

### Description

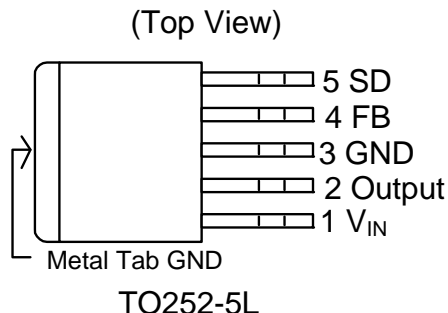
The AP1507 is a monolithic IC designed for a step-down DC/DC converter and is capable of driving a 3A load without an external transistor. Due to reducing the number of external components, the board space can be saved easily. The external shutdown function can be controlled by logic level and then come 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 is to prevent over temperature operating from damaging the device, and current limit is against over current operating of the output switch. If the current limit function occurred and  $V_{FB}$  is down to 0.5V below, the switching frequency will be reduced. The AP1507 series operates at a switching frequency of 150KHz thus allowing 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 a fixed 3.3V, 5V, 12V, and an adjustable type. AP1507 is available in a 5-lead TO-252 lead-free or green package.

### Features

- Output Voltage: 3.3V, 5V, 12V and Adjustable Output Version
- Adjustable Version Output Voltage Range, 1.23V to 18V  $\pm 4\%$
- 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: 3A
- Low Power Standby Mode
- Built-in Switching Transistor On Chip
- AP1507-XXD5L-XX
  - **Totally Lead-Free; RoHS Compliant (Notes 1 & 2)**
- AP1507-XXD5-XX
  - **Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)**
  - **Halogen and Antimony Free. "Green" Device (Note 3)**

Notes: 1. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS) & 2011/65/EU (RoHS 2) compliant.  
 2. See <http://www.diodes.com> 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.

### Pin Assignments

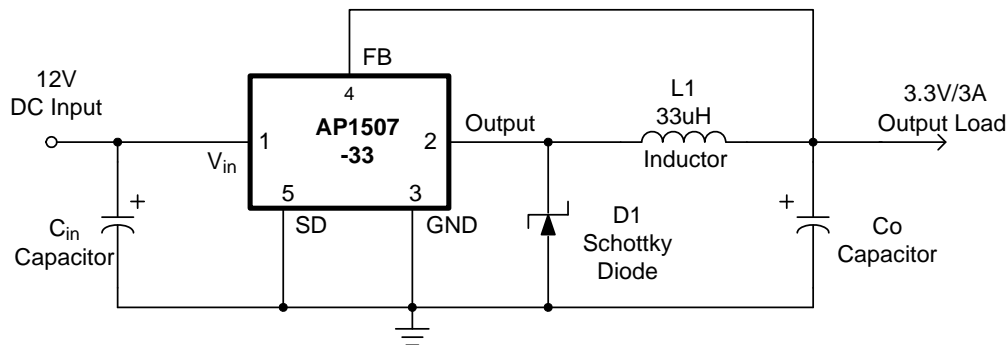


### Applications

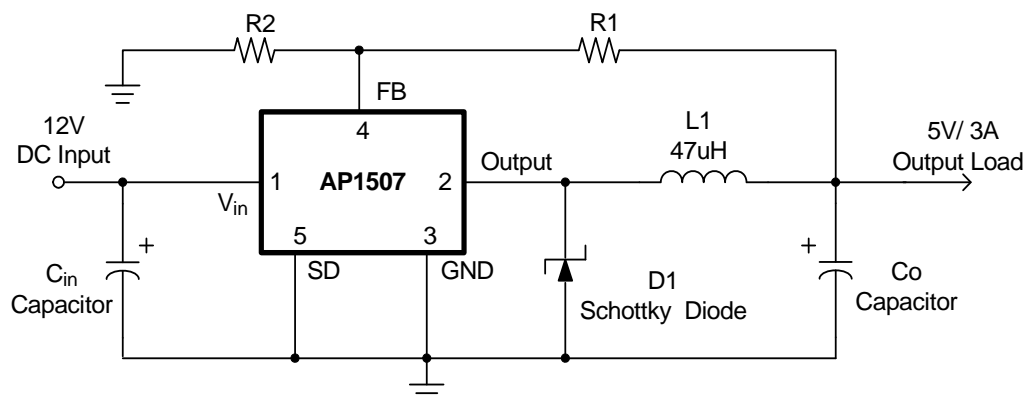
- Simple High-Efficiency Step-Down Regulator
- On-Card Switching Regulators
- Positive to Negative Converter

