LA5751/52/53/54

Simple Switching 3A Step-Down Voltage Regulator

General Description

The LA575x series of regulators are monolithic integrated that provide all the active functions for a step-down switching regulator, capable driving 3A load with excellent line and load regulation.
These devices are available in fixed output voltage of 3.3V, 5V, 12V, and an adjustable output version.

Features

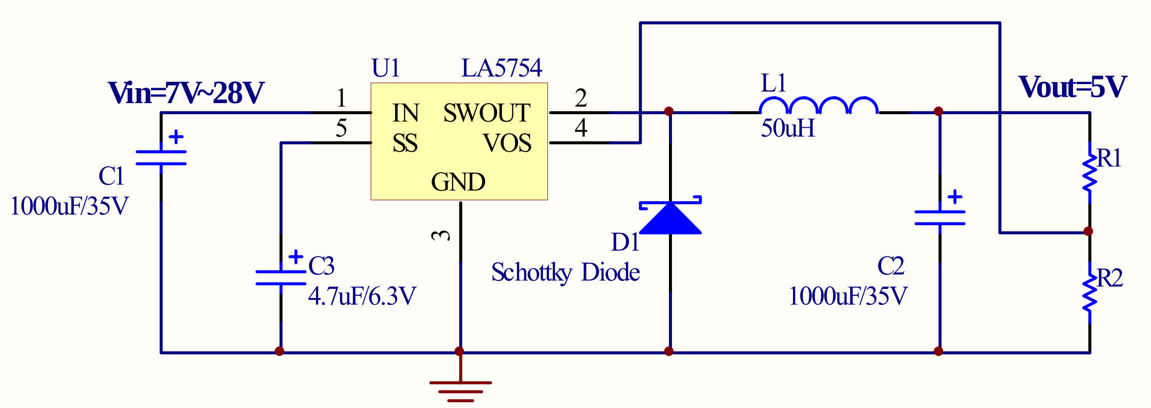
- 3.3V, 5V, 12V, and adjustable output versions
- Adjustable output voltage range, 2.6V to V_{IN}-2V
- Guaranteed 3A output current
- High Efficiency
- Few external parts (4 only)
- Built-in reference oscillator,
  LA5751/52/53 is 60 kHz
  LA5754 is 125 kHz
- Thermal shutdown capability
- Includes soft start circuit
- Current limit capability
- Uses readily available standard inductor

Applications

- Simple high –efficiency step-down (Buck) regulator
- Efficiency pre-regulator for line regulators
- On-card switching regulators
- Positive to negative converter (Buck-Boost)

Typical Application Circuit

Adjustable Output Voltage Version



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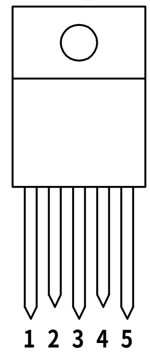
Absolute Maximum Rating (Note 1)

Maximum Input Voltage	30V
Maximum Output Current	3A
Impressed Reverse Voltage at SW Pin	-1V
Power Dissipation	Internally Limited
Maximum Junction Temperature	125℃
Storage Temperature	-40°C to +125°C
SS Pin	$-0.3V \leqq V \leqq +V_{IN}$

Operating Ranges

Supply Voltage	28V
Temperature Ranges	-40°C to +125°C

Package / Order information



Pin out

1 V_{IN}
2 SW_{OUT}
3 GND
4 VOS
5 SS

Part Number	Voltage	Package

LA5751, LA5754-3.3V (Note 2)
Electrical Characteristics

Specification with standard type face for T_J=25℃.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
V_{OUT}	Output Voltage	V_{IN}=12, I_{LOAD}=0.5A		3.3		V
V_{OUT}	Output Voltage	$7V \leq V_{IN} \leq 28V$, $0.5 \leq I_{LOAD} \leq 3A$		3.3		V
V_{OUT}	Adjustable Output Voltage	$7V \leq V_{IN} \leq 28V$, $0.5 \leq I_{LOAD} \leq 3A$		3.3		V
Efficiency	η	V_{IN}=12V, I_{LOAD}=3A V_{OUT}=3.3V	73			%

