LM2576/LM2576HV Series
3A Step-Down Switching Regulator

DESCRIPTION

The LM2576 series of regulators are monolithic integrated circuits that provide all the active functions for a step-down (buck) switching regulator, capable of driving 3A load with excellent line and load regulation. These devices are available in fixed output voltages of 3.3V, 5V, 12V, 15V, and an adjustable output version.

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

The LM2576 series offers a high-efficiency replacement for popular three-terminal linear regulators. It substantially reduces the size of the heat sink, and in some cases no heat sink is required.

A standard series of inductors optimized for use with the LM2576 are available from several different manufacturers. This feature greatly simplifies the design of switch-mode power supplies.

Other features include a guaranteed ±4% tolerance on output voltage within specified input voltages and output load conditions, and ±10% on the oscillator frequency. External shutdown is included, featuring 50 μA (typical) standby current.

The output switch includes cycle-by-cycle current limiting, as well as thermal shutdown for full protection under fault conditions.

FEATURES

- 3.3V, 5V, 12V, 15V, and adjustable output versions
- Adjustable version output voltage range, 1.23V to 37V (57V for HV version) ±4% max over line and load conditions
- Guaranteed 3A output current
- Wide input voltage range, 40V up to 60V for HV version
- Requires only 4 external components
- 52 kHz fixed frequency internal oscillator
- TTL shutdown capability, low power standby mode
- High efficiency
- Uses readily available standard inductors
- Thermal shutdown and current limit protection

APPLICATIONS

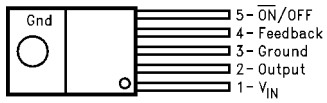
- Simple high-efficiency step-down (buck) regulator
- Efficient pre-regulator for linear regulators
- On-card switching regulators
- Positive to negative converter (Buck-Boost)
- Negative step-up converters
- Power supply for battery chargers
- The pin-pin replacement of National Semi. and On Semi. Lm2576

ORDERING INFORMATION

Temperature Range	Output Voltage					Package Type
	3.3	5.0	12	15	ADJ	
	LM2576S-3.3	LM2576S-5.0	LM2576S-12	LM2576S-15	LM2576S-ADJ	TO-263
	LM2576HVS-3.3	LM2576HVS-5.0	LM2576HVS-12	LM2576HVS-15	LM2576HVS-ADJ	
	LM2576T-3.3	LM2576T-5.0	LM2576T-12	LM2576T-15	LM2576T-ADJ	TO-220
	LM2576HVT-3.3	LM2576HVT-5.0	LM2576HVT-12	LM2576HVT-15	LM2576HVT-ADJ	

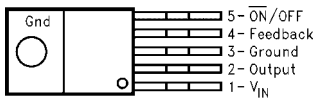
PIN CONNECTION

Straight Leads
5-Lead TO-220 (T)
Top View

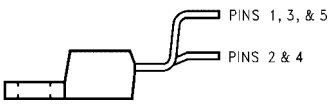


LM2576T-XX or LM2576HVT-XX

Bent, Staggered Leads
5-Lead TO-220 (T)
Top View

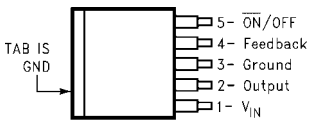


Side View

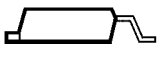


LM2576T-XX or LM2576HVT-XX

TO-263 (S)
5-Lead Surface-Mount Package
Top View



Side View



LM2576S-XX or LM2576HVS-XX

TYPICAL APPLICATION (Fixed Output Voltage Versions)