### Typical Application Circuit

#### (1) Fixed Type Circuit



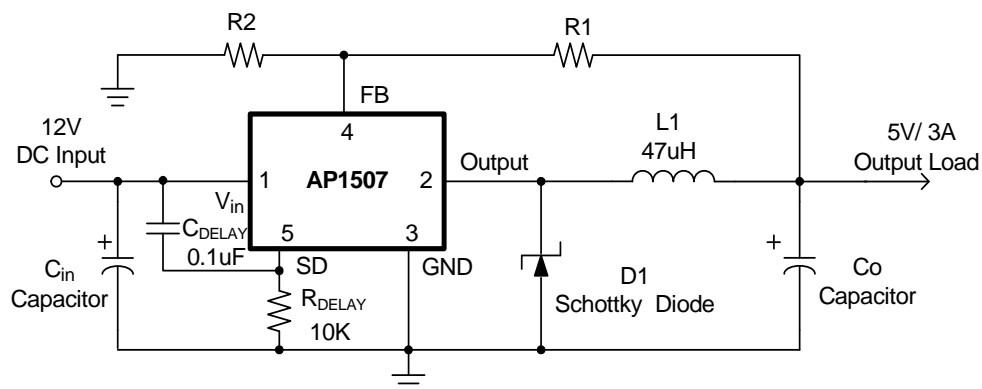
#### (2) Adjustable Type Circuit



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

$$V_{FB} = 1.23V, R2 = 1K \sim 3K$$

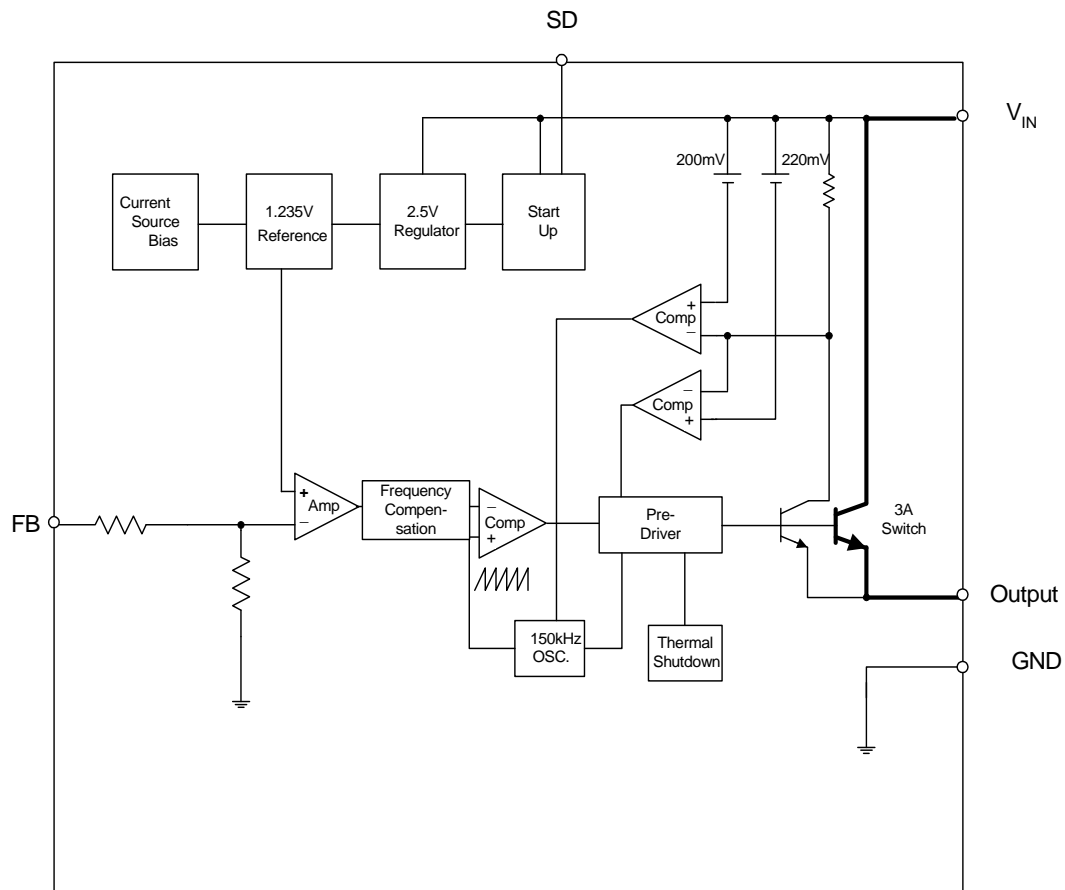
#### (3) Delay Start Circuit



## Pin Descriptions

| Pin Number | Pin Name        | Description                     |
|------------|-----------------|---------------------------------|
| 1          | V <sub>IN</sub> | Operating Voltage Input         |
| 2          | Output          | Switching Output                |
| 3          | GND             | Ground                          |
| 4          | FB              | Output Voltage Feedback Control |
| 5          | SD              | ON / OFF Shutdown               |

## Functional Block Diagram



### Absolute Maximum Ratings ( $T_A = 25^\circ\text{C}$ ) (Note4)

| 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        | $^\circ\text{C}$ |
| $T_J$     | Operating Junction Temperature  | -40 to +125        | $^\circ\text{C}$ |

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 ( $T_A = 25^\circ\text{C}$ )