LA5752, LA5754-5V (Note 2)
Electrical Characteristics

Specification with standard type face for T_J=25℃.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
V_{OUT}	Output Voltage	V_{IN}=12, I_{LOAD}=0.5A		5		V
V_{OUT}	Output Voltage	$10V \leq V_{IN} \leq 28V$, $0.5 \leq I_{LOAD} \leq 3A$		5		V
V_{OUT}	Adjustable Output Voltage	$10V \leq V_{IN} \leq 28V$, $0.5 \leq I_{LOAD} \leq 3A$		5		V
Efficiency	η	V_{IN}=12V, I_{LOAD}=3A V_{OUT}=5V	78			%

LA5753, LA5754-12V (Note 2)
Electrical Characteristics

Specification with standard type face for T_J=25℃.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit

LA5753, LA5754-12V (Note 2)

Electrical Characteristics (continued)

Specification with standard type face for T_J=25℃.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
V_{OUT}	Output Voltage	V_{IN}=12, I_{LOAD}=0.5A		12		V
V_{OUT}	Output Voltage	14V ≤ V_{IN} ≤ 28V, 0.5 ≤ I_{LOAD} ≤ 3A		12		V
V_{OUT}	Adjustable Output Voltage	14V ≤ V_{IN} ≤ 28V, 0.5 ≤ I_{LOAD} ≤ 3A		12		V
Efficiency	η	V_{IN}=25V, I_{LOAD}=3A V_{OUT}=12V	87			%

LA5754-15V (Note 2)

Electrical Characteristics

Specification with standard type face for T_J=25℃.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
V_{OUT}	Output Voltage	V_{IN}=12, I_{LOAD}=0.5A		15		V
V_{OUT}	Output Voltage	25V ≤ V_{IN} ≤ 28V, 0.5 ≤ I_{LOAD} ≤ 3A		15		V
V_{OUT}	Adjustable Output Voltage	25V ≤ V_{IN} ≤ 28V, 0.5 ≤ I_{LOAD} ≤ 3A		15		V
Efficiency	η	V_{IN}=25V, I_{LOAD}=3A V_{OUT}=15V	88			%

All Output Voltage Versions

Electrical Characteristics

Specification with standard type face for T_J=25℃, unless otherwise specified, V_{IN}=12V for the 3.3V, 5.0V, and Adjustable version, V_{IN}=25V for the 12V version, and V_{IN}=28V for the 15V version.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Feedback Voltage	VOS	V_{OUT}=5.0V		2.6		V
Max Duty Cycle(ON)				98		% (NOTE3)
Current Limit	I_S		3.5			A
Quiescent Current	I_Q	V_{IN}=12V V_{OUT}=5.0V		5	10	mA (NOTE4)
Output Leakage Current	I_L			0.3		mA (NOTE4,5)
Switching Frequency (Fixed Version)	F			60		kHz
Switching Frequency (Adjustable Version)	F			125		kHz
Ripple Rejection	RREJ	F=100~120Hz		45		dB
Temperature Coefficient of Output Voltage	$\frac{\Delta V_O}{\Delta T_A}$			±0.5		mV/℃
Thermal Shutdown	TSD				165	℃

Simple Switching 3A Step-Down Voltage Regulator

All Output Voltage Versions

Electrical Characteristics (continued)

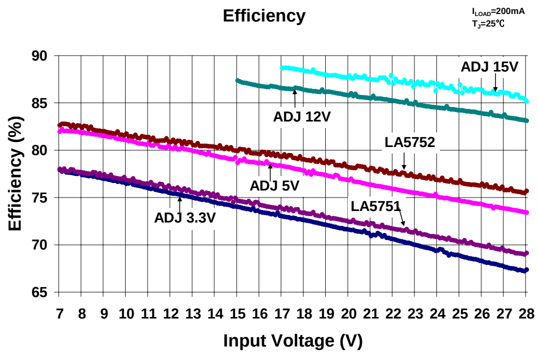
Specification with standard type face for T_J=25℃, unless otherwise specified, V_{IN}=12V for the 3.3V, 5.0V, and Adjustable version, V_{IN}=25V for the 12V version, and V_{IN}=28V for the 15V version.

