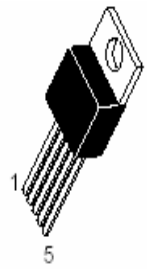
3.0A, 150Khz, Step-Down Switching Regulator LM2596

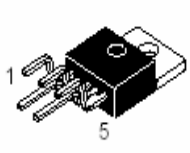
FEATURES

- 3.3V, 5.0V, 12V, 15V, and Adjustable Output Versions
- Adjustable Version Output Voltage Range, 1.23 to 37V +/- 4%. Maximum Over Line and Load Conditions
- Guaranteed 3.0A Output Current
- Wide Input Voltage Range
- Requires Only 4 External Components
- 150Khz Fixed Frequency Internal Oscillator
- TTL Shutdown Capability, Low Power Standby Mode
- High Efficiency
- Uses Readily Available Standard Inductors
- Thermal Shutdown and Current Limit Protection
- Moisture Sensitivity Level(MSL) Equals1

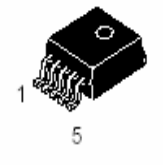
TO-220



TO-220V



TO-263(D2)



1. Vin
2. Output
3. Ground
4. Feedback
5. On/Off

Applications

- Simple High-Efficiency Step-Down(Buck) Regulator
- Efficient Pre-Regulator for Linear Regulators
- On-Card Switching Regulators
- Positive to Negative Converter(Buck-Boost)
- Negative Step-Up Converters
- Power Supply for Battery Chargers

DESCRIPTION

The LM2596 series of regulators are monolithic integrated circuits ideally suited for easy and convenient design of a step-down switching regualtor(buck converter).

All circuits of this series are capable of driving a 3.0A load with excellent line and load regulation. These devices are available in fixed output voltages of 3.3V, 5.0V,12V, 15V, and an adjustable output version.

These regulatiors were designed to minimize the number of externalcomponents to simplify the power supply design. Standard series of inductors optimized for use with the LM2576 are offered by several different inductor manufacturers.

Since the LM2596 converter is a switch-mode power supply, its efficiency is significantly higher in comparison with popular three-terminal limear reguators, especially with higher input voltages.

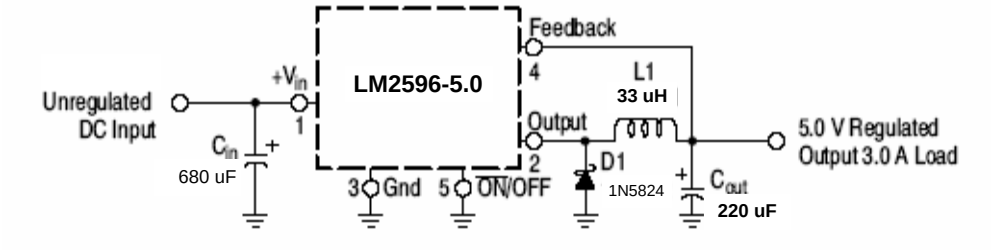
In many cases, the power dissipated is so low that no heatsink is required or its size could be reduced dramatically. A standard series of inductors optimized for use with the LM2596 are available from several different manufacturers. This feature greatly simplifies the design of switch-mode power supplies. The LM2596 features include a guaranteed +/- 4% tolerance on output voltage within specified input voltages and output load conditions, and +/-15% on the oscillator frequency (+/- 2% over 0oC to 125 oC).

External shutdown is included, featuring 80 uA(typical) standby current. The output switch includes cycle-bycycle current limiting, as well as thermal shutdown for full protection under fault conditions.

ORDERING INFORMATION

Device	Marking	Package
LM2596T-X.X	LM2596T-X.X	TO-220
LM2596TV-X.X	LM2596T-X.X	TO-220V
LM2596R	LM2596R-X.X	TO-263

Typical Application (Fixed Output Voltage Versions)