| 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 | $^\circ\text{C}$ |

**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  $T_J = 25^\circ C$ .

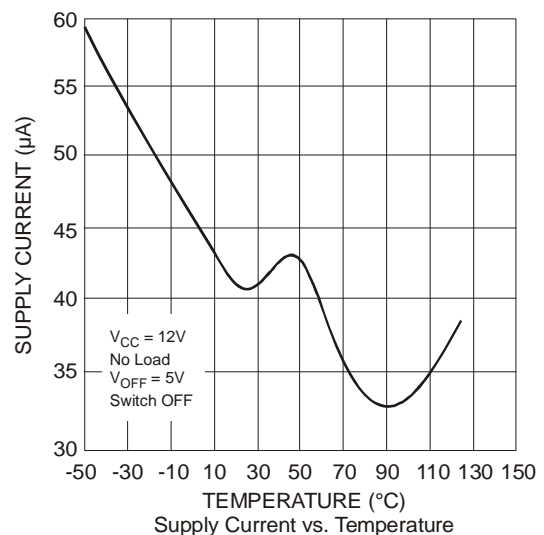
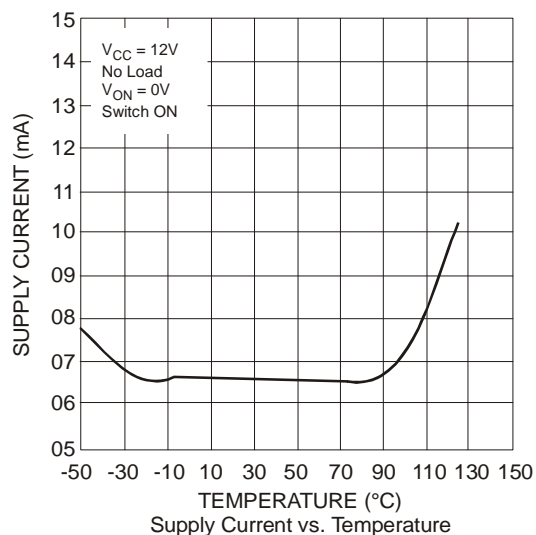
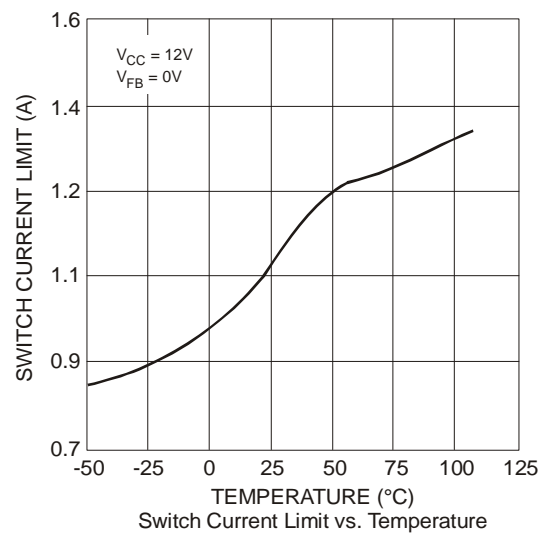
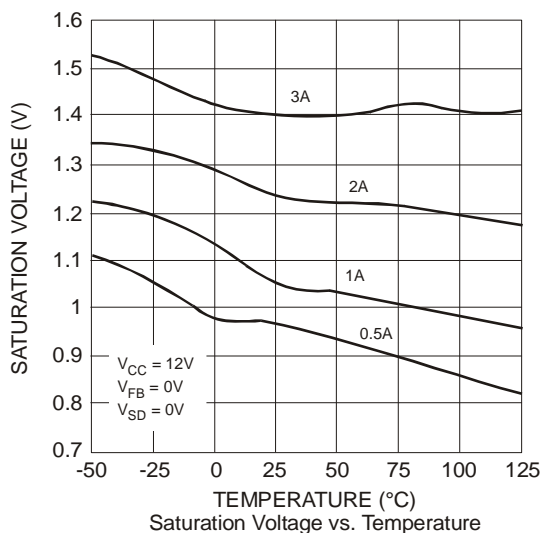
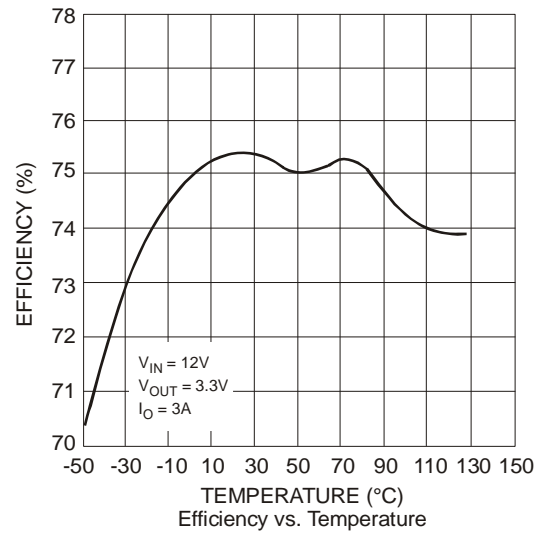
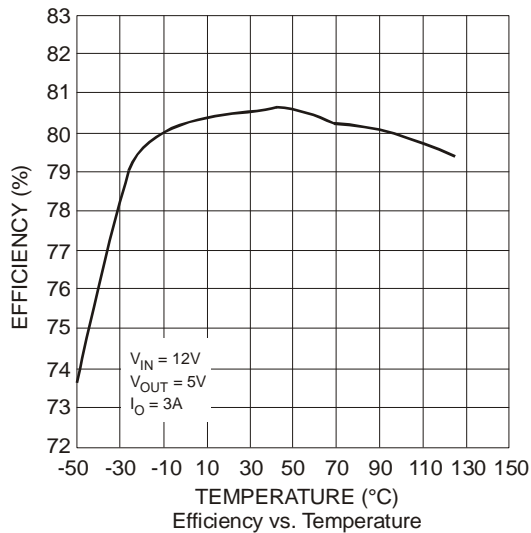
| Symbol            | Parameter   |                              | Conditions  |                        | Min               | Typ  | Max                | Unit |
|-------------------|---|------------------------------|---|------------------------|-------------------|------|--------------------|------|
| I <sub>FB</sub>   | Feedback Bias Current   |                              | V <sub>FB</sub> = 1.3V<br>( Adjustable Version Only )                               |                        |                   | -10  | -50<br><b>-100</b> | nA   |
| F <sub>OSC</sub>  | Oscillator Frequency  |                              |   |                        | 127<br><b>110</b> | 150  | 173<br><b>173</b>  | KHz  |
| F <sub>SCP</sub>  | Oscillator Frequency of Short<br>Circuit Protect                    |                              | When current limit Occurred and<br>V <sub>FB</sub> < 0.5V, T <sub>A</sub> = 25°C    |                        | 10                | 30   | 50                 | KHz  |
| V <sub>SAT</sub>  | Saturation Voltage  |                              | I <sub>OUT</sub> = 3A<br>No Outside Circuit<br>V <sub>FB</sub> = 0V Force Driver On |                        |                   | 1.4  | 1.6<br><b>1.7</b>  | V    |