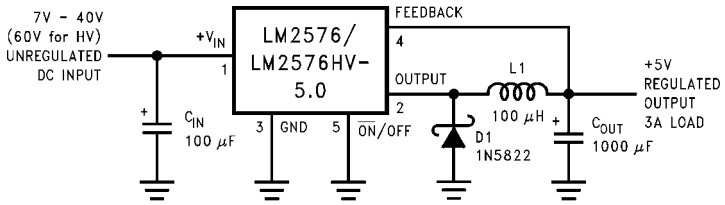
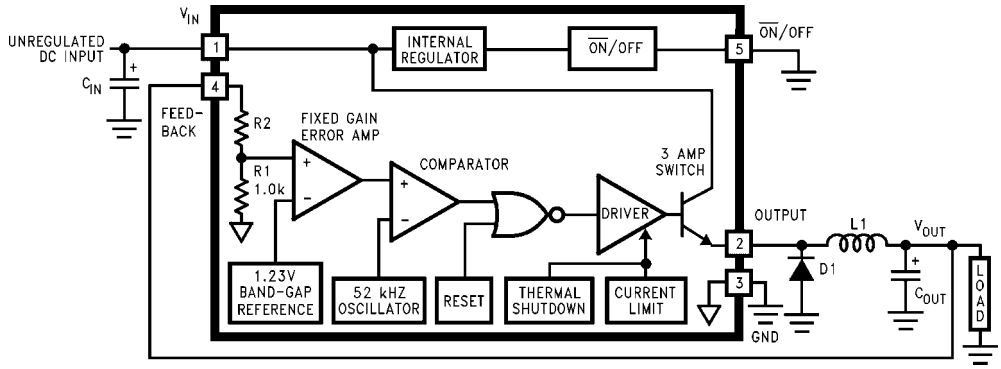


FIGURE 1.

BLOCK DIAGRAM



3.3V R2 = 1.7k
5V, R2 = 3.1k
12V, R2 = 8.84k
15V, R2 = 11.3k
For ADJ. Version
R1 = Open, R2 = 0Ω

ABSOLUTE MAXIMUM RATINGS (Note 1)

Maximum Supply Voltage
LM2576 45V
LM2576HV 63V
ON /OFF Pin Input Voltage -0.3V ≤ V ≤ +V_{IN}
Output Voltage to Ground (Steady State) -1V
Power Dissipation Internally Limited

Storage Temperature Range -65°C to +150°C
Maximum Junction Temperature 150°C
Minimum ESD Rating
(C = 100 pF, R = 1.5 kΩ) 2kV
Lead Temperature
(Soldering, 10 Seconds) 260°C

OPERATING RATINGS

Temperature Range
LM2576/LM2576HV -40°C ≤ T_J ≤ +125°C

Supply Voltage
LM2576 40V
LM2576HV 60V

LM2576-3.3, LM2576HV-3.3 ELECTRICAL CHARACTERISTICS

Specifications with standard type face are for T_J = 25°C, and those with **boldface type** apply over full Operating Temperature Range.

Symbol	Parameter	Conditions	LM2576-3.3 LM2576HV-3.3		Units (Limits)
			Type	Limit (Note 2)	
SYSTEM PARAMETERS (Note 3) **Test Circuit** *Figure 2*					
V_{OUT}	Output Voltage	V_{IN} = 12V, I_{LOAD} = 0.5A Circuit of *Figure 2*	3.3	 3.234 3.366	V V(Min) V(Max)
V_{OUT}	Output Voltage LM2576	6V ≤V_{IN} ≤ 40V, 0.5A ≤ I_{LOAD} ≤ 3A Circuit of *Figure 2*	3.3	 3.168/**3.135** 3.432/**3.465**	V V(Min) V(Max)
V_{OUT}	Output Voltage LM2576HV	6V ≤V_{IN} ≤ 60V, 0.5A ≤ I_{LOAD} ≤ 3A Circuit of *Figure 2*	3.3	 3.168/**3.135** 3.450/**3.482**	V V(Min) V(Max)
η	Efficiency	V_{IN} = 12V, I_{LOAD} = 3A	75		%

LM2576-5.0, LM2576HV-5.0 ELECTRICAL CHARACTERISTICS

Specifications with standard type face are for T_J = 25°C, and those with **boldface type** apply over full Operating Temperature Range.

