

High Voltage 3A 150KHZ PWM Buck DC/DC Converter

TD1501H

General Description

The TD1501H is a series of easy to use fixed and adjustable step-down (buck) switch-mode voltage regulators. These devices are available in fixed output voltage of 5V, and an adjustable output version. Both versions are capable of driving a 3A load with excellent line and load regulation.

Requiring a minimum number of external components, these regulators are simple to use and include internal frequency compensation, and a fixed-frequency oscillator.

The output voltage is guaranteed to $\pm 3\%$ tolerance under specified input voltage and output load conditions. The oscillator frequency is guaranteed to $\pm 15\%$. External shutdown is included, featuring typically 80 μA standby current. Self protection features include a two stage frequency reducing current limit for the output switch and an over temperature shutdown for complete protection under fault conditions.

The TD1501H is available in TO-263-5L packages.

- 5V and adjustable output versions
- Output adjustable from 1.23 V to 57 V
- Fixed 150KHz frequency internal oscillator
- Guaranteed 3A output load current
- **Input voltage range up to 60 V**
- Low power standby mode, I_Q typically 80 μA
- TTL shutdown capability
- Excellent line and load regulation
- Requires only 4 external components
- High efficiency
- Thermal shutdown and current limit protection
- Available in TO-220B TO220 and TO-263 packages

Applications

- PoE Equipments(PoE Hub/Switch/IP-cam .etc)
- Simple High-efficiency step-down regulator
- On-card switching regulators
- Positive to negative converter
- LCD monitor and LCD TV
- DVD recorder and PDP TV
- Battery charger
- Step-down to 3.3V for microprocessors

Features

Package Types

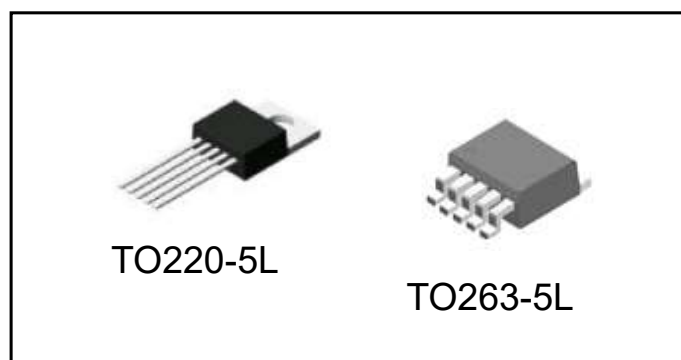


Figure 1. Package Types of TD1501H

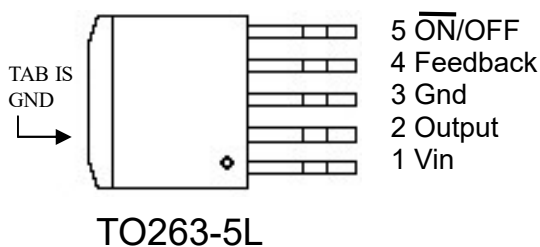
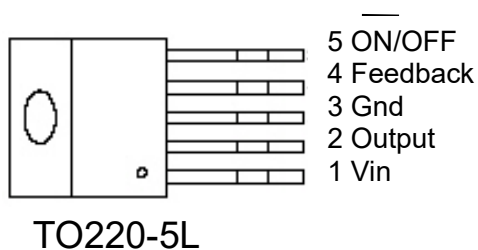
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Pin Assignments

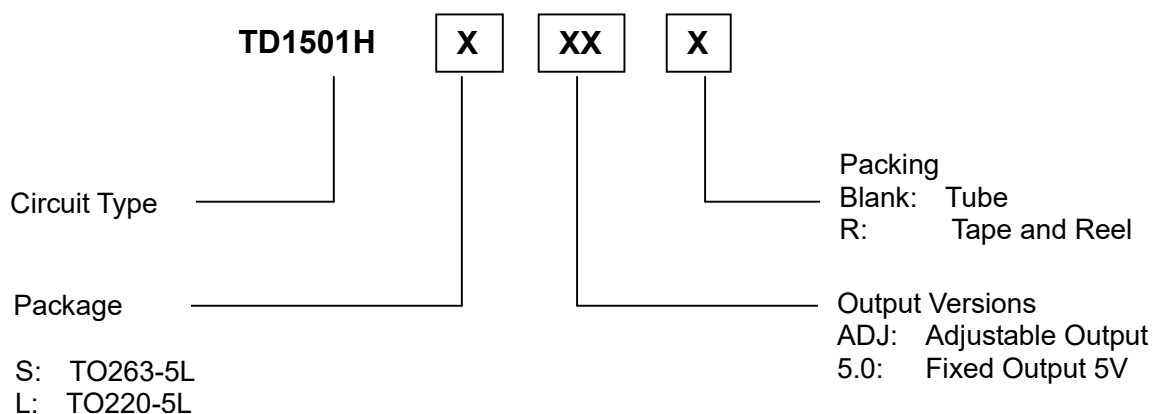
Pin Descriptions

Pin Assignments



Name	Description
Vin	Input supply voltage
Output	Switching output
Gnd	Ground
Feedback	Output voltage feedback
ON/OFF	ON/OFF shutdown Active is "Low" or GND

Ordering Information



Function 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 $-2.0V$, 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.