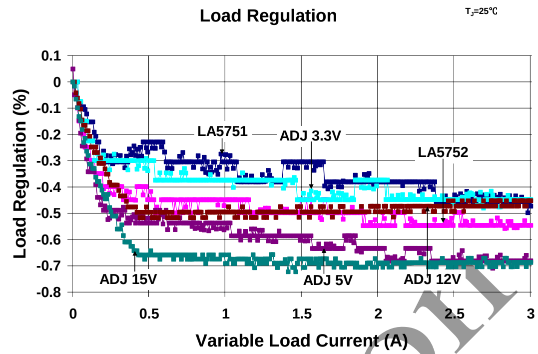
Parameter	Symbol	Conditions	Min	Typ	Max	Unit
TSD Hysteresis	ΔTSD				15	℃

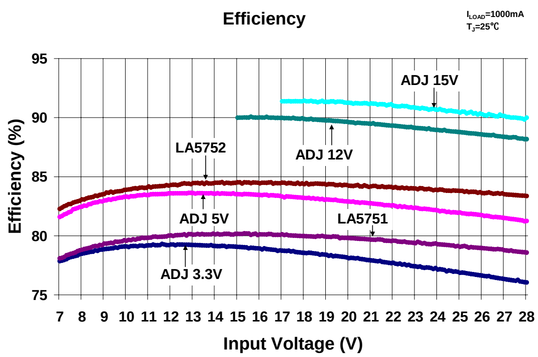
Note1: Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device intended to be functional, but do not guarantee specific performance limits. For guarantee specifications and test conditions, see Electrical Characteristics.
Note2: External components such as the input and output capacitors, inductor and catch diode can affect switching regulator system performance. When the LM5751/52/53/54 is used as shown in the Figure 1 test circuit, system performance will be shown in system parameter section of Electrical Characteristics.
Note3: VOS pin removed from output and connected to GND (0V).
Note4: VOS pin removed from output and connected to +12V for the Adjustable, 3.3V and 5.0V version, and +25V for the 12V and 15V version, to force the output transistor OFF.
Note5: V_{IN}=28V.

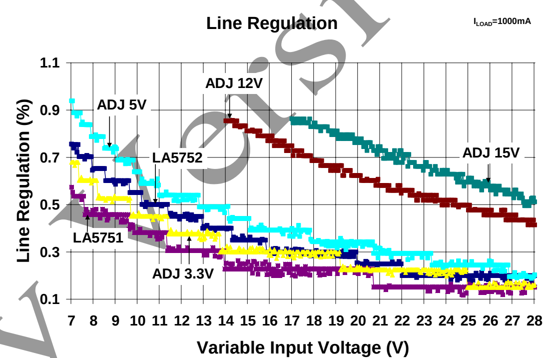
Simple Switching 3A Step-Down Voltage Regulator

