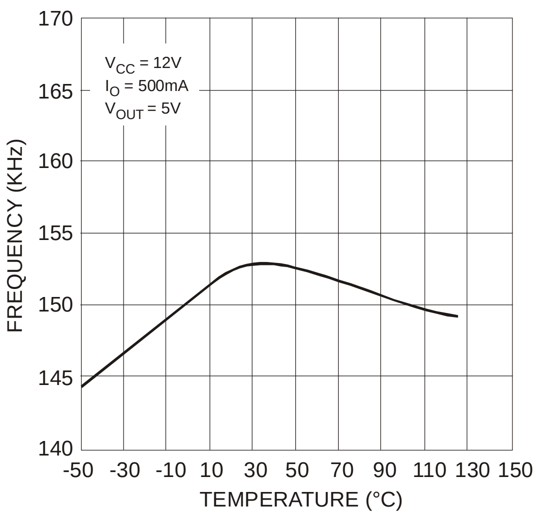
Typical Characteristics (continued)



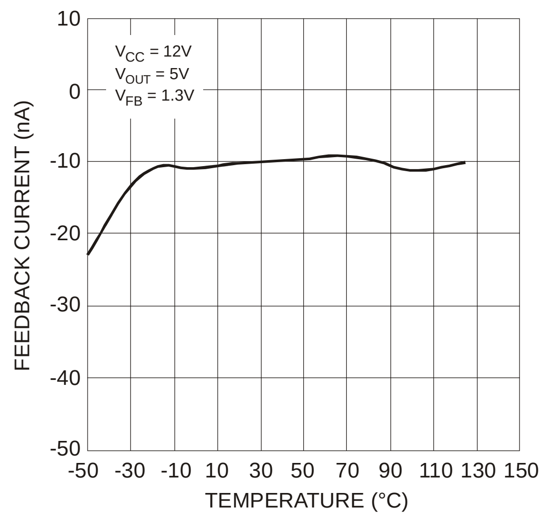
Threshold Voltage vs. Temperature



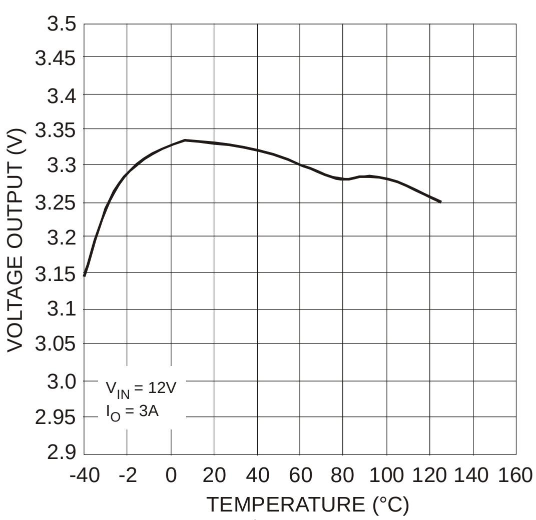
ON/OFF Current vs. ON/OFF Voltage



Frequency vs. Temperature



Feedback Current vs. Temperature



Output Voltage vs. Temperature

Application Information

Pin Functions

+V_{IN}
This is the positive input supply for the IC switching regulator. A suitable input bypass capacitor must be present 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 PCB copper area connected to this pin must be kept at a minimum.

Feedback (FB)
Senses the regulated output voltage to complete the feedback loop.

ON/OFF (SD)
Allows the switching regulator circuit to be shutdown using logic level signals thus dropping the total input supply current to approximately 150µA. 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 required, the ON/OFF pin can be wired to the ground pin.

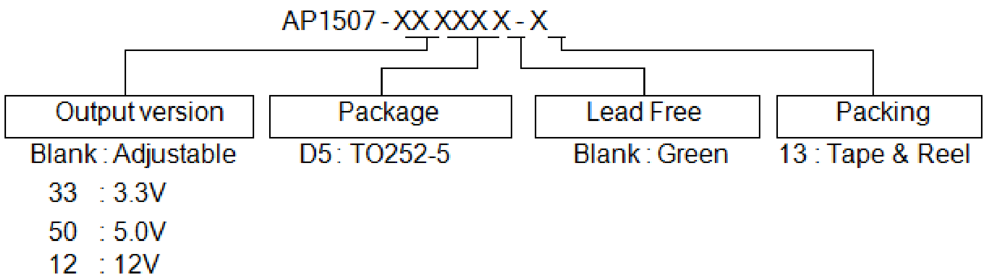
Thermal Considerations
The TO-252 surface mount package tab is designed to be soldered to the copper on a PCB. The copper and the board are the heat sink for this package and the other heat producing components, such as the catch diode and inductor. The PCB copper area that the package is soldered to should be at least 0.8 in^2 and ideally should have two or more square inches of 2oz additional copper area, which improves the thermal characteristics. With copper areas greater than approximately 6in^2, only small improvements in heat dissipation are realized. If further thermal improvements are required, double sided, multi-layer PCBs with large copper areas and/or airflow are recommended.

The AP1507 (TO-252 package) junction temperature rises above ambient temperature with a 3A load for various input and output voltages. This data was taken with the circuit operating as a buck-switching regulator with all components mounted on a PCB to simulate the junction temperature under actual operating conditions. This curve can be used for a quick check for the approximate junction temperature for various conditions, but there are many factors that can affect the junction temperature. When load currents higher than 3A are used, double-sided or multi-layer PCBs with large copper areas and/or airflow might be required, especially for high ambient temperatures and high output voltages.