$\overline{ON/OFF}$

Allows the switching regulator circuit to be shutdown using logic level signals thus dropping the total input supply current to approximately 80uA.

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 32V**) shuts the regulator down. If this shutdown feature is not needed, the ON /OFF pin can be wired to the ground pin , the regulator will be in the ON condition. The ON /OFF pin should not be left open .

Functional Block Diagram

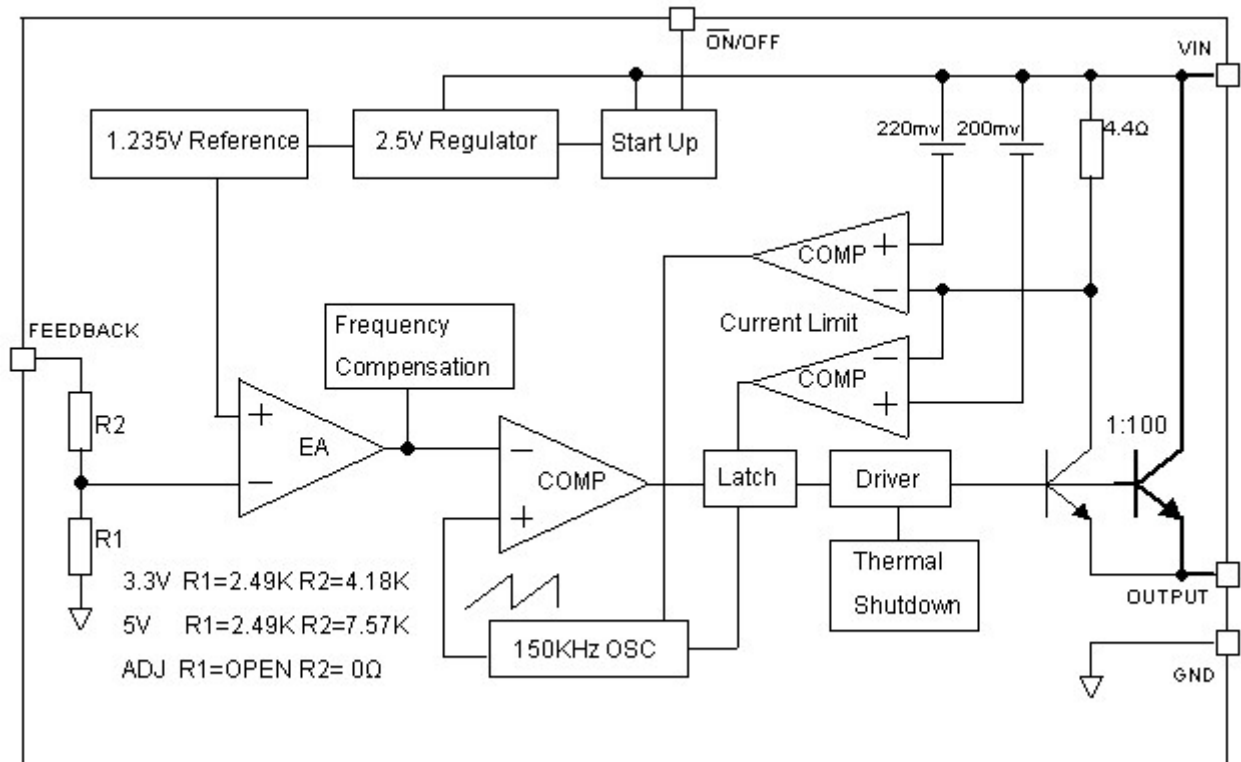


Figure 2. Functional Block Diagram of TD1501H

Typical Application (Fixed Output Voltage Versions)

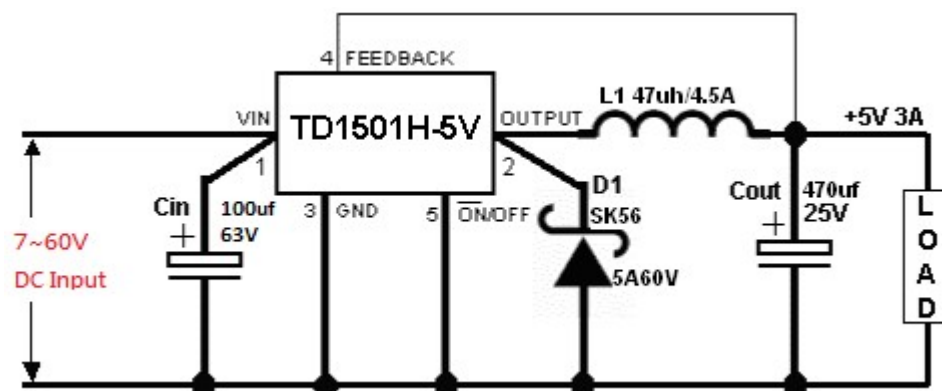


Figure 3. Typical Application of TD1501H

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Absolute Maximum Ratings

Note1: Stresses greater than those listed under Maximum Ratings may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions above those indicated in the operation is not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.