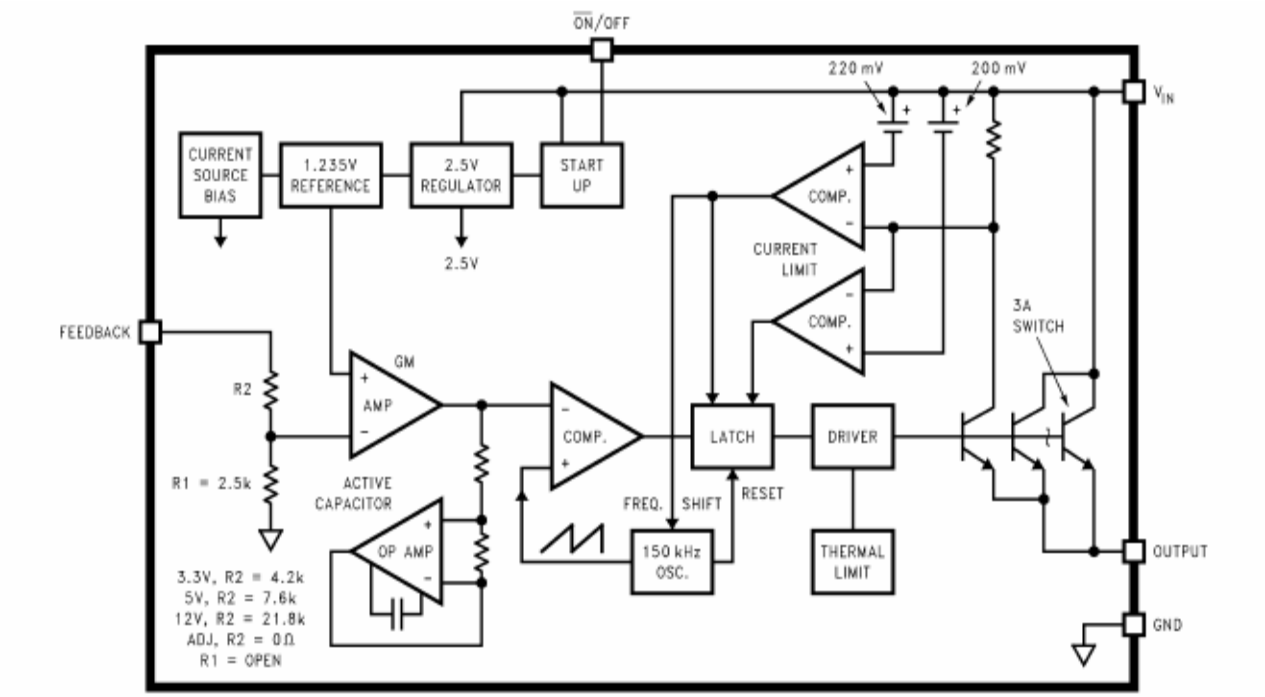


Figure 1. Block Diagram and Typical Application

ABSOLUTE MAXIMUM RATINGS

(Absolute Maximum Ratings indicate limits beyond which damage to the device may occur.)

Rating	Symbol	Value	Unit
Maximum Supply Voltage	V_{in}	45	V
ON/OFF Pin Input Voltage	–	$-0.3\ V \le V \le +V_{in}$	V
Output Voltage to Ground (Steady–State)	–	–1.0	V
Power Dissipation			
TO–220, 5–Lead	P_D	Internally Limited	W
Thermal Resistance, Junction–to–Ambient	$R_{\theta JA}$	65	°C/W
Thermal Resistance, Junction–to–case	$R_{\theta JC}$	5.0	°C/W
TO–263	P_D	Internally Limited	W
Thermal Resistance, Junction–to–Ambient	$R_{\theta JA}$	70	°C/W
Thermal Resistance, Junction–to–case	$R_{\theta JC}$	5.0	°C/W
Storage Temperature Range	T_{stg}	–65 to +150	°C
Minimum ESD Rating (Human Body Model: C = 100 pF, R = 1.5 kΩ)	–	2.0	kV
Lead Temperature (Soldering, 10 seconds)	–	260	°C
Maximum Junction Temperature	T_J	150	°C

OPERATING RATINGS (Operating Ratings indicate conditions for which the device is intended to be functional, but do not guarantee specific performance limits. For guaranteed specifications and test conditions, see the Electrical Characteristics.)

Rating	Symbol	Value	Unit
Operating Junction Temperature Range	T_J	–40 to +125	°C
Supply Voltage	V_{in}	40	V

ELECTRICAL CHARACTERISTICS / SYSTEM PARAMETERS ([Note 1] Test Circuit Figure 2)
(Unless otherwise specified, Vin = 12 V for the 3.3 V, 5.0 V, and Adjustable version, Vin = 25 V for the 12 V version, and Vin = 30 V for the 15 V version. ILoad = 500 mA. For typical values TJ = 25°C, for min/max values TJ is the operating junction temperature range that applies [Note 2], unless otherwise noted.)