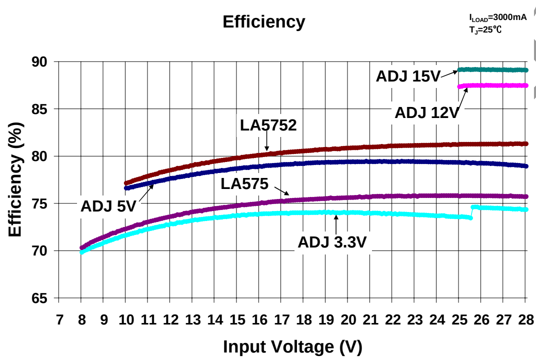
Typical Characteristics



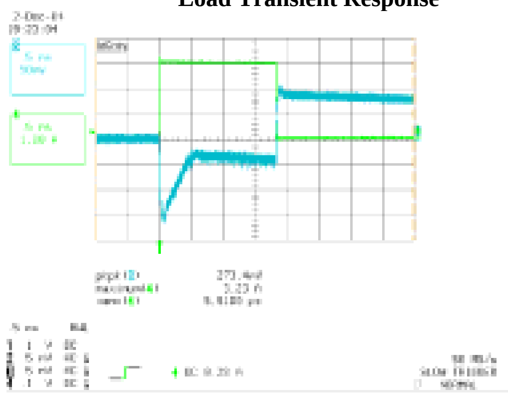




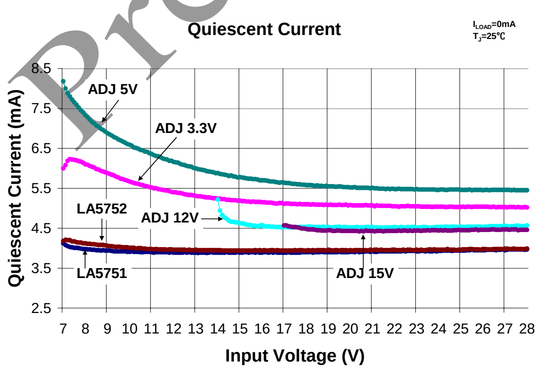




Load Transient Response

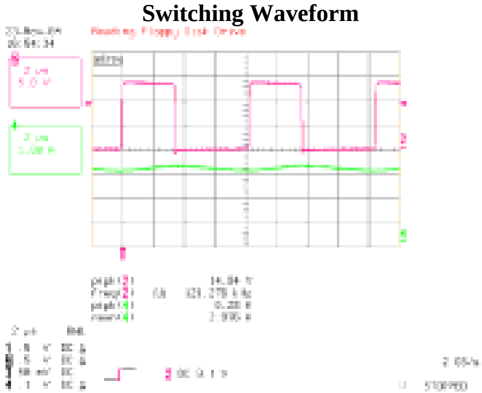


V_{OUT}=5.0V CH3: Output Pin Voltage
CH4: Output Load Current



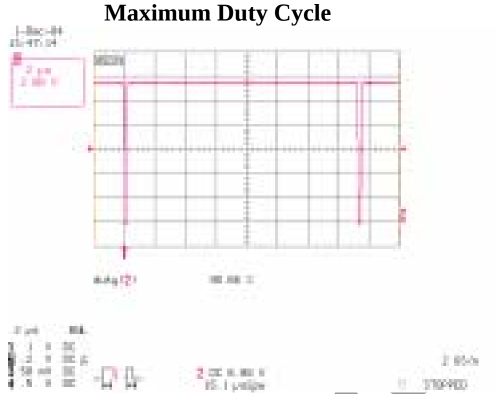
Typical Characteristics (CONTINUED)

Switching Waveform



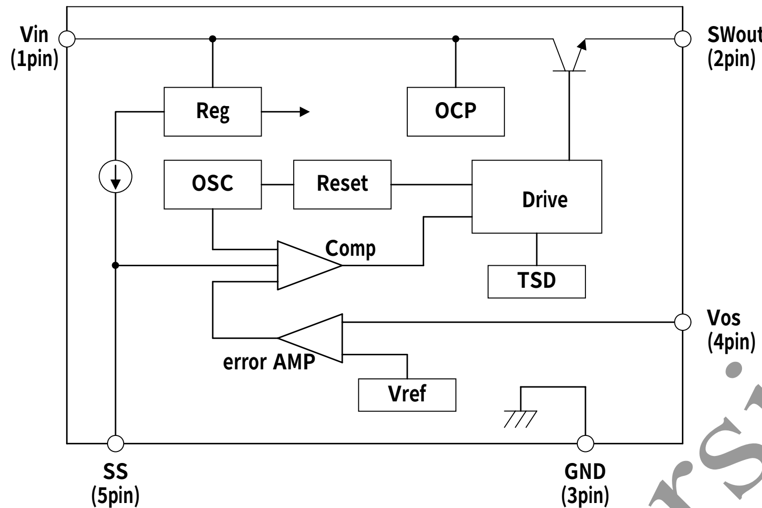
V_{OUT}=5.0V CH2: Output Pin Voltage
CH4: Output Load Current