Parameter	Value	Unit
Supply Voltage V_{in}	-0.3 to 62	V
Feedback VFB pin voltage	-0.3 to $V_{in}+0.3$	V
ON/OFF Pin voltage	-0.3 to 32V	V
Output pin voltage	-0.3 to $V_{in}+0.3$	V
Output Voltage to Ground (Steady State)	-1	V
Power Dissipation	Internally limited	W
Operating Temperature Range	-40 to +125	°C
Storage Temperature	-65 to +150	°C
Lead Temperature (Soldering, 10 sec)	200	°C
ESD(HM)	4000	V

Electrical Characteristics (All Output Voltage Versions)

Unless otherwise specified, $V_{in} = 12V$ for 3.3V, 5V, adjustable version. $I_{load} = 0.5A$, $T_a = 25^{\circ}C$.

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
I_b	Feedback bias current	Adjustable only, $V_{FB}=1.3V$		10	50/ 100	nA
I_Q	Quiescent current	$V_{FB}=12V$ force driver off		5	10	mA
I_{STBY}	Standby quiescent current	ON/OFF=5V, $V_{IN}=36V$		80	200/ 250	uA
F_{OSC}	Oscillator frequency		127	150	173	KHz
V_{SAT}	Saturation voltage	$I_{OUT}=3A$		1.4	1.8/ 2.0	V
I_{CL}	Current Limit	Peak Current ($V_{FB}=0V$)		4.5	5.5/ 6.5	A
I_L	Output leakage current	Output=0V ($V_{FB}=12V$)			50	uA
I_L	Output leakage current	Output=-1V ($V_{IN}=36V$)		2	30	mA
V_{IL}	ON/OFF pin logic input	Low (Regulator ON)		1.3	0.6	V
V_{IH}	Threshold voltage	High (Regulator OFF)	2.0	1.3		V

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I_H I_L	ON/OFF pin input current	$V_{LOGIC}=2.5V$ (Regulator OFF)		5	15	μA
		$V_{LOGIC}=0.5V$ (Regulator ON)		0.02	5	μA
θ_{JC}	Thermal Resistance Junction to Case	TO220B-5L/TO220-5L TO263-5L		2.5 3.5		$^{\circ}C/W$
θ_{JA}	Thermal Resistance Junction to Ambient (Note1)	TO220B-5L/TO220-5L TO263-5L		28 23		$^{\circ}C/W$
TD1501H ADJ	Vout: Output Voltage	$11V \leq V_{IN} \leq 60V$, $0.2A \leq I_{LOAD} \leq 3A$, V_{OUT} for 9V	1.193/ 1.180	1.23	1.267/ 1.280	V
	η : Efficiency	$V_{IN}=12V$, $V_{OUT}=9V$, $I_{LOAD}=3A$		88		%
TD1501H 5V	Vout: Output Voltage	$7V \leq V_{IN} \leq 60V$, $0.2A \leq I_{LOAD} \leq 3A$	4.800/ 4.750	5.0	5.200/ 5.250	V
	η : Efficiency	$V_{IN}=12V$, $I_{LOAD}=3A$		83		%

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

Note1: Thermal resistance with copper area of approximately 3 in².