Characteristics	Symbol	Min	Typ	Max	Unit
LM2596-3.3 ([Note 1]. Test Circuit Figure 2)					
Output Voltage (V_{in} = 12 V, I_{Load} = 0.5 A, T_J = 25°C)	V_{out}	3.234	3.3	3.366	V
Output Voltage (6.0 V ≤ V_{in} ≤ 40 V, 0.5 A ≤ I_{Load} ≤ 3.0 A) T_J = 25°C T_J = –40 to +125°C	V_{out}	 3.168 3.135	 3.3 –	 3.432 3.465	V
Efficiency (V_{in} = 12 V, I_{Load} = 3.0 A)	η	–	73	–	%
LM2596-5.0 ([Note 1]. Test Circuit Figure 2)					
Output Voltage (V_{in} = 12 V, I_{Load} = 0.5 A, T_J = 25°C)	V_{out}	4.9	5.0	5.1	V
Output Voltage (8.0 V ≤ V_{in} ≤ 40 V, 0.5 A ≤ I_{Load} ≤ 3.0 A) T_J = 25°C T_J = –40 to +125°C	V_{out}	 4.8 4.75	 5.0 –	 5.2 5.25	V
Efficiency (V_{in} = 12 V, I_{Load} = 3.0 A)	η	–	80	–	%
LM2596-12 ([Note 1]. Test Circuit Figure 2)					
Output Voltage (V_{in} = 25 V, I_{Load} = 0.5 A, T_J = 25°C)	V_{out}	11.76	12	12.24	V
Output Voltage (15 V ≤ V_{in} ≤ 40 V, 0.5 A ≤ I_{Load} ≤ 3.0 A) T_J = 25°C T_J = –40 to +125°C	V_{out}	 11.52 11.4	 12 –	 12.48 12.6	V
Efficiency (V_{in} = 15 V, I_{Load} = 3.0 A)	η	–	90	–	%
LM2596-15 ([Note 1]. Test Circuit Figure 2)					
Output Voltage (V_{in} = 30 V, I_{Load} = 0.5 A, T_J = 25°C)	V_{out}	14.7	15	15.3	V
Output Voltage (18 V ≤ V_{in} ≤ 40 V, 0.5 A ≤ I_{Load} ≤ 3.0 A) T_J = 25°C T_J = –40 to +125°C	V_{out}	 14.4 14.25	 15 –	 15.6 15.75	V
Efficiency (V_{in} = 18 V, I_{Load} = 3.0 A)	η	–	98	–	%
LM2596-ADJ ([Note 1]. Test Circuit Figure 2)					
Feedback Voltage (V_{in} = 12 V, I_{Load} = 0.5 A, V_{out} = 5.0 V, T_J = 25°C)	V_{out}	1.217	1.23	1.243	V
Feedback Voltage (8.0 V ≤ V_{in} ≤ 40 V, 0.5 A ≤ I_{Load} ≤ 3.0 A, V_{out} = 5.0 V) T_J = 25°C T_J = –40 to +125°C	V_{out}	 1.193 1.18	 1.23 –	 1.267 1.28	V
Efficiency (V_{in} = 12 V, I_{Load} = 3.0 A, V_{out} = 5.0 V)	η	–	73	–	%

ELECTRICAL CHARACTERISTICS / Device Parameters

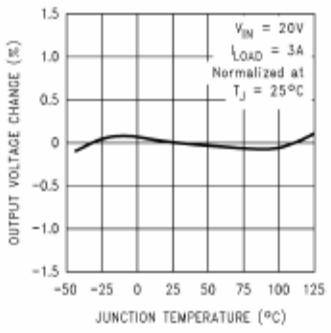
(Unless otherwise specified, Vin = 12 V for the 3.3 V, 5.0 V, and Adjustable version, Vin = 25 V for the 12 V version, and Vin = 30 V for the 15 V version. ILoad = 500 mA. For typical values Tj = 25°C, for min/max values Tj is the operating junction temperature range that applies [Note 2], unless otherwise noted.)

Characteristics	Symbol	Min	Typ	Max	Unit
ALL OUTPUT VOLTAGE VERSIONS					
Feedback Bias Current (V_{out} = 5.0 V [Adjustable Version Only]) T_J = 25°C T_J = 0 to +125°C	I_b	 – –	 10 –	 50 100	nA
Oscillator Frequency [Note 3] T_J = 25°C T_J = 0 to +125°C	f_{osc}	 127 110	 150 – –	 173 173	kHz
Saturation Voltage (I_{out} = 3.0 A [Note 4]) T_J = 25°C T_J = 0 to +125°C	V_{sat}	 – –	 1.16 –	 1.4 1.5	V
Max Duty Cycle ("on") [Note 5]	DC	-	100	–	%
Current Limit (Peak Current [Notes 3 and 4]) T_J = 25°C T_J = 0 to +125°C	I_{CL}	 3.6 3.4	 4.5 –	 6.9 7.5	A
Output Leakage Current [Notes 6 and 7], T_J = 25°C Output = 0 V Output = –1.0 V	I_L	 – –	 - 2	 50 30	mA
Quiescent Current [Note 6] T_J = 25°C T_J = 0 to +125°C	I_Q	 – –	 5 –	 - 10	mA
Standby Quiescent Current ($\overline{ON}$/OFF Pin = 5.0 V ("off")) T_J = 25°C T_J = 0 to +125°C	I_{stby}	 – –	 80 –	 200 250	µA
$\overline{ON}$/OFF Pin Logic Input Level (Test Circuit Figure 2) V_{out} = 0 V T_J = 25°C T_J = 0 to +125°C V_{out} = Nominal Output Voltage T_J = 25°C T_J = 0 to +125°C	V_{IH} V_{IL}	 - 2.0 2.0	 1.3 – 1.3 –	 0.6 0.6 - -	V
$\overline{ON}$/OFF Pin Input Current (Test Circuit Figure 2) V LOGIC = 2.5V (Regulator OFF) V LOGIC = 0.5V (Regulator ON)	I_{IH} I_{IL}	 – –	 5 0.02	 15 5.0	µA