Maximum Duty Cycle



V_{IN}=12V CH2: SW_{OUT} Pin Voltage

Block Diagram



Pin Functions

V_{IN} (Pin 1)

The LA575x series operates from +7V to +28V unregulated input. Highest efficiency operation is from a supply voltage around +28V.

SW_{OUT} (Pin2)

This is the output of a power BJT switch connected directly to the input voltage. The switch provides energy to an inductor, an output capacitor and the load circuitry under control of an internal pulse-width-modulator (PWM). The PWM controller is internally clocked by fixed oscillator. In a standard step-down application the duty cycle (Time ON/Time OFF) of the power switch is proportion to the ratio of the power supply output voltage to the input voltage. The voltage on pin 2 switches between V_{IN} (switch ON) and below ground by the voltage drop of the external Schottky diode (switch OFF).

GND (Pin3)

This is the ground reference connection for all components in the power supply. In fast-switching, high-current application such as those implemented with the LA575x series; it is recommended that a board ground plane be used to minimum signal coupling throughout the circuit.

VOS (Pin4)

For adjustable output version require an external resistive voltage divider from the output voltage to ground, connected from the 2.6V tap to VOS. For fixed output version require connected output to VOS.

SS (Pin5)

A capacitor connected from SS pin to ground allows for a slow turn-on of the switching regulator. The capacitor sets a time delay to gradually increase the duty cycle of the internal power switch. This can significantly reduce the amount of surge current required from the input supply during an abrupt application of the input voltage. If soft- start is not required this pin should be left open circuit.

Application Note

Input Capacitor

Fast changing current in high current switching regulators place a significant dynamic load on the unregulated power source. Input capacitors to provide additional current to the power supply as well as smooth out input voltage variations.
Like the output capacitor, the major specifications for the input capacitor are RMS current rating and working voltage. The RMS current flowing through the input capacitor is equal to one-half of the maximum dc load current so the capacitor should be rated to handle this. It may be necessary to add a small valued (0.1uF or 0.47uF) ceramic type capacitor in parallel with the input capacitor to prevent to minimize any ringing. Paralleling multiple capacitors proportionally increase the current rating of the total capacitance. The voltage rating should be selected to be 1.3 times the input voltage. According to the input power source, under light load conditions the maximum input voltage could be significantly highly than normal operation and should be considered when selecting an input capacitor.

Output Capacitor

The output capacitor acts to smooth the dc output voltage and also provides energy storage. Selection of an output capacitor, with an associated equivalent series resistance (ESR), impacts both the amount of output ripple voltage and stability of the control loop. The output ripple voltage of the power supply is the product of the capacitor ESR and the inductor ripple current. The capacitor types recommend in “Low ESR” capacitors.
In addition, both surface mount tantalum capacitors and through-hold aluminum electrolytic capacitors are offered as solution.

Inductor

The inductor is the major key component in a switching regulator. For efficiency the inductor stores energy during the switch ON and then transfers energy to the load while the switch is OFF.
Monographs are used to select the inductance value required for a given set of operating conditions. The monographs assume that the circuit is operating in continuous mode.
The minimum inductance can be calculated with follow simple formula:

$$L_{BUCK} \geq \frac{V_O * V_O * T_S}{2 P_{O,\,MIN}} (1 - \frac{V_O}{V_{I,\,MAX}})$$

Selection the inductors in Ferrite stick core, benefits are typically lowest cost and can withstand ripple and transient peak currents above the rated value. These inductors have an external magnetic field, which may generate EMI.