Typical Performance Characteristics

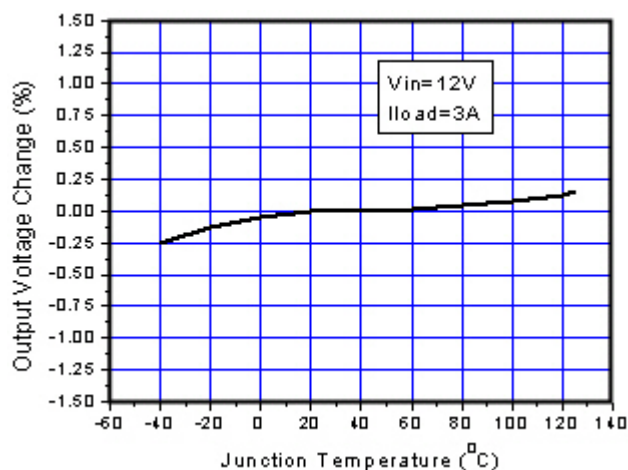


Figure 4. Output Voltage vs. Temperature

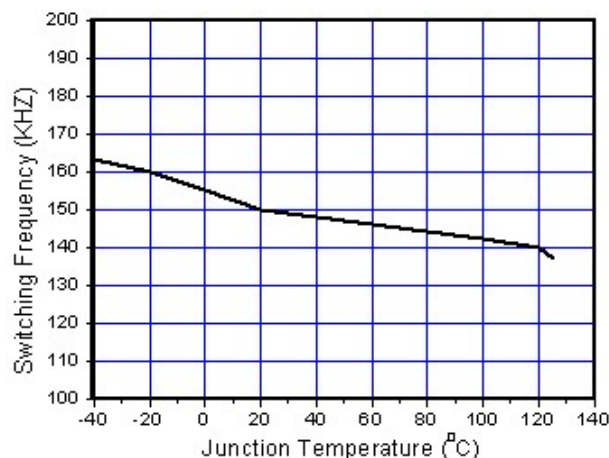


Figure 5. Switching Frequency vs. Temperature

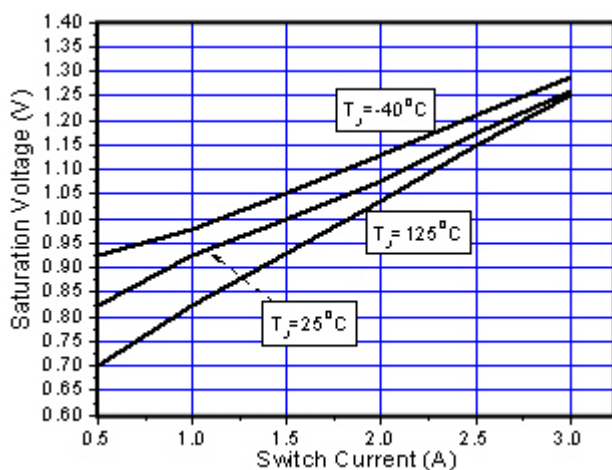


Figure 6. Output Saturation Characteristics

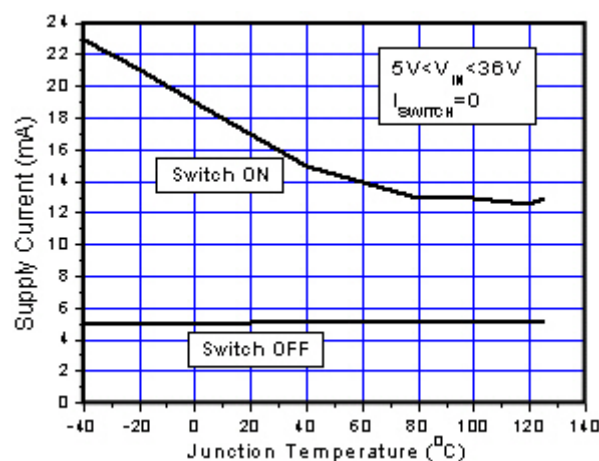


Figure 7. Quiescent Current vs. Temperature

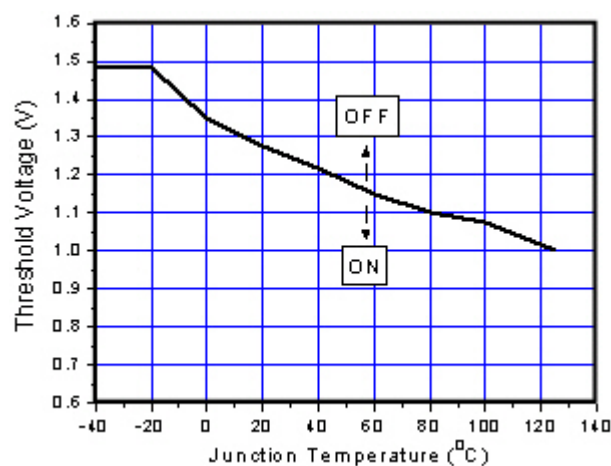


Figure 8. ON/OFF Pin Voltage

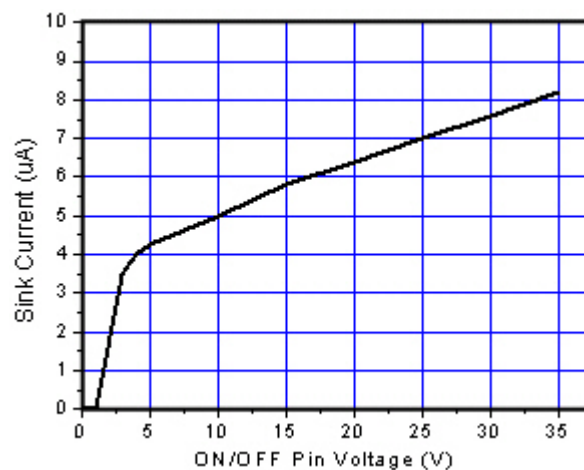


Figure 9. ON/OFF Pin Sink Current

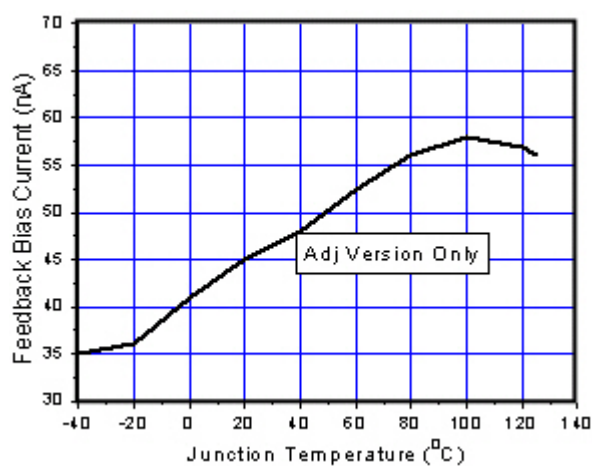


Figure 10. Output Saturation Characteristics

Typical Application Circuit (5V Fixed Output Voltage Version)

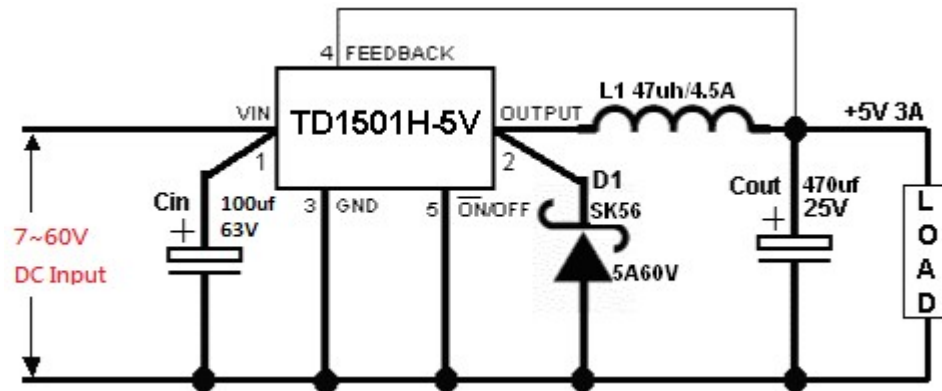


Figure 12. Typical Application of TD1501H For 5V

Input Voltage	Inductor (L1)	Output Capacitor (Cout)	
		Through Hole Electrolytic	Surface Mount Tantalum
8V ~ 18V	33uh	330uf/25V	220uf/10V
8V ~ 60V	47uh	470uf/25V	330uf/10V