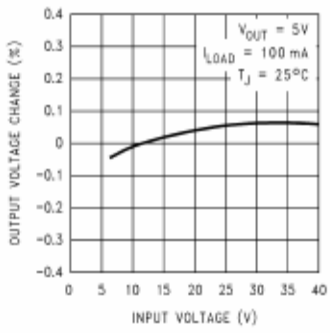
1. External components such as the catch diode, inductor, input and output capacitors can affect switching regulator system performance.
   When the LM2596 is used as shown in the Figure 1 test circuit, system performance will be as shown in system parameters section .
2. Tested junction temperature range for the LM2596 : T_{LOW} = –0°C T_{HIGH} = +125°C
3. The oscillator frequency reduces to approximately 18 kHz in the event of an output short or an overload which causes the regulated output voltage to drop approximately 40% from the nominal output voltage. This self protection feature lowers the average dissipation of the IC by lowering the minimum duty cycle from 5% down to approximately 2%.
4. Output (Pin 2) sourcing current. No diode, inductor or capacitor connected to output pin.
5. Feedback (Pin 4) removed from output and connected to 0 V.
6. Feedback (Pin 4) removed from output and connected to +12 V for the Adjustable, 3.3 V, and 5.0V ersions, and +25 V for the 12 V and15 V versions, to force the output transistor "off".
7. Vin = 40 V.

TYPICAL PERFORMANCE CHARACTERISTICS (Circuit of Figure 2)

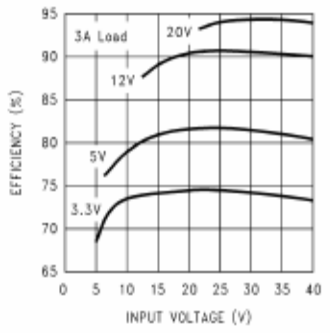
Normalized Output Voltage



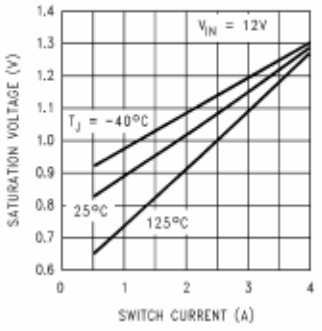
Line Regulation



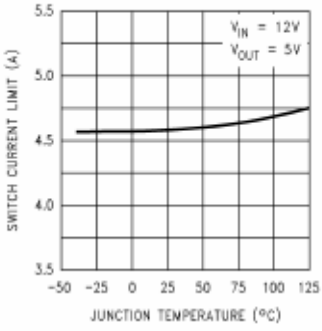
Efficiency



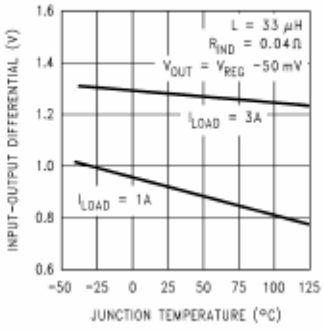
Switch Saturation Voltage



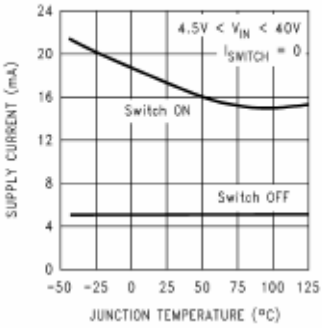
Switch Current Limit



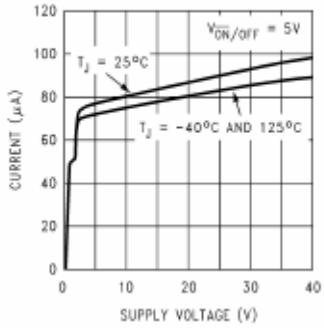
Dropout Voltage



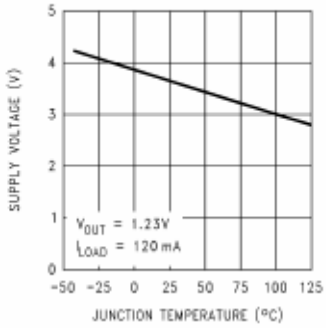
Operating Quiescent Current



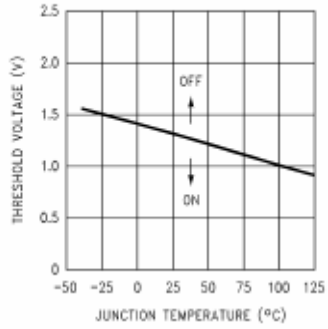
Shutdown Quiescent Current



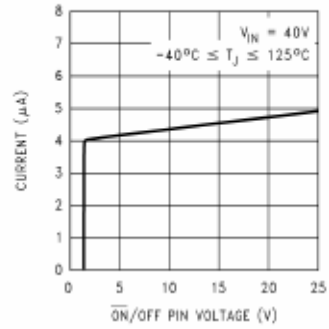
Minimum Operating Supply Voltage



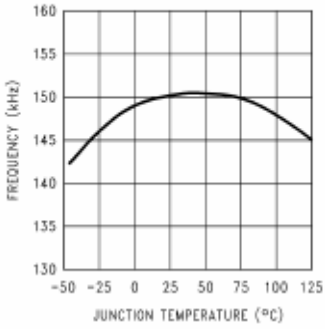
$\overline{ON}$ /OFF Threshold Voltage



$\overline{ON}$ /OFF Pin Current (Sinking)