Catch Diode

When the power switch of BJT turns OFF, the current through the inductor continuous to flow. The part for this current is through the diode connected between the switch output and ground. This forward biased diode clamps the switch output to a voltage less than ground. This negative voltage must be greater than -1V so a low voltage drops (particularly at high current levels) Schottky diode is recommended. Total efficiency of the entire power supply is significantly impacted by the power lost in the output catch diode.

The average current through the catch diode is dependent on the switch duty cycle (D) and is equal to the load current times (1-D). Use of a diode rated for much higher current than is required by than actual application helps to minimize the voltage drop and power loss in the diode.

During ON switch ON time the diode will be reversed biased by the input voltage. The reverse voltage rating of the diode should be at least 1.3 times greater than the maximum input voltage.

C_{SS} Soft-Start Capacitor

This capacitor control the rate at switch the LA575x series starts up at power on. The capacitor is charged linearly by an internal current source (28uA). This voltage ramp gradually increase the duty cycle of the power switch until it reaches the normal operating duty cycle defined primary by the ratio of the output voltage to the input voltage. The soft-start turn-on time is programmable by the selection of C_{SS}

Setting Output Voltage

The adjustable version of LA5754 can be set to different output voltage. The relationship in the following formula is based on a voltage divider from the output to the VOS pin, which is set to an internal reference voltage of 2.6V. Standard 1% metal film resistors of surface mount size 0603 are recommended and R2 would be 5.1kΩ.

$$V_{OUT} = 2.6 * (\frac{R1}{R2} + 1) = 2.6 * (\frac{R1}{5.1k\Omega} + 1)$$

$$R1 = \frac{R1 * (V_{OUT} - 2.6)}{2.6} = \frac{5.1k\Omega * (V_{OUT} - 2.6)}{2.6}$$

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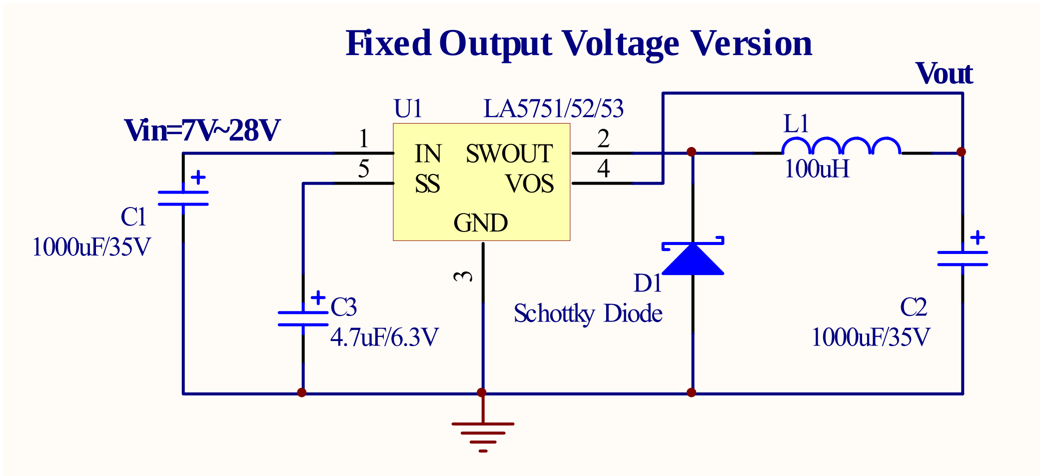
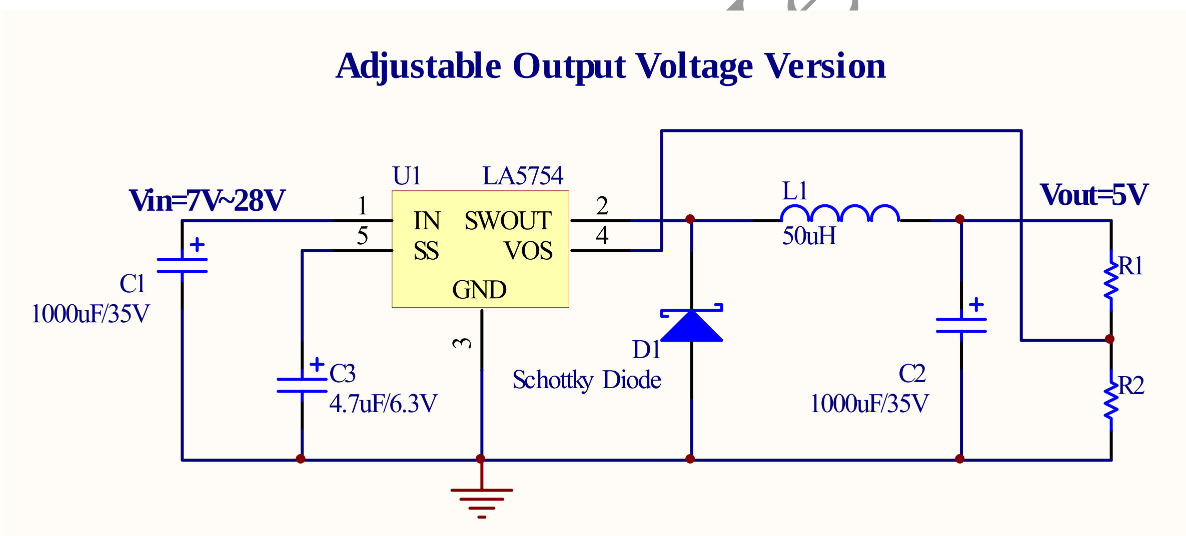
Test Circuit