| DC                | Max. Duty Cycle (ON)  |                              | V <sub>FB</sub> = 0V Force Driver On  |                        |                   | 100  |                    | %    |
|                   | Min. Duty Cycle (OFF)   |                              | V <sub>FB</sub> = 12V Force Driver Off  |                        |                   | 0    |                    |      |
| I <sub>CL</sub>   | Current Limit   |                              | Peak Current<br>No Outside Circuit<br>V <sub>FB</sub> = 0V Force Driver On          |                        | 3.6               | 4.5  | 5.5<br>6.5         | A    |
|                   |   |                              |   |                        |                   |      |                    |      |
| I <sub>LEAK</sub> | Output = 0V   | Output<br>leakage<br>current | No Outside Circuit<br>V <sub>FB</sub> = 12V Force Driver Off                        |                        |                   |      | -200               | μA   |
|                   | Output = -1V  |                              | V <sub>IN</sub> = 22V   |                        |                   | -5   |                    | mA   |
| I <sub>Q</sub>    | Quiescent Current   |                              | V <sub>FB</sub> = 12V Force Driver Off  |                        |                   | 5    | 10                 | mA   |
| I <sub>STBY</sub> | Standby Quiescent<br>Current  |                              | ON/OFF Pin = 5V<br>V <sub>IN</sub> = 22V  |                        |                   | 70   | 150<br><b>200</b>  | μA   |
|                   |   |                              |   |                        |                   |      |                    |      |
| V <sub>IL</sub>   | ON/OFF Pin Logic Input Threshold                                    |                              | Low (Regulator ON)  |                        | -                 | 1.3  | 0.6                | V    |
| V <sub>IH</sub>   | Voltage   |                              | High (Regulator OFF)  |                        | 2.0               |      | -                  |      |
| I <sub>H</sub>    | ON/OFF Pin Logic Input Current                                      |                              | V <sub>LOGIC</sub> = 2.5V (OFF)   |                        |                   |      | -0.01              | μA   |
| I <sub>L</sub>    | ON/OFF Pin Input Current  |                              | V <sub>LOGIC</sub> = 0.5V (ON)  |                        |                   | -0.1 | -1                 |      |
| θ <sub>JA</sub>   | Thermal Resistance  |                              | TO252-5L  | Junction to Case       |                   | 10   |                    | °C/W |
| θ <sub>JC</sub>   | Thermal Resistance<br>with copper area of approximately<br>2cm x2cm |                              | TO252-5L  | Junction to<br>Ambient |                   | 50   |                    | °C/W |

