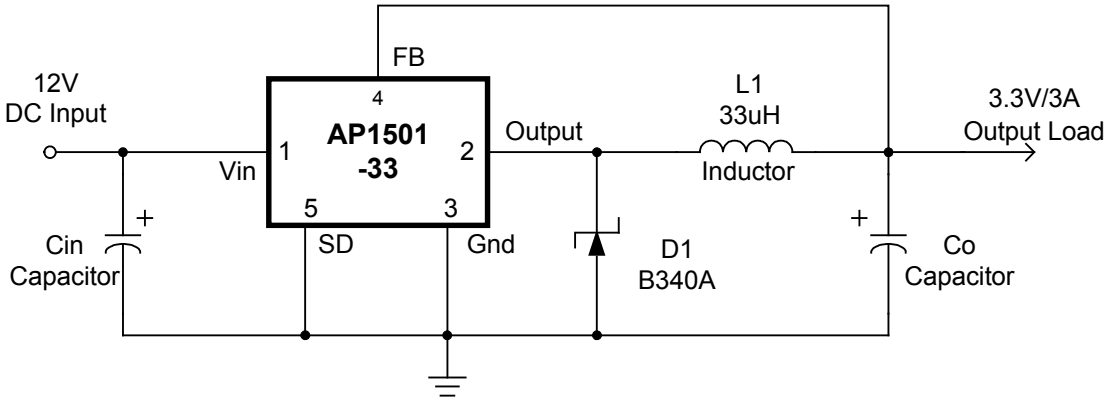
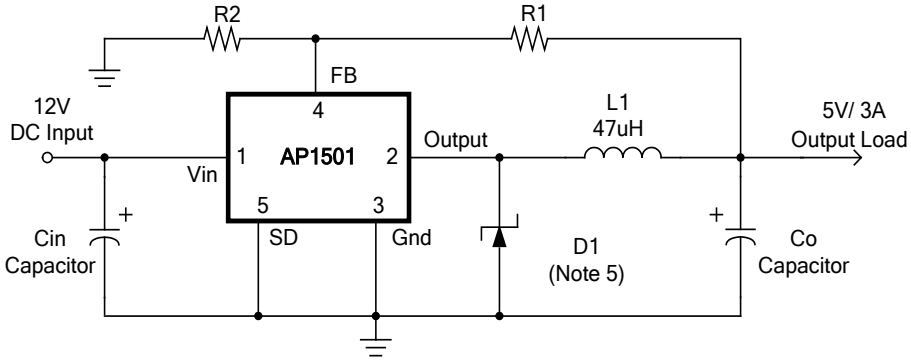
Typical Applications Circuit

(1) Fixed Type Circuit



Typical Applications Circuit (continued)