Table 2. TD1501H Series Buck Regulator Design Procedure For 5V

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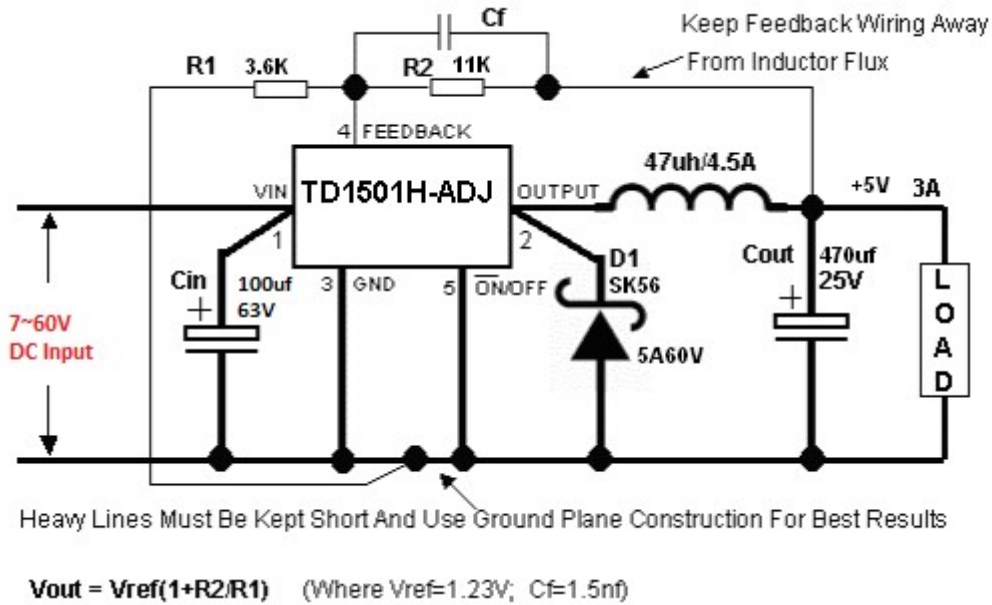
Typical Application Circuit (Adjustable Output Voltage Version)

Figure 13. Typical Application of TD1501H For ADJ

Vout	R1	R2	Cf (Operational)
3.3V	1.6K	2.7K	33nf
5V	3.6K	11K	10nf
9V	6.8K	43K	1.5nf
12V	1.5K	13K	1nf

Table 3. Vout VS. R1, R2, Cf Select Table

Output Voltage	Input Voltage	Inductor (L1)	Output Capacitor (Cout)
			Through Hole Electrolytic
3.3V	6V ~ 18V	47uh	470uf/25V
	6V ~ 60V	68uh	560uf/25V
5V	8V ~ 18V	33uh	330uf/25V
	8V ~ 60V	47uh	470uf/25V
9V	12V ~ 18V	47uh	330uf/25V
	12V ~ 60V	47uh	470uf/25V
12V	15V ~ 18V	47uh	220uf/25V
	15V ~ 60V	47uh	330uf/25V

Table 4. Typical Application Buck Regulator Design Procedure

Application Hints and Layout Guidelines

Heat Sink / Thermal Considerations

The TD1501H is available in two packages, a 5-pin TO-220B/TO220 and a 5-pin surface mount TO-263.