### Electrical Characteristics (All Output Voltage Versions)

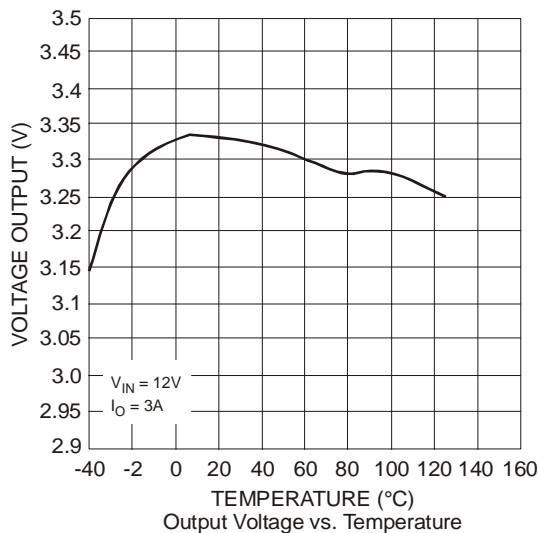
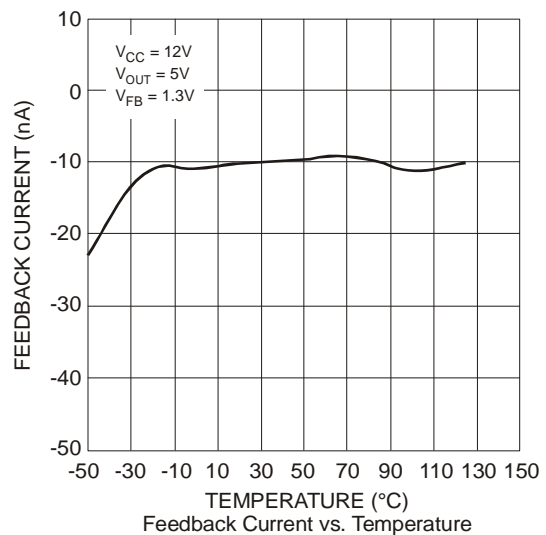
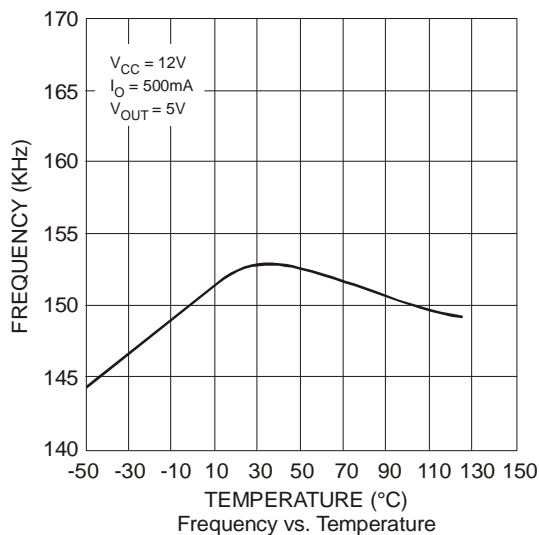
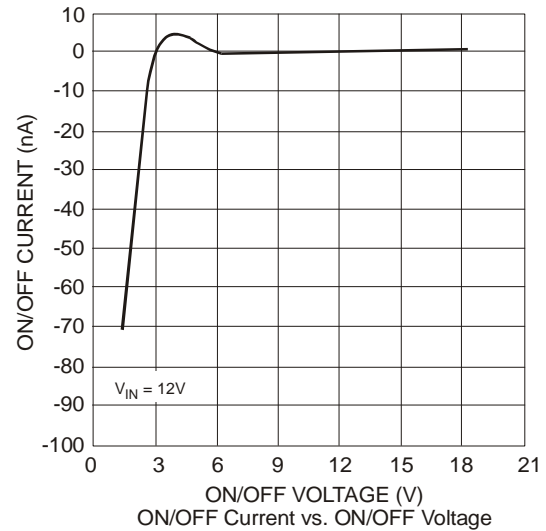
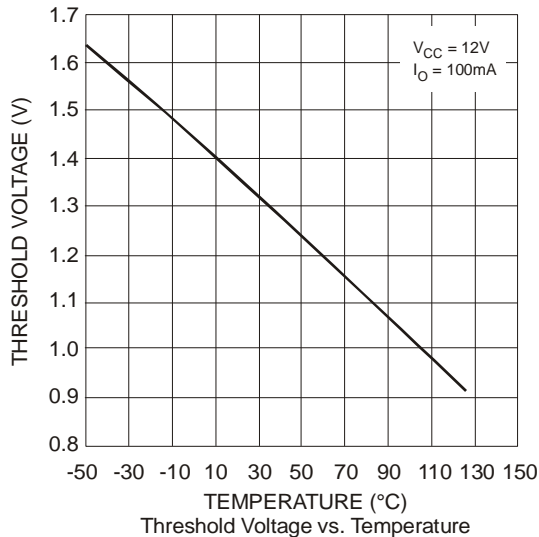
Specifications with **boldface type** are for full operating temperature range, the other type are for  $T_J = 25^\circ\text{C}$ .