(2) Adjustable Type Circuit

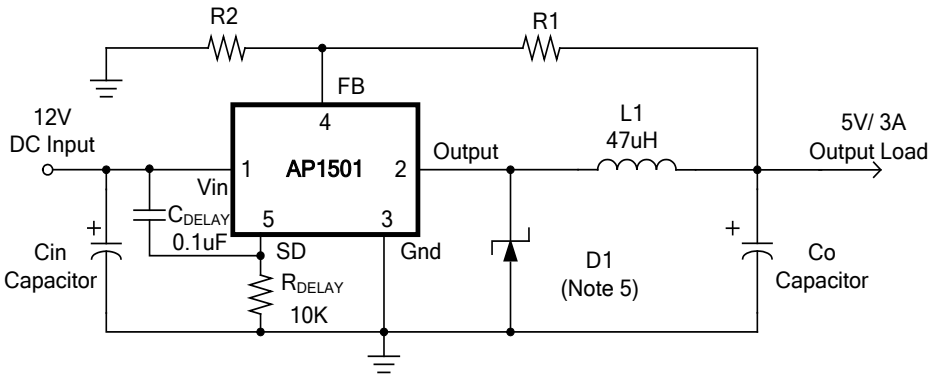


$$V_{out} = V_{FB} \times (1 + \frac{R1}{R2})$$

V_{FB} = 1.23V

R2 = 1K ~ 3K

(3) Delay Start Circuit

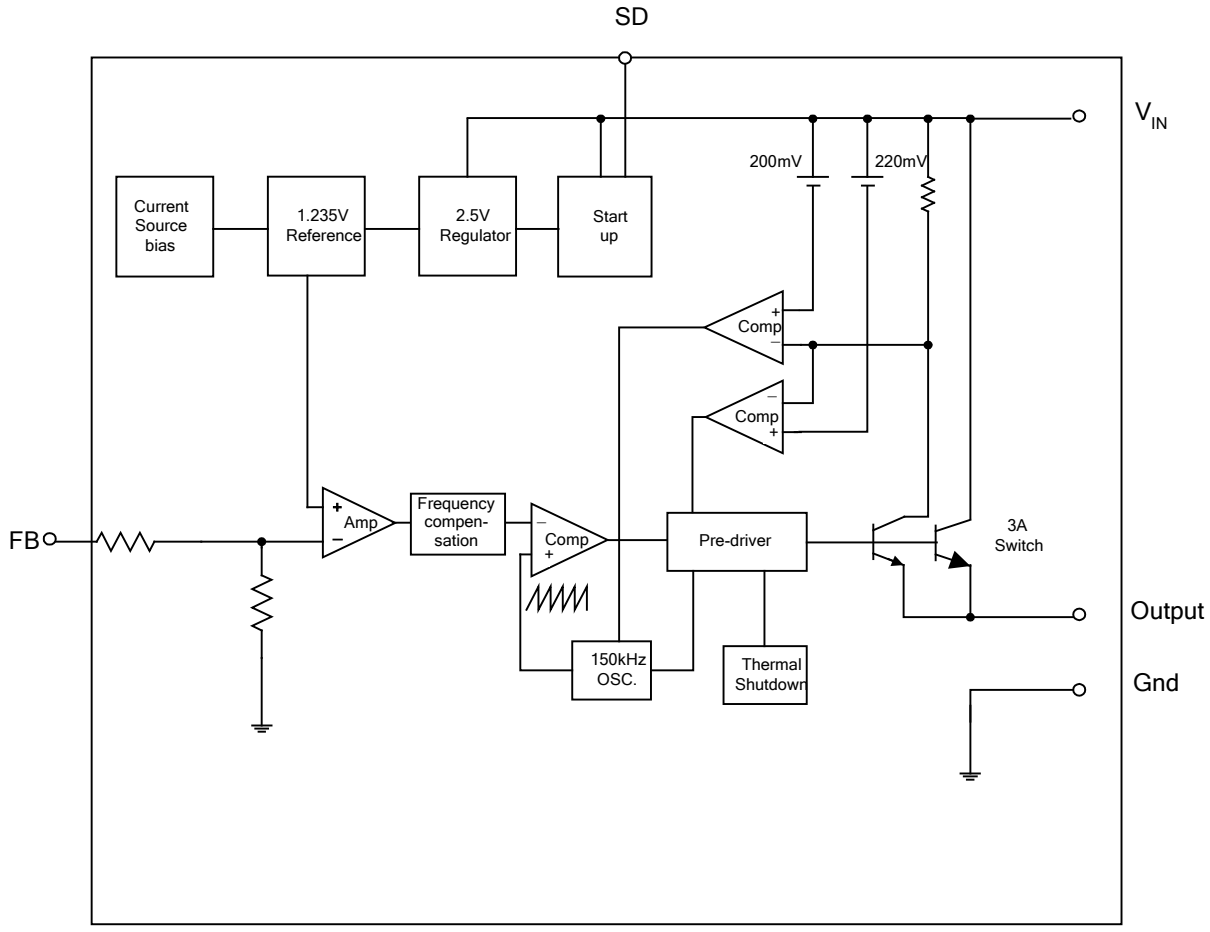


Note: Suggested Diodes Incorporated's Power Schottky: B340A or PDS340 series.

Pin Descriptions

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 MM	Machine Model ESD Protection	400	V
V_{CC}	Supply Voltage	+45	V
V_{SD}	ON/OFF Pin Input Voltage	-0.3 to +40	V
V_{FB}	Feedback Pin Voltage	-0.3 to +40	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	-20 to +125	°C
T_{MJ}	Maximum Junction Temperature	+150	°C

Electrical Characteristics (@ T_A = +25°C, unless otherwise specified.)