The TO-220B/TO220 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 TD1501H 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 TD1501H (TO-220B/TO220 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 in², 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 in², only small improvements in heat dissipation are realized. If further thermal improvements are needed, double sided, multilayer PC board with large copper areas and/or airflow are recommended.

The TD1501H (TO-263 package) junction temperature rise 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 be aware that there are many factors that can affect the junction temperature. When load currents higher than 3A 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. (Once 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.

Output Voltage Ripple and Transients

The output voltage of a switching power supply will contain a sawtooth ripple voltage at the switcher frequency, typically about 1% of the output voltage, and may also contain short voltage spikes at the peaks of the sawtooth waveform.

The output ripple voltage is due mainly to the inductor sawtooth ripple current multiplied by the ESR of the output capacitor.

The voltage spikes are present because of the fast switching action of the output switch, and the parasitic inductance of the output filter capacitor. To minimize these voltage spikes, special low inductance capacitors can be used, and their lead lengths must be kept short. Wiring inductance, stray capacitance, as well as the scope probe used to evaluate these transients, all contribute to the amplitude of these spikes.

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A large value inductor will also result in lower output ripple voltage, but will have a larger physical size, higher series resistance, and/or lower saturation current. An additional small LC filter can be added to the output (as shown in Figure 14) to further reduce the amount of output ripple and transients.