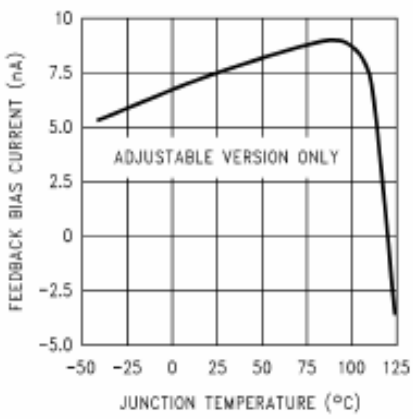


Switching Frequency

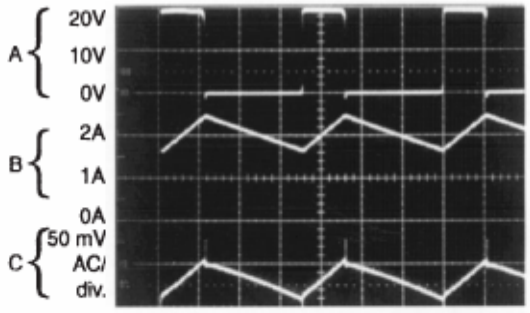


TYPICAL PERFORMANCE CHARACTERISTICS (Circuit of Figure 2)

Feedback Pin Bias Current



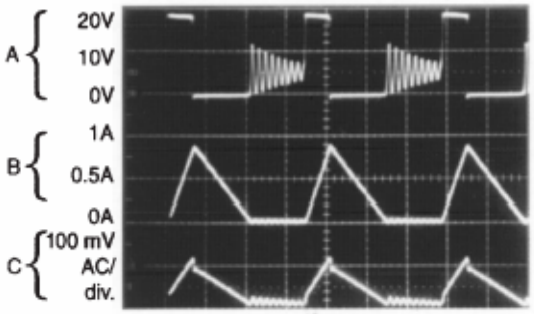
Continuous Mode Switching Waveforms
V_{IN} = 20V, V_{OUT} = 5V, I_{LOAD} = 2A
L = 32 µH, C_{OUT} = 220 µF, C_{OUT} ESR = 50 mΩ



Horizontal Time Base: 2 µs/div.

A: Output Pin Voltage, 10V/div.
B: Inductor Current 1A/div.
C: Output Ripple Voltage, 50 mV/div.

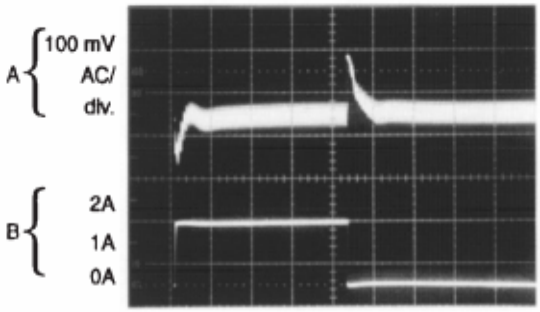
Discontinuous Mode Switching Waveforms
V_{IN} = 20V, V_{OUT} = 5V, I_{LOAD} = 500 mA
L = 10 µH, C_{OUT} = 330 µF, C_{OUT} ESR = 45 mΩ



Horizontal Time Base: 2 µs/div.

A: Output Pin Voltage, 10V/div.
B: Inductor Current 0.5A/div.
C: Output Ripple Voltage, 100 mV/div.

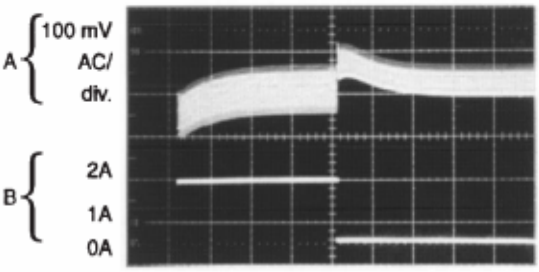
Load Transient Response for Continuous Mode
V_{IN} = 20V, V_{OUT} = 5V, I_{LOAD} = 500 mA to 2A
L = 32 µH, C_{OUT} = 220 µF, C_{OUT} ESR = 50 mΩ



Horizontal Time Base: 100 µs/div.

A: Output Voltage, 100 mV/div. (AC)
B: 500 mA to 2A Load Pulse

Load Transient Response for Discontinuous Mode
V_{IN} = 20V, V_{OUT} = 5V, I_{LOAD} = 500 mA to 2A
L = 10 µH, C_{OUT} = 330 µF, C_{OUT} ESR = 45 mΩ



Horizontal Time Base: 200 µs/div.