Unless otherwise specified, V_{IN} = 12V for 3.3V, 5V, adjustable version and V_{IN} = 24V 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 = +25ºC.

Symbol	Parameter	Conditions	Min	Typ.	Max	Unit
I_{FB}	Feedback Bias Current	V_{FB} = 1.3V (Adjustable Version Only) (Note 4)	—	40	60	nA
					100	
F_{OSC}	Oscillator Frequency	—	127	150	173	kHz
			110	—	**173**	
V_{SAT}	Saturation Voltage	I_{OUT} = 3A No Outside Circuit V_{FB} = 0V Force Driver On	—	1.3	1.4	V
					1.5	
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	4.0	5.5	A
					6.5	
I_L	Output = 0 (Output Leakage Current)	—	—	200	200	µA
	Output = -1 (Output Leakage Current)	—	2	60	60	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} = 40V	—	150	250	µA
					350	
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)	—	15	25	µA
I_L	ON/OFF Pin Input Current	V_{LOGIC} = 0.5V (ON)	—	0.02	5	
θ_{JA}	Thermal Resistance Junction to Ambient	TO263-5 (Note 5)	—	37	—	°C/W
		TO220-5 (Note 5)	—	31	—	
θ_{JC}	Thermal Resistance Junction to Case	TO263-5 (Note 5)	—	6	—	°C/W
		TO220-5 (Note 5)	—	5	—	

Notes: 4. Feedback pin removed from output and connected to 0V to force the output transistor switch ON. Feedback pin removed from output and connected to 12V for the 3.3V, 5V, and the ADJ. version, and 15V for the 12V version, to force the output transistor switch OFF.
5. Test condition: Device mounted with copper area of approximately 3 in^2,1oz, no air flow.

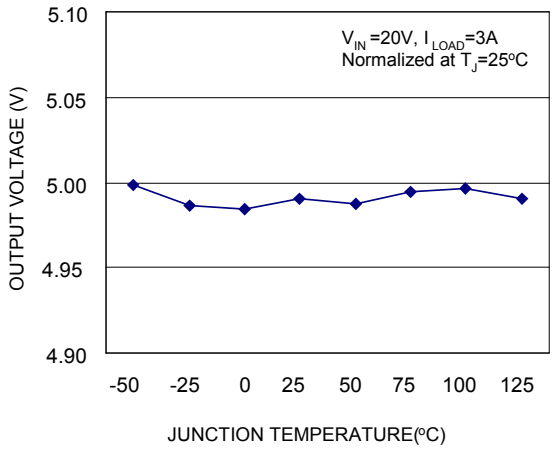
Electrical Characteristics (continued) (@ T_A = +25°C, unless otherwise specified.)

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

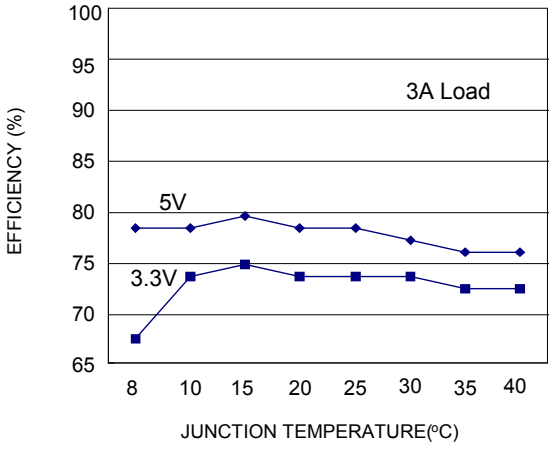
—	Symbol	Parameter	Conditions	V_{Min}	Typ.	V_{Max}	Unit
AP1501-ADJ	V_{FB}	Output Feedback	4.5V ≤ V_{IN} ≤ 40V 0.2A ≤ I_{LOAD} ≤ 3A V_{OUT} programmed for 3V	1.193 **1.18**	1.23	1.267 **1.28**	V
	η	Efficiency	V_{IN} = 12V, I_{LOAD} = 3A	—	73	—	%
AP1501-3.3V	V_{OUT}	Output Voltage	4.75V ≤ V_{IN} ≤ 40V 0.2A ≤ I_{LOAD} ≤ 3A	3.168 **3.135**	3.3	3.432 **3.465**	V
	η	Efficiency	V_{IN} = 12V, I_{LOAD} = 3A	—	73	—	%
AP1501-5V	V_{OUT}	Output Voltage	7V ≤ V_{IN} ≤ 40V 0.2A ≤ I_{LOAD} ≤ 3A	4.8 **4.75**	5	5.2 **5.25**	V
	η	Efficiency	V_{IN} = 12V, I_{LOAD} = 3A	—	80	—	%
AP1501-12V	V_{OUT}	Output Voltage	15V ≤ V_{IN} ≤ 40V 0.2A ≤ I_{LOAD} ≤ 3A	11.52 **11.4**	12	12.48 **12.6**	V
	η	Efficiency	V_{IN} = 15V, I_{LOAD} = 3A	—	90	—	%