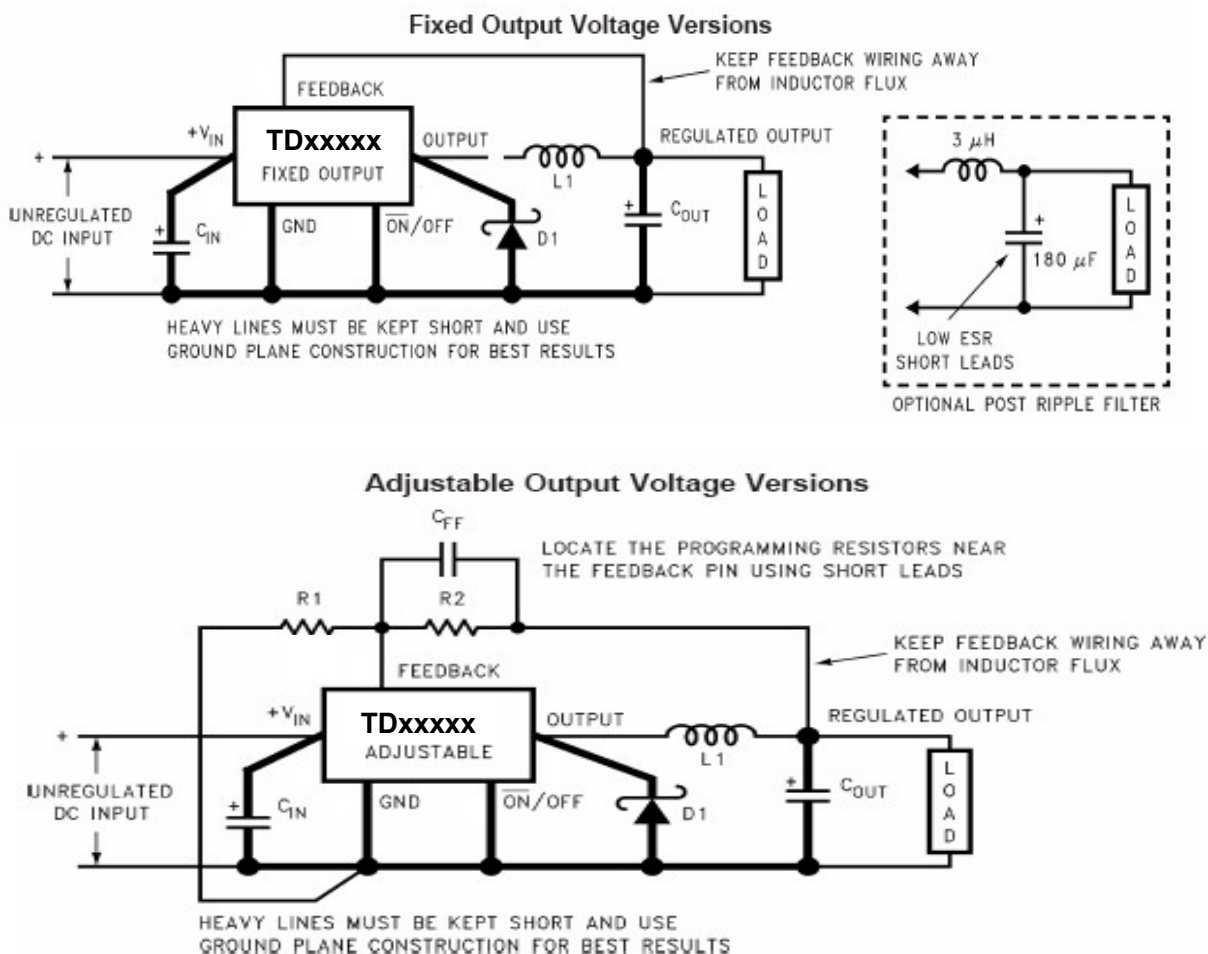
Layout Guidelines

As in any switching regulator, layout is very important. Rapidly switching currents associated with wiring inductance can generate voltage transients which can cause problems. For minimal inductance and ground loops, the wires indicated by **heavy lines** should be wide printed circuit traces and should be kept as short as possible. For best results, external components should be located as close to the switcher IC as possible using ground plane construction or single point grounding.

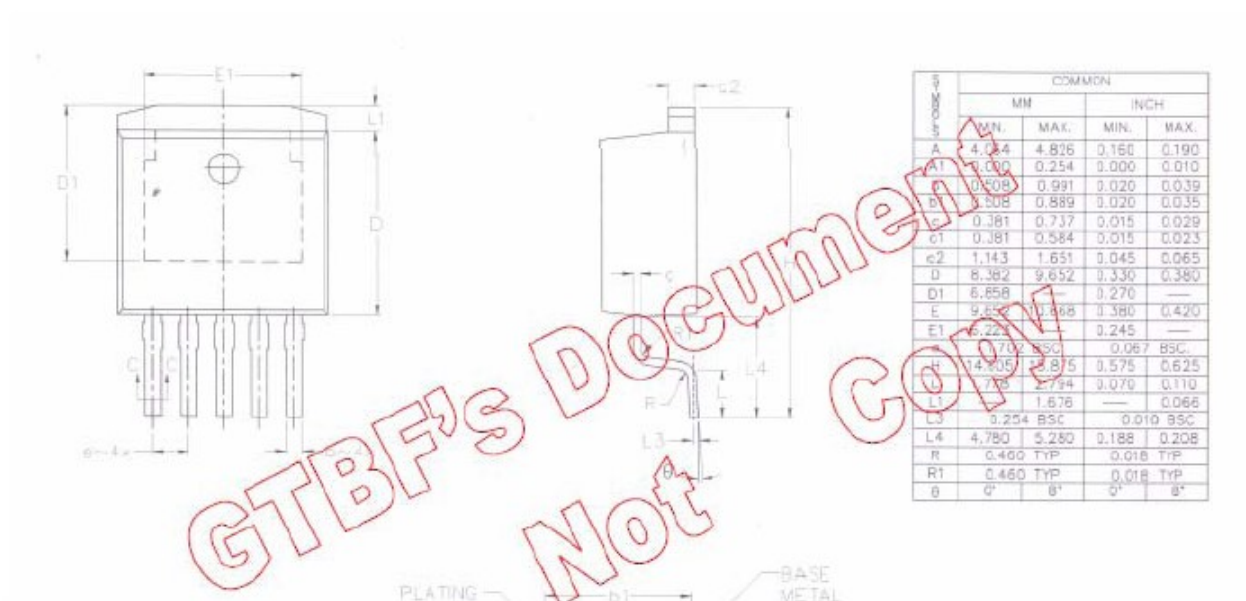
If open core inductors are used, special care must be taken as to the location and positioning of this type of inductor. Allowing the inductor flux to intersect sensitive feedback, IC groundpath and C_{OUT} wiring can cause problems.

When using the adjustable version, special care must be taken as to the location of the feedback resistors and the associated wiring. **Physically locate both resistors near the IC, and route the wiring away from the inductor especially an open core type of inductor.**