For the best thermal performance, wide copper traces and generous amounts of PCB copper should be used in the board layout. One exception to this 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 rise numbers are all approximate, and there are many factors that will affect these numbers. Some of these factors include board size, shape, thickness, position, location, and even board temperature. Other factors are trace width, total PC copper area, copper thickness, single- or double-sided, multi-layer board, and the amount of solder on the board. The effectiveness of the PCB 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, add heat to the PCB, and the heat can vary as the input voltage changes. Depending on the physical size, type of core material, and the DC resistance, the inductor can either act as a heat sink taking heat away from the board, or it could add heat to the board.

Ordering Information

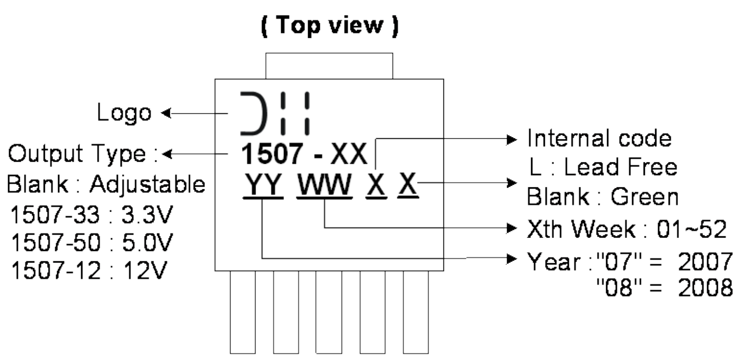


Device	Voltage (V)	Package Code	Package (Note 6)	Lead Free/Green	Quantity	Part Number Suffix		Status (Note 5)	Alternative
						Tube	13” Tape and Reel		
AP1507-12D5-13	12	K5	TO252-5	Green	800	NA	-13	End of Life	None
AP1507-33D5-13	3.3	K5	TO252-5	Green	800	NA	-13	End of Life	None
AP1507-50D5-13	5.0	K5	TO252-5	Green	800	NA	-13	In production	—
AP1507-D5-13	ADJ	K5	TO252-5	Green	800	NA	-13	In production	—

Notes: 5. All lead-free versions in TO252-5 are End of Life (EOL) with limited replacement.
All green versions with 12 V / 3.3 V output voltage are End of Life (EOL) without any alternative.
6. For packaging details, go to our website at: http://www.diodes.com/package-outlines.html.

Marking Information

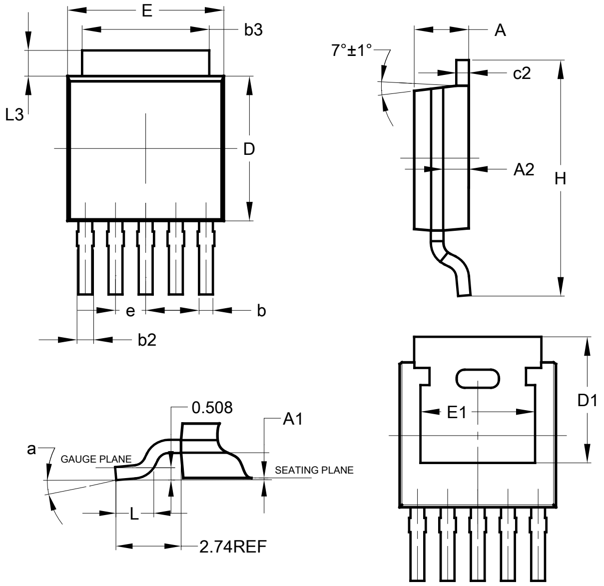
(1) TO252-5



Package Outline Dimensions (All Dimensions in mm)

Please see http://www.diodes.com/package-outlines.html for the latest version.

TO252-5

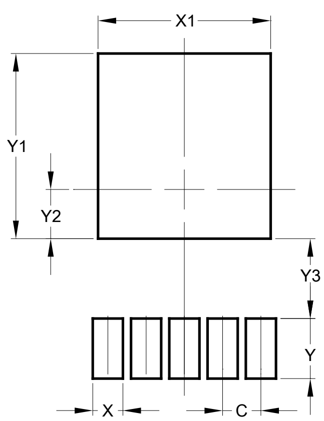


TO252-5			
Dim	**Min**	**Max**	**Typ**
A	2.19	2.39	2.29
A1	0.00	0.13	0.08
A2	0.97	1.17	1.07
b	0.51	0.71	0.583
b2	0.61	0.79	0.70
b3	5.21	5.46	5.33
c2	0.45	0.58	0.531
D	6.00	6.20	6.10
D1	5.21	—	—
e	—	—	1.27
E	6.45	6.70	6.58
E1	4.32	—	—
H	9.40	10.41	9.91
L	1.40	1.78	1.59
L3	0.88	1.27	1.08
a	0°	10°	—
All Dimensions in mm			

Suggested Pad Layout

Please see http://www.diodes.com/package-outlines.html for the latest version.

TO252-5



Dimensions	Value (in mm)
C	1.27
X	1.00
X1	5.73
Y	2.00
Y1	6.17
Y2	1.64
Y3	2.66