Performance Characteristics

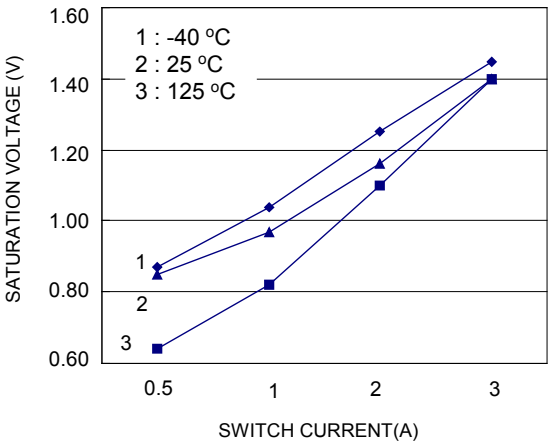
Typical Performance Characteristics
Normalized Output Voltage



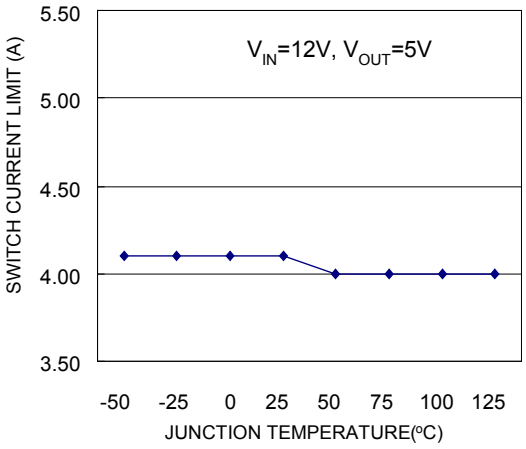
Efficiency



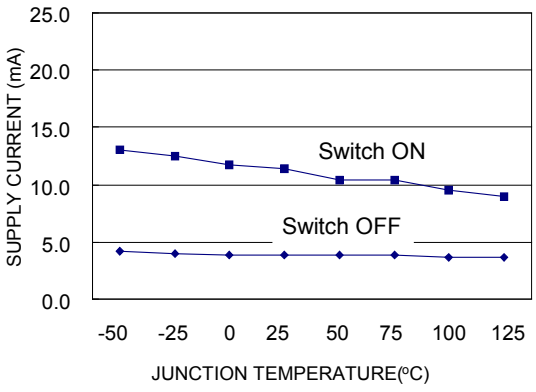
Switch Saturation Voltage



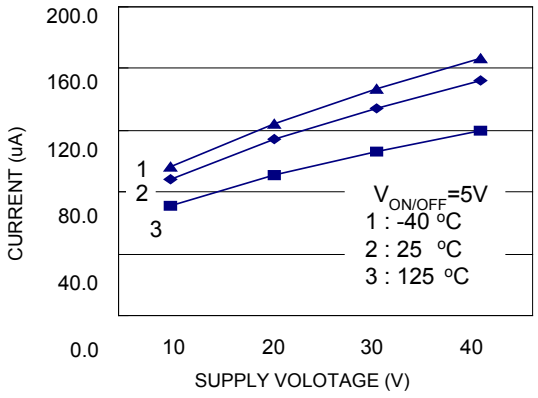
Switch Current Limit



Operating Quiescent Current

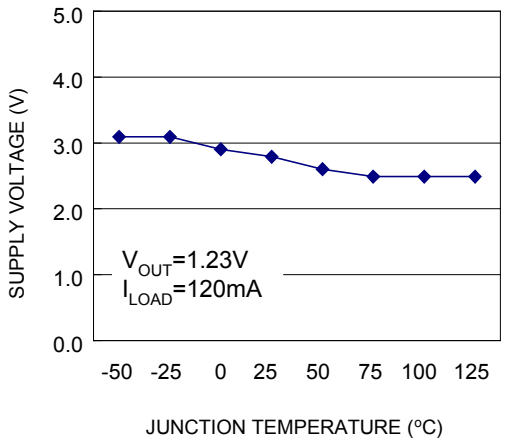


Shutdown Quiescent Current

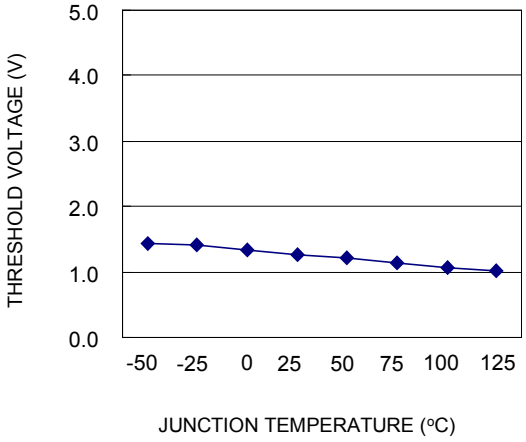


Performance Characteristics (continued)

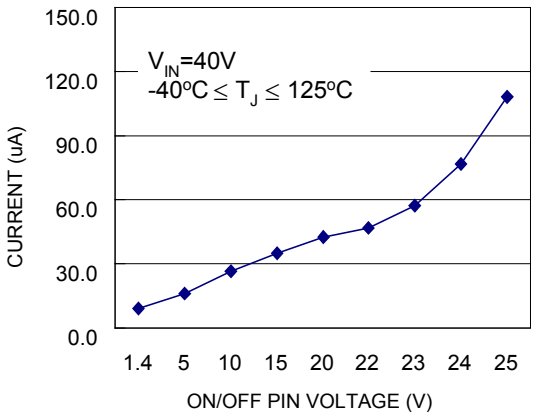
Minimum Operating Supply Voltage



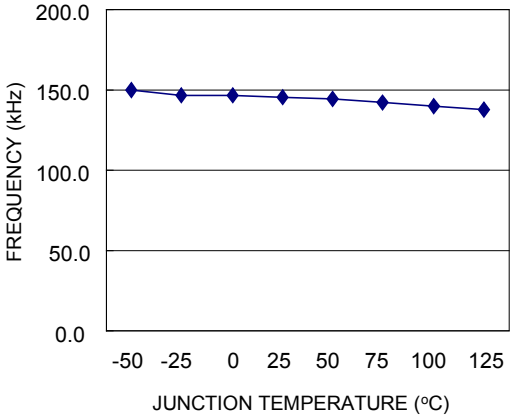
ON/OFF Threshold Voltage



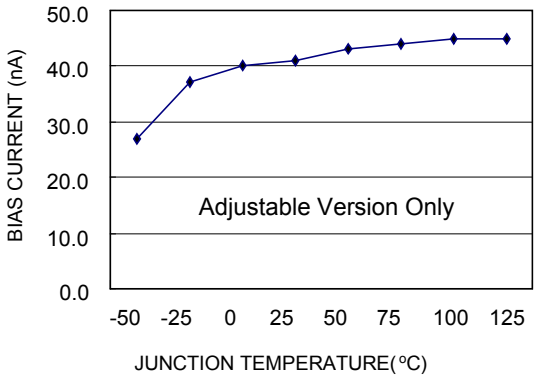
ON/OFF Pin Current (Sinking)



Switch Frequency



Feedback Pin Bias Current



Operation Description

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 PC board copper area connected to this pin should be kept a minimum.

Feedback

Senses the regulated output voltage to complete the feedback loop.

ON/OFF

Allows the switching regulator circuit to be shut down 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 40V) shuts the regulator down. If this shutdown feature is not needed, the ON/OFF pin can be wired to the ground pin, or it can be left open. In either case the regulator will be in the ON condition.