A: Output Voltage, 100 mV/div. (AC)
B: 500 mA to 2A Load Pulse

Test Circuit and Layout Guidelines

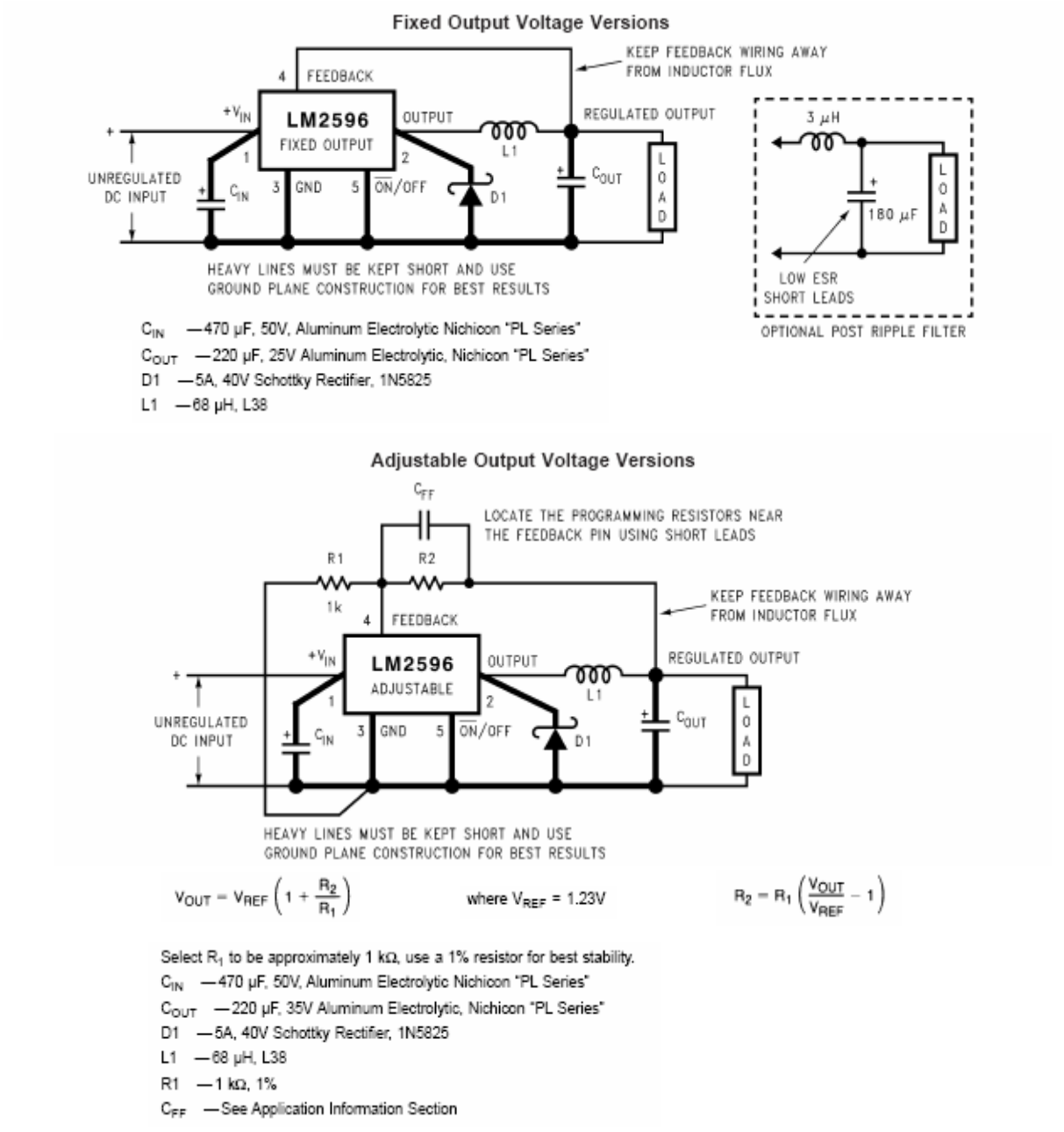


Figure 2. Typical Test Circuits and Layout Guide

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.

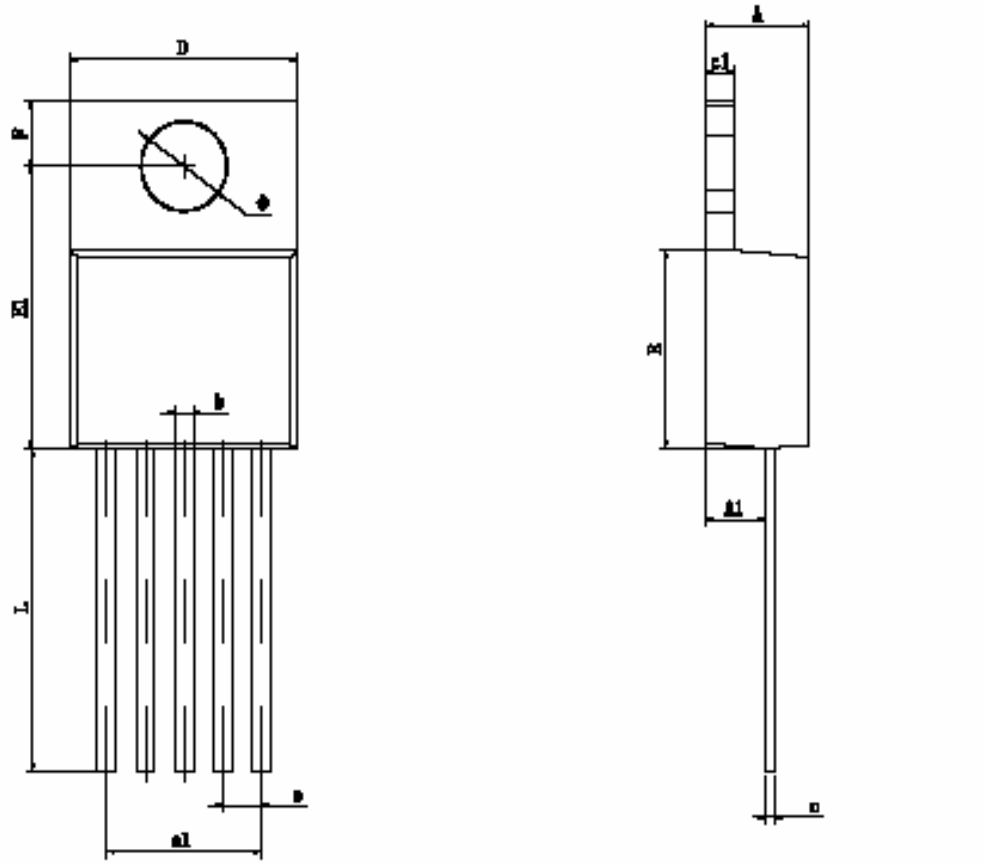
If open core inductors are used, special care must be taken as to the location and positioning of this type of inductor. Allowing the inductor flux to intersect sensitive feedback, IC groundpath and COUT wiring can cause problems.