Symbol	Parameter	Conditions	LM2576-5.0 LM2576HV-5.0		Units (Limits)
			Type	Limit (Note 2)	
SYSTEM PARAMETERS (Note 3) **Test Circuit** *Figure 2*					
V_{OUT}	Output Voltage	V_{IN} = 12V, I_{LOAD} = 0.5A Circuit of *Figure 2*	5.0	 4.900 5.100	V V(Min) V(Max)
V_{OUT}	Output Voltage LM2576	8V ≤V_{IN} ≤ 40V, 0.5A ≤ I_{LOAD} ≤ 3A Circuit of *Figure 2*	5.0	 4.800/**4.750** 5.200/**5.250**	V V(Min) V(Max)
V_{OUT}	Output Voltage LM2576HV	8V ≤V_{IN} ≤ 60V, 0.5A ≤ I_{LOAD} ≤ 3A Circuit of *Figure 2*	5.0	 4.800/**4.750** 5.225/**5.275**	V V(Min) V(Max)
η	Efficiency	V_{IN} = 12V, I_{LOAD} = 3A	77		%

LM2576-12, LM2576HV-12 ELECTRICAL CHARACTERISTICS

Specifications with standard type face are for T_J = 25°C, and those with **boldface type** apply over full Operating Temperature Range.

Symbol	Parameter	Conditions	LM2576-12 LM2576HV-12		Units (Limits)
			Type	Limit (Note 2)	
SYSTEM PARAMETERS (Note 3) **Test Circuit** *Figure 2*					
V_{OUT}	Output Voltage	V_{IN} = 25V, I_{LOAD} = 0.5A Circuit of *Figure 2*	12	 11.76 12.24	V V(Min) V(Max)
V_{OUT}	Output Voltage LM2576	15V ≤V_{IN} ≤ 40V, 0.5A ≤ I_{LOAD} ≤ 3A Circuit of *Figure 2*	12	 11.52/**11.40** 12.48/**12.60**	V V(Min) V(Max)
V_{OUT}	Output Voltage LM2576HV	15V ≤V_{IN} ≤ 60V, 0.5A ≤ I_{LOAD} ≤ 3A Circuit of *Figure 2*	12	 11.52/**11.40** 12.54/**12.66**	V V(Min) V(Max)
η	Efficiency	V_{IN} = 15V, I_{LOAD} = 3A	88		%

LM2576-15, LM2576HV-15 ELECTRICAL CHARACTERISTICS

Specifications with standard type face are for T_J = 25°C, and those with **boldface type** apply over full Operating Temperature Range.

Symbol	Parameter	Conditions	LM2576-15 LM2576HV-15		Units (Limits)
			Type	Limit (Note 2)	
SYSTEM PARAMETERS (Note 3) **Test Circuit** *Figure 2*					
V_{OUT}	Output Voltage	V_{IN} = 25V, I_{LOAD} = 0.5A Circuit of *Figure 2*	15	 14.70 15.30	V V(Min) V(Max)
V_{OUT}	Output Voltage LM2576	18V ≤V_{IN} ≤ 40V, 0.5A ≤ I_{LOAD} ≤ 3A Circuit of *Figure 2*	15	 14.40/**14.25** 15.60/**15.75**	V V(Min) V(Max)
V_{OUT}	Output Voltage LM2576HV	18V ≤V_{IN} ≤ 60V, 0.5A ≤ I_{LOAD} ≤ 3A Circuit of *Figure 2*	15	 14.40/**14.25** 15.68/**15.83**	V V(Min) V(Max)
η	Efficiency	V_{IN} = 18V, I_{LOAD} = 3A	88		%

LM2576-ADJ, LM2576HV-ADJ ELECTRICAL CHARACTERISTICS

Specifications with standard type face are for T_J = 25°C, and those with **boldface type** apply over full Operating Temperature Range.