Thermal Considerations

The AP1501 is available in the 5-pin surface mount TO-263 and TO-220.

Under most conditions, the TO-220 package requires a heat sink. The size of the heat sink depends on the input voltage, the output voltage, the load current, and the ambient temperature. The AP1501 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 AP1501 (TO-220 package) operating as a buck switching regulator in an ambient temperature of 25°C (still air). These temperature rise numbers are all approximate and there are many factors that can affect these temperatures. Higher ambient temperatures require more heat sinking.

The TO-263 surface mount package tab is designed to be soldered to the copper on a printed circuit board. 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 PC board copper area that the package is soldered to should be at least 0.4 in^2, and ideally should have 2 or more square inches of 2 oz. Additional copper area improves the thermal characteristics, but with copper areas greater than approximately 6 in^2, only small improvements in heat dissipation are realized. If further thermal improvements are needed, double-sided multilayer PC boards with large copper areas and/or airflow are recommended.

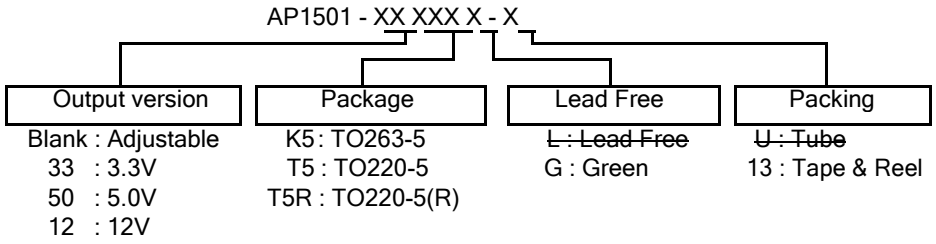
The AP1501 (TO-263 package) junction temperature rises above ambient temperature with a 2A load for various input and output voltages. This data was taken with the circuit operating as a buck switching regulator with all components mounted on a PC board to simulate the junction temperature under actual operating conditions. This curve can be used for a quick check for the approximate junction temperature for various conditions, but be aware that there are many factors that can affect the junction temperature. When load currents higher than 2A are used, double-sided or multilayer PC boards with large copper areas and/or airflow might be needed, especially for high ambient temperatures and high output voltages.

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 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 printed circuit copper area, copper thickness, the board being single or double-sided, the board being multilayered, 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 add heat to the board or act as a heat sink taking heat away from the board.

Ordering Information

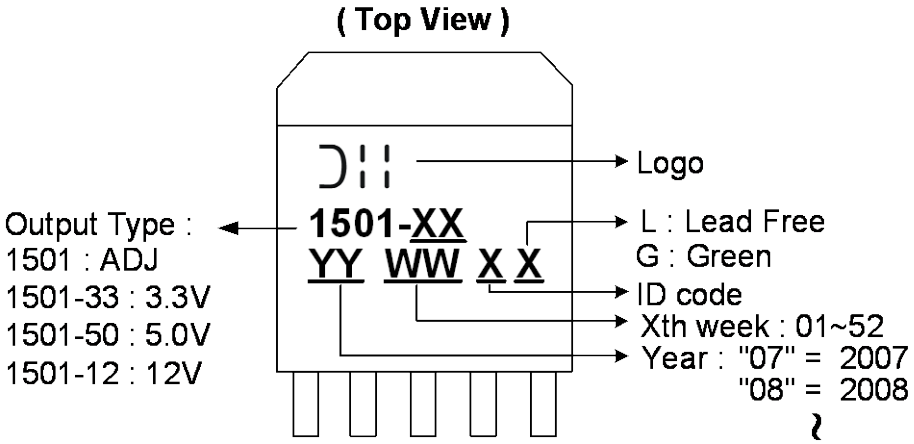


Device (Note 4)	Voltage	Package Code	Package (Note 7)	Lead Free/ Green	Quantity	Part Number Suffix		Status (Note 6)
						Tube	13"Tape and reel	
AP1501-50K5G-13	50	K5	TO263-5	Green	800	NA	-13	Active
AP1501-K5G-13	ADJ	K5	TO263-5	Green	800	NA	-13	Active
AP1501-12K5G-13	12	K5	TO263-5	Green	800	NA	-13	NRND
AP1501-33K5G-13	33	K5	TO263-5	Green	800	NA	-13	NRND