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.

PIN FUNCTION DESCRIPTION

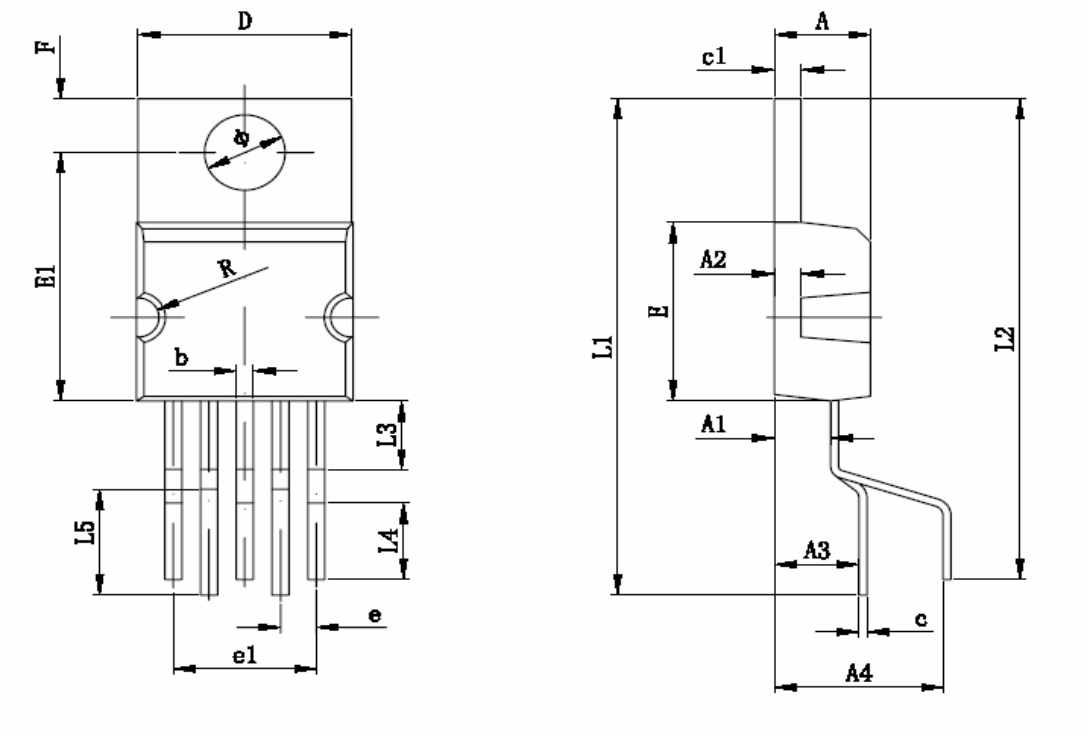
	Symbol	Description
1	Vin	This pin is the positive input supply for the LM2596 step–down switching regulator.In order to minimize voltage transients and to supply the switching currents needed by the regulator, a suitable input bypass capacitor must be present .(Cin in Figure 1).
2	Output	This is the emitter of the internal switch. The saturation voltage Vsat of this output switch is typically 1.5 V. It should be kept in mind that the PCB area connected to this pin should be kept to a minimum in order to minimize coupling to sensitive circuitry.
3	Gnd	Circuit ground pin. See the information about the printed circuit board layout.
4	Feedback	This pin senses regulated output voltage to complete the feedback loop. The signal is divided by the internal resistor divider network R2, R1 and applied to the non–inverting input of the internal error amplifier. In the Adjustable version of the LM2596 switching regulator this pin is the direct input of the error amplifier and the resistor network R2, R1 is connected externally to allow programming of the output voltage.
5	ON/OFF	It allows the switching regulator circuit to be shut down using logic level signals, thus dropping the total input supply current to approximately 80 mA. The threshold voltage is typically 1.4 V. Applying a voltage above this value (up to +Vin) shuts the regulator off. If the voltage applied to this pin is lower than 1.4V or if this pin is left open, the regulator will be in the "on" condition