Symbol	Parameter	Conditions	LM2576-ADJ LM2576HV-ADJ		Units (Limits)
			Type	Limit (Note 2)	
SYSTEM PARAMETERS (Note 3) **Test Circuit** *Figure 2*					
V_{OUT}	Feedback Voltage	V_{IN} = 12V, I_{LOAD} = 0.5A V_{OUT} = 5V Circuit of *Figure 2*	1.230	 1.217 1.243	V V(Min) V(Max)
V_{OUT}	Feedback Voltage LM2576	8V ≤V_{IN} ≤ 40V, 0.5A ≤ I_{LOAD} ≤ 3A V_{OUT} = 5V Circuit of *Figure 2*	1.230	 1.193/**1.180** 1.267/**1.280**	V V(Min) V(Max)
V_{OUT}	Feedback Voltage LM2576HV	8V ≤V_{IN} ≤ 60V, 0.5A ≤ I_{LOAD} ≤ 3A V_{OUT} = 5V Circuit of *Figure 2*	1.230	 1.193/**1.180** 1.273/**1.286**	V V(Min) V(Max)
η	Efficiency	V_{IN} = 12V, I_{LOAD} = 3A, V_{OUT} = 5V	77		%

ALL OUTPUT VOLTAGE VERSIONS ELECTRICAL CHARACTERISTICS

Specifications with standard type face are for T_J = 25°C, and those with **boldface type** apply over full Operating Temperature Range. Unless otherwise specified, V_{IN} = 12V for the 3.3V, 5V, and Adjustable version, V_{IN} = 25V for the 12V version, and V_{IN} = 30V for the 15V version. I_{LOAD} = 500 mA.

Symbol	Parameter	Conditions	LM2576-XX / LM2576HV-XX		Units (Limits)
			Type	Limit (Note 2)	
DEVICE PARAMETERS					
I_b	Feedback Bias Current	V_{OUT} = 5V (Adjustable Version Only)	50	100/**500**	nA
f_O	Oscillator Frequency	(Note 11)	52	47/**42** 58/**63**	kHz kHz(Min) kHz(Max)
V_{SAT}	Saturation Voltage	I_{OUT} = 3A (Note 4)	1.4	1.8/**2.0**	V V(Max)
DC	Max Duty Cycle (ON)	(Note 5)	98	93	% %(Min)
I_{CL}	Current Limit	(Notes 4, 11)	5.8	4.2/**3.5** 6.9/**7.5**	A A(Min) A(Max)
I_L	Output Leakage Current	(Notes 6, 7): Output = 0V Output = -1V Output = -1V	7.5	2 30	mA(Max) mA mA(Max)
I_Q	Quiescent Current	(Note 6)	5	10	mA mA(Max)
I_{STBY}	Standby Quiescent Current	$\overline{ON}$ /OFF Pin = 5V (OFF)	50	200	µA µA(Max)
θ_{JA} θ_{JA} θ_{JC} θ_{JA}	Thermal Resistance	T Package, Junction to Ambient (Note 8) T Package, Junction to Ambient (Note 9) T Package, Junction to Case S Package, Junction to Ambient (Note 10)	65 45 2 50		°C/W
$\overline{ON}$ /OFF CONTROL Test Circuit Figure 2					
V_{IH}	$\overline{ON}$ /OFF Pin Logic Input Level	V_{OUT} = 0V	1.4	2.2/**2.4**	V(Min)
V_{IL}		V_{OUT} = Nominal Output Voltage	1.2	1.0/**0.8**	V(Max)
I_{IH}	$\overline{ON}$ /OFF Pin Input Current	$\overline{ON}$ /OFF Pin = 5V (OFF)	12	30	µA µA(Max)
I_{IL}		$\overline{ON}$ /OFF Pin = 0V (ON)	0	10	µA µA(Max)

Note 1: Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. 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.

Note 2: All limits guaranteed at room temperature (standard type face) and at temperature extremes (**bold type face**).

Note 3: External components such as the catch diode, inductor, input and output capacitors can affect switching regulator system performance. When the LM2576/ LM2576HV is used as shown in the *Figure 2* test circuit, system performance will be as shown in system parameters section of Electrical Characteristics.

Note 4: Output pin sourcing current. No diode, inductor or capacitor connected to output.

Note 5: Feedback pin removed from output and connected to 0V.

Note 6: Feedback pin removed from output and connected to +12V for the Adjustable, 3.3V, and 5V versions, and +25V for the 12V and 15V versions, to force the output transistor OFF.