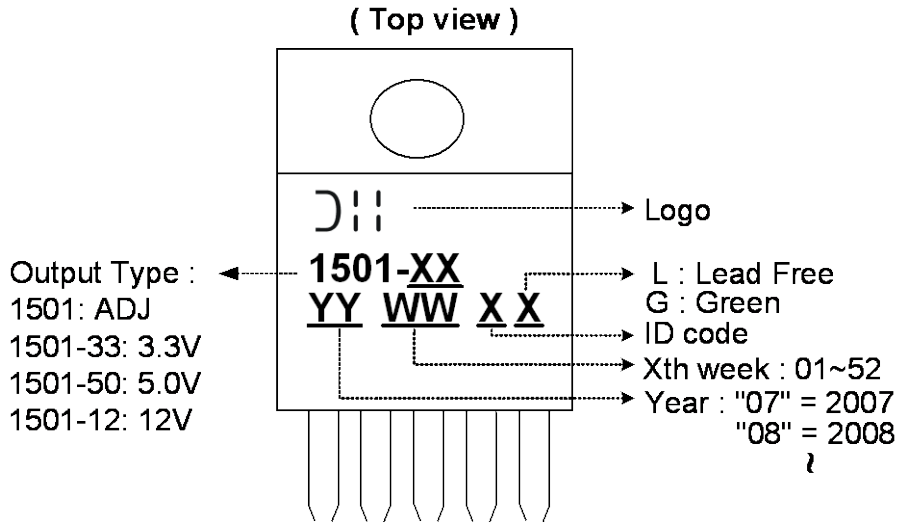
Notes: 6. AP1501-50K5G-13 and AP1501-K5G-13 are Active. All other versions are NRND or EOL. For recommended alternatives to NRND/EOL devices, Contact Us.
7. For packaging details, go to our website at: https://www.diodes.com/design/support/packaging/diodes-packaging/diodes-package-outlines-and-pad-layouts/.

Marking Information

(1) TO263-5



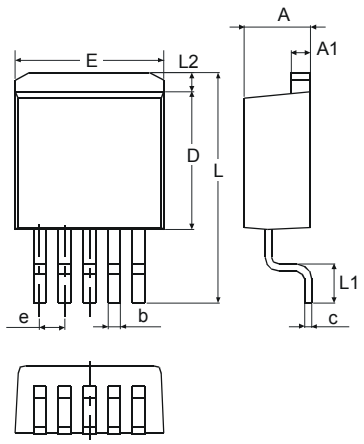
(2) TO220-5



Package Outline Dimensions

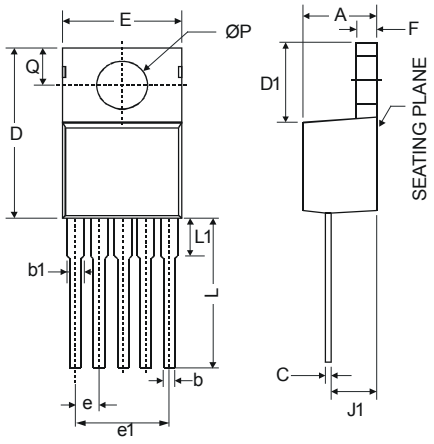
Please see http://www.diodes.com/package-outlines.html for the latest version.

(1) Package Type: TO263-5



TO263-5		
Dim	**Min**	**Max**
A	4.07	4.85
A1	1.14	1.40
b	0.66	1.02
c	0.36	0.64
D	8.65	9.65
E	9.78	10.54
e	1.57	1.85
L	14.61	15.88
L1	2.29	2.79
L2	-	2.92
All Dimensions in mm		