|             | Symbol           | Parameter       | Conditions  | V <sub>MIN</sub>      | Typ. | V <sub>MAX</sub>      | Unit |
|-------------|------------------|-----------------|---|-----------------------|------|-----------------------|------|
| AP1507-ADJ  | V <sub>FB</sub>  | Output Feedback | 5V ≤ V <sub>IN</sub> ≤ 22V<br>0.2A ≤ I <sub>LOAD</sub> ≤ 3A<br>V <sub>OUT</sub> Programmed for 3V | 1.193<br><b>1.18</b>  | 1.23 | 1.267<br><b>1.28</b>  | V    |
|             | η                | Efficiency      | V <sub>IN</sub> = 12V, I <sub>LOAD</sub> = 3A   |                       | 74   |                       | %    |
| AP1507-3.3V | V <sub>OUT</sub> | Output Voltage  | 5.5V ≤ V <sub>IN</sub> ≤ 22V<br>0.2A ≤ I <sub>LOAD</sub> ≤ 3A                                     | 3.168<br><b>3.135</b> | 3.3  | 3.432<br><b>3.465</b> | V    |
|             | η                | Efficiency      | V <sub>IN</sub> = 12V, I <sub>LOAD</sub> = 3A   |                       | 75   |                       | %    |
| AP1507-5V   | V <sub>OUT</sub> | Output Voltage  | 8V ≤ V <sub>IN</sub> ≤ 22V<br>0.2A ≤ I <sub>LOAD</sub> ≤ 3A                                       | 4.8<br><b>4.75</b>    | 5    | 5.2<br><b>5.25</b>    | V    |
|             | η                | Efficiency      | V <sub>IN</sub> = 12V, I <sub>LOAD</sub> = 3A   |                       | 80   |                       | %    |
| AP1507-12V  | V <sub>OUT</sub> | Output Voltage  | 15V ≤ V <sub>IN</sub> ≤ 22V<br>0.2A ≤ I <sub>LOAD</sub> ≤ 3A                                      | 11.52<br><b>11.4</b>  | 12   | 12.48<br><b>12.6</b>  | V    |
|             | η                | Efficiency      | V <sub>IN</sub> = 16V, I <sub>LOAD</sub> = 3A   |                       | 89   |                       | %    |

## Typical Characteristics



**Typical Characteristics (cont.)**





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## Application Information

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### Pin Functions

#### +V<sub>IN</sub>

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<sub>IN</sub> – V<sub>SAT</sub>) and approximately – 0.5V, with a duty cycle of approximately V<sub>OUT</sub> / V<sub>IN</sub>. To minimize coupling to sensitive circuitry, the PC board copper area connected to this pin should 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 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 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 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 0.8 in<sup>2</sup>, and ideally should have 2 or more square inches of 2 oz. additional copper area which improves the thermal characteristics. With copper areas greater

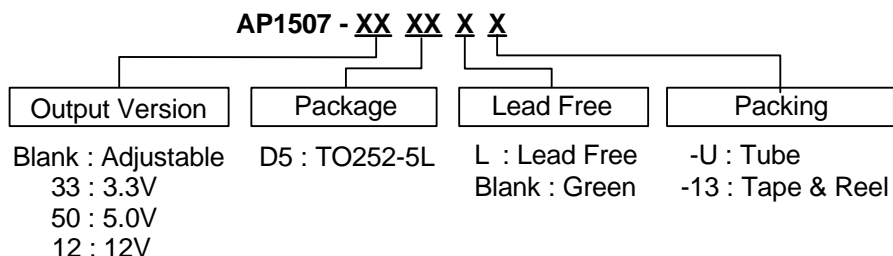
than approximately 6in<sup>2</sup>, only small improvements in heat dissipation are realized. If further thermal improvements are needed, double sided, multi-layer PC board with large copper areas and/or airflow will be recommended.