PACKAGES DIMENSION : TO220-5L



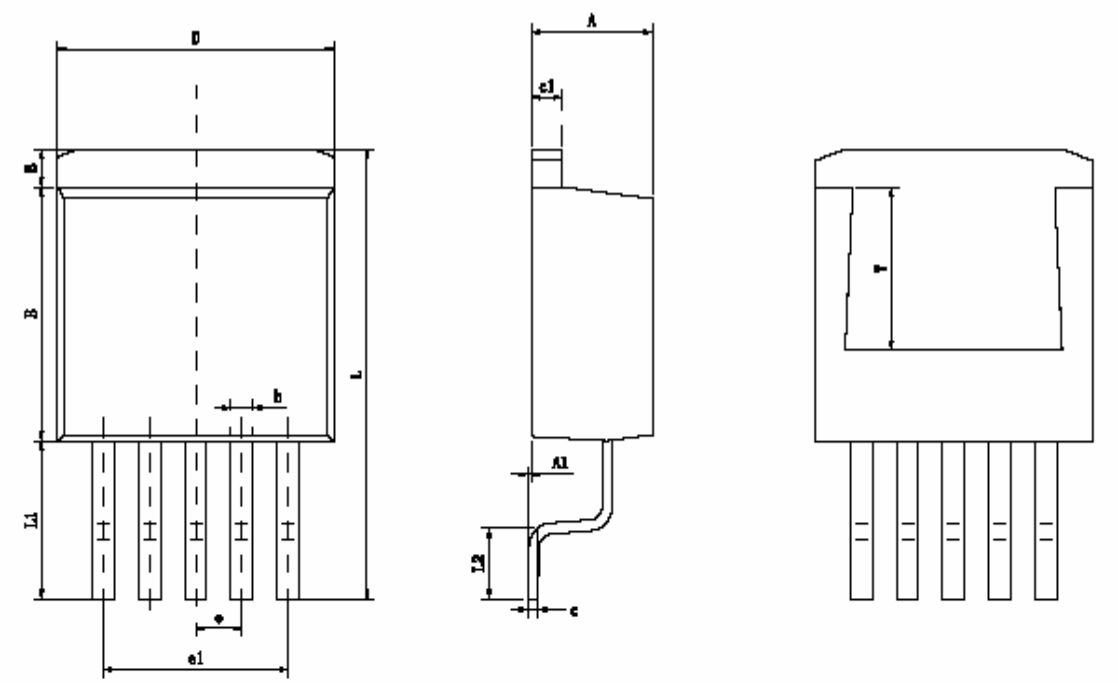
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	4.470	4.670	0.176	0.184
A1	2.520	2.820	0.099	0.111
b	0.710	0.910	0.028	0.036
c	0.310	0.530	0.012	0.021
c1	1.170	1.370	0.046	0.054
D	9.850	10.150	0.388	0.400
E	8.200	8.600	0.323	0.339
E1	11.760	12.160	0.463	0.479
e	1.700TYP		0.067TYP	
e1	6.700	6.900	0.264	0.272
F	2.590	2.890	0.102	0.114
L	13.500	13.900	0.531	0.547
Φ	3.790	3.890	0.149	0.153

PACKAGES DIMENSION : TO220V-5L



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	4.470	4.670	0.176	0.184
A1	2.520	2.820	0.099	0.111
A2	1.170	1.370	0.046	0.054
A3	4.250	4.550	0.167	0.179
A4	8.250	8.550	0.325	0.337
b	0.710	0.910	0.028	0.036
c	0.310	0.530	0.012	0.021
c1	1.170	1.370	0.046	0.054
D	10.010	10.310	0.394	0.406
E	8.900	9.300	0.350	0.366
E1	12.460	12.860	0.491	0.506
e	1.700TYP		0.220TYP	
e1	6.700	6.900	0.264	0.272
e2	3.300	3.500	0.130	0.138
F	2.590	2.890	0.102	0.114
L1	25.100	25.500	0.988	1.004
L2	24.300	24.700	0.957	0.972
L3	3.400	3.600	0.134	0.142
L4	3.800	4.000	0.150	0.157
L5	5.300	5.500	0.209	0.217
R	0.950	1.050	0.037	0.041
Φ	3.790	3.890	0.149	0.153

PACKAGES DIMENSION : TO263-5L



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	4.470	4.670	0.176	0.184
A1	0.000	0.150	0.000	0.006
B	1.560	1.760	0.061	0.069
b	0.710	0.910	0.028	0.036
c	0.310	0.530	0.012	0.021
c1	1.170	1.370	0.046	0.054
D	9.880	10.180	0.389	0.401
E	8.200	8.600	0.323	0.339
e	1.700TYP		0.067TYP	
e1	6.700	6.900	0.264	0.272
L	15.140	15.540	0.596	0.612
L1	5.080	5.480	0.200	0.216
L2	2.340	2.740	0.092	0.108
V	5.600REF		0.220REF	