(2) Package Type: TO220-5

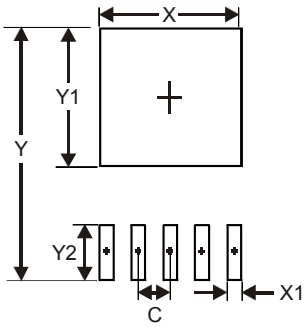


TO220-5		
Dim	**Min**	**Max**
A	3.55	4.85
b	0.51	1.14
b1	1.14	1.78
C	0.31	1.14
D	14.20	16.50
D1	5.84	6.86
E	9.78	10.54
e	1.6	1.8
e1	6.6	7.0
F	0.51	1.40
J1	2.03	2.92
L	12.72	14.72
L1	3.66	6.35
P	3.53	4.09
Q	2.54	3.43
All Dimensions in mm		

Suggested Pad Layout

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

(1) Package Type: TO263-5



Dimensions	Value (in mm)
X	10.9
X1	1.05
Y	15.7
Y1	9.1
Y2	2.5
C	1.7

IMPORTANT NOTICE

1. DIODES INCORPORATED AND ITS SUBSIDIARIES ("DIODES") MAKE NO WARRANTY OF ANY KIND, EXPRESS OR IMPLIED, WITH REGARDS TO ANY INFORMATION CONTAINED IN THIS DOCUMENT, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS (AND THEIR EQUIVALENTS UNDER THE LAWS OF ANY JURISDICTION).

2. The Information contained herein is for informational purpose only and is provided only to illustrate the operation of Diodes products described herein and application examples. Diodes does not assume any liability arising out of the application or use of this document or any product described herein. This document is intended for skilled and technically trained engineering customers and users who design with Diodes products. Diodes products may be used to facilitate safety-related applications; however, in all instances customers and users are responsible for (a) selecting the appropriate Diodes products for their applications, (b) evaluating the suitability of the Diodes products for their intended applications, (c) ensuring their applications, which incorporate Diodes products, comply the applicable legal and regulatory requirements as well as safety and functional-safety related standards, and (d) ensuring they design with appropriate safeguards (including testing, validation, quality control techniques, redundancy, malfunction prevention, and appropriate treatment for aging degradation) to minimize the risks associated with their applications.

3. Diodes assumes no liability for any application-related information, support, assistance or feedback that may be provided by Diodes from time to time. Any customer or user of this document or products described herein will assume all risks and liabilities associated with such use, and will hold Diodes and all companies whose products are represented herein or on Diodes' websites, harmless against all damages and liabilities.

4. Products described herein may be covered by one or more United States, international or foreign patents and pending patent applications. Product names and markings noted herein may also be covered by one or more United States, international or foreign trademarks and trademark applications. Diodes does not convey any license under any of its intellectual property rights or the rights of any third parties (including third parties whose products and services may be described in this document or on Diodes' website) under this document.

5. Diodes products are provided subject to Diodes' Standard Terms and Conditions of Sale (https://www.diodes.com/about/company/terms-and-conditions/terms-and-conditions-of-sales/) or other applicable terms. This document does not alter or expand the applicable warranties provided by Diodes. Diodes does not warrant or accept any liability whatsoever in respect of any products purchased through unauthorized sales channel.

6. Diodes products and technology may not be used for or incorporated into any products or systems whose manufacture, use or sale is prohibited under any applicable laws and regulations. Should customers or users use Diodes products in contravention of any applicable laws or regulations, or for any unintended or unauthorized application, customers and users will (a) be solely responsible for any damages, losses or penalties arising in connection therewith or as a result thereof, and (b) indemnify and hold Diodes and its representatives and agents harmless against any and all claims, damages, expenses, and attorney fees arising out of, directly or indirectly, any claim relating to any noncompliance with the applicable laws and regulations, as well as any unintended or unauthorized application.

7. While efforts have been made to ensure the information contained in this document is accurate, complete and current, it may contain technical inaccuracies, omissions and typographical errors. Diodes does not warrant that information contained in this document is error-free and Diodes is under no obligation to update or otherwise correct this information. Notwithstanding the foregoing, Diodes reserves the right to make modifications, enhancements, improvements, corrections or other changes without further notice to this document and any product described herein. This document is written in English but may be translated into multiple languages for reference. Only the English version of this document is the final and determinative format released by Diodes.

8. Any unauthorized copying, modification, distribution, transmission, display or other use of this document (or any portion hereof) is prohibited. Diodes assumes no responsibility for any losses incurred by the customers or users or any third parties arising from any such unauthorized use.

www.diodes.com