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 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 there are many factors that can affect the junction temperature. When load currents higher than 3A are used, double sided or multi-layer 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, 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

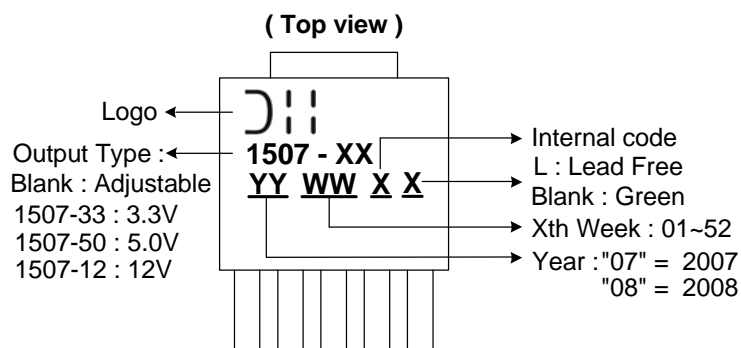


| Device          | Package Code | Packaging (Note 5) | Tube/Bulk     |                    | 13" Tape and Reel |                    |
|-----------------|--------------|--------------------|---------------|--------------------|-------------------|--------------------|
|                 |              |                    | Quantity      | Part Number Suffix | Quantity          | Part Number Suffix |
| AP1507-XXD5L-XX | D5           | TO252-5L           | 80            | -U                 | 2500/Tape & Reel  | -13                |
| AP1507-XXD5-XX  | D5           | TO252-5L           | Not available |                    | 2500/Tape & Reel  | -13                |

Note: 5. 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>

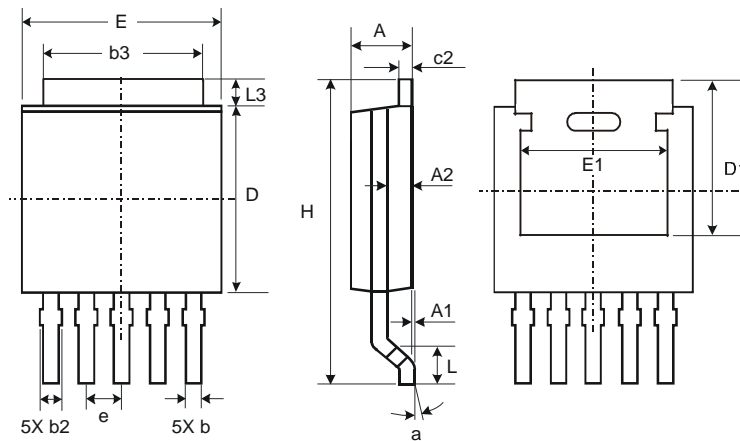
## Marking Information

### (1) TO252-5L



## Package Outline Dimensions (All Dimensions in mm)

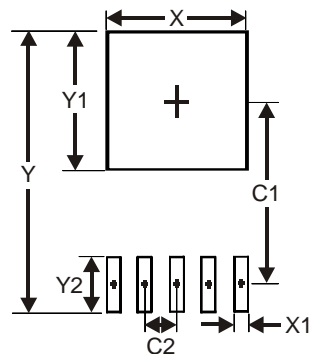
Package Type: TO252-5L



| TO252-5L             |      |       |       |
|----------------------|------|-------|-------|
| 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

Package Type: TO252-5L



| Dimensions | Value (in mm) |
|------------|---------------|
| X          | 5.6           |
| X1         | 0.6           |
| Y          | 11.0          |
| Y1         | 5.6           |
| Y2         | 2.0           |
| C1         | 7.2           |
| C2         | 1.27          |

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