D1	3A Schottky Diode
C1, C2	35ME1000AX, SANYO Low ESR Capacitor
L1	100uH for fixed version, 50uH for adjustable version
R1	4.7 kΩ, 1% for 5V adjustable version
R2	5.1kΩ, 1%

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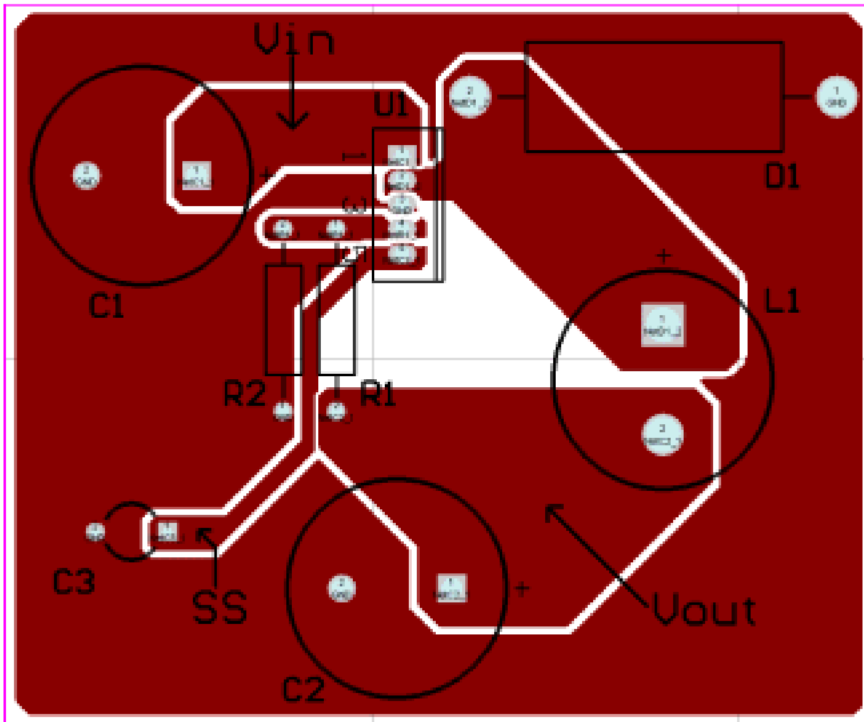
Layout Guideline



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