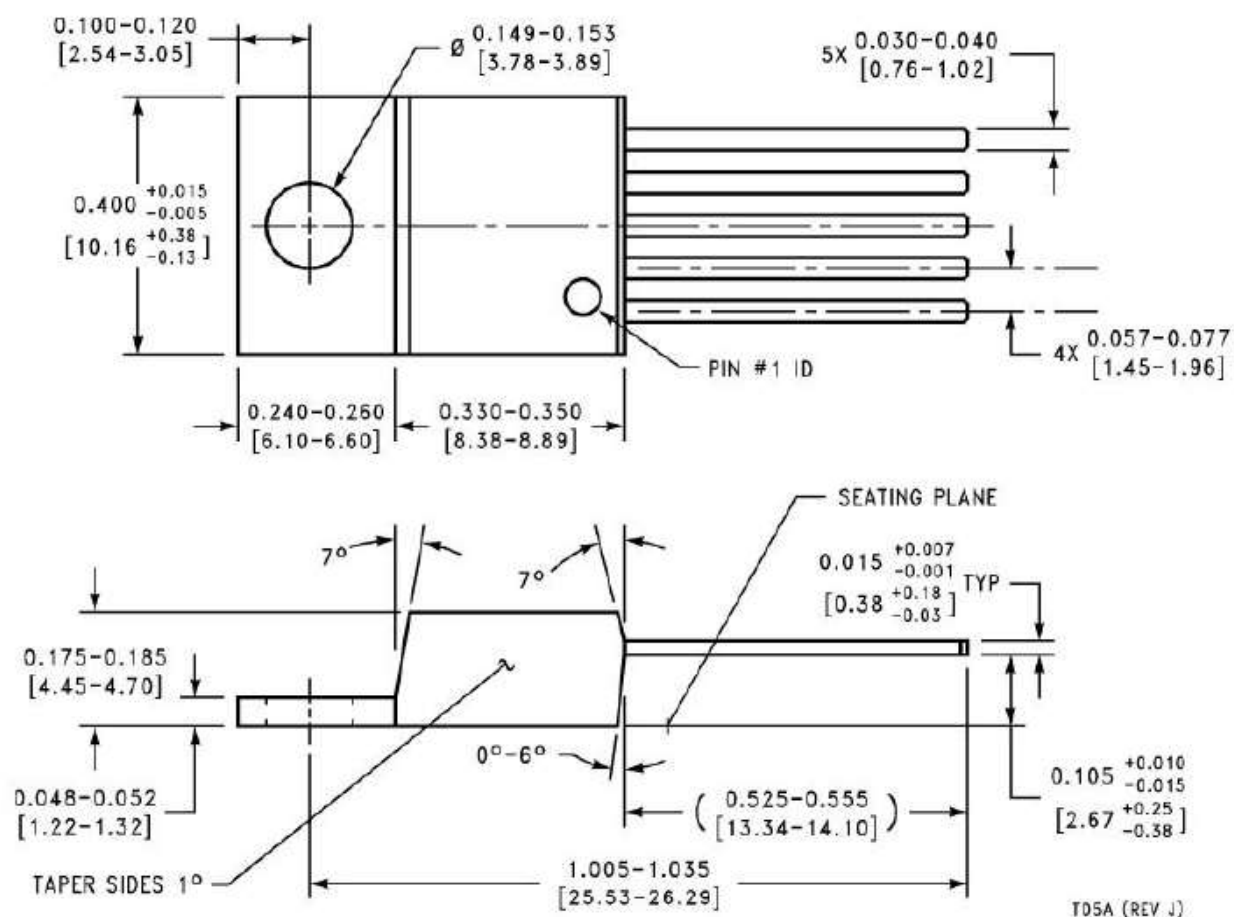
Figure 14, Layout Guidelines and Post Ripple Filter

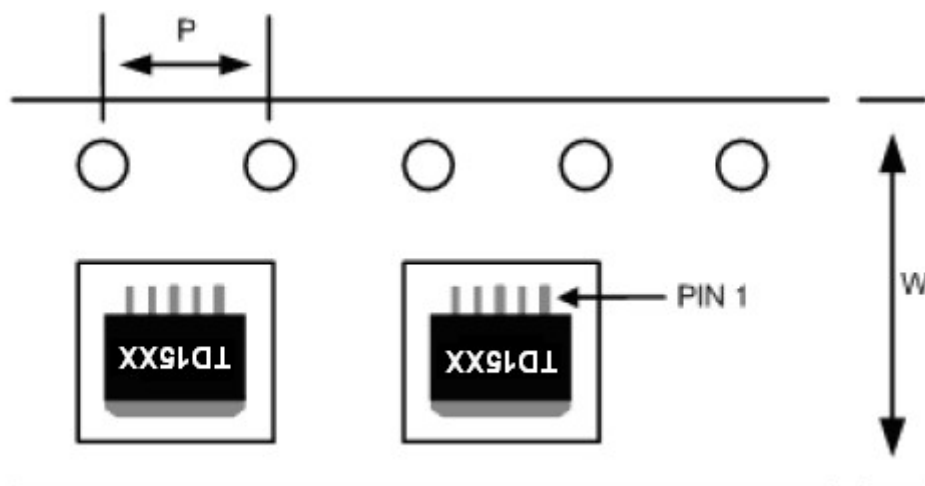


Package Information (TO263-5L)



Package Information (TO220-5L)



TO263-5L Carrier Tape Outline Dimensions**Carrier Tape, Number of Components Per Reel and Reel Size**

Package	Carrier Width (W)	Pitch (P)	Part Per Full Reel	Reel Size
TO263-5L	24.0 ± 0.1mm	4.0 ± 0.1mm	800 PCS	330 ± 2mm