Note 7: V_{IN} = 40V (60V for high voltage version).

Note 8: Junction to ambient thermal resistance (no external heat sink) for the 5 lead TO-220 package mounted vertically, with 1/2 inch leads in a socket, or on a PC board with minimum copper area.

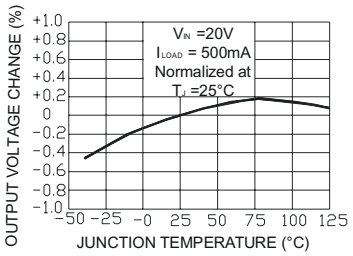
Note 9: Junction to ambient thermal resistance (no external heat sink) for the 5 lead TO-220 package mounted vertically, with 1/4 inch leads soldered to a PC board containing approximately 4 square inches of copper area surrounding the leads.

Note 10: If the TO-263 package is used, the thermal resistance can be reduced by increasing the PC board copper area thermally connected to the package. Using 0.5 square inches of copper area, θ_{JA} is 50°C/W, with 1 square inch of copper area, θ_{JA} is 37°C/W, and with 1.6 or more square inches of copper area, θ_{JA} is 32°C/W.

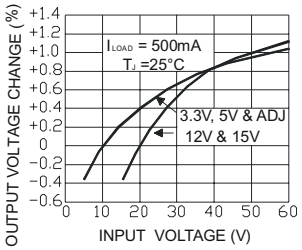
Note 11: The oscillator frequency reduces to approximately 11 kHz in the event of an output short or an overload which causes the regulated output voltage to drop approximately 40% from the nominal output voltage. This self protection feature lowers the average power dissipation of the IC by lowering the minimum duty cycle from 5% down to approximately 2%.

TYPICAL PERFORMANCE CHARACTERISTICS (Circuit of *Figure 2*)

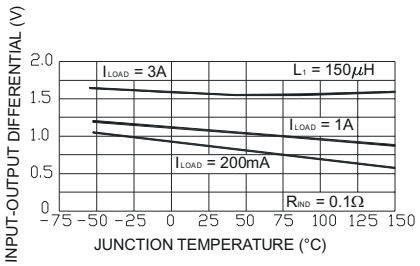
Normalized Output Voltage



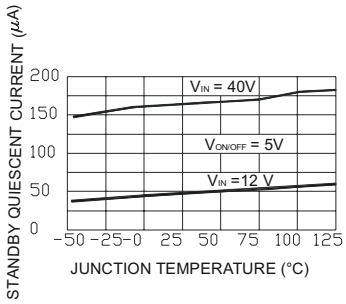
Line Regulation



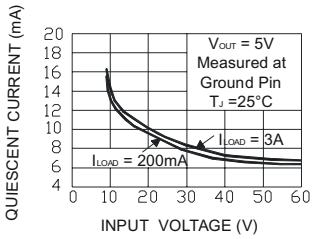
Dropout Voltage



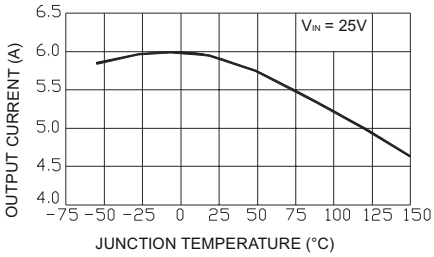
Standby Quiescent Current



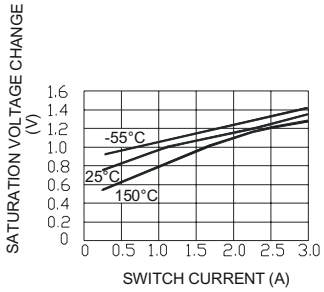
Quiescent Current



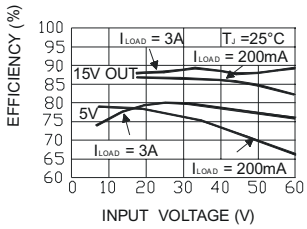
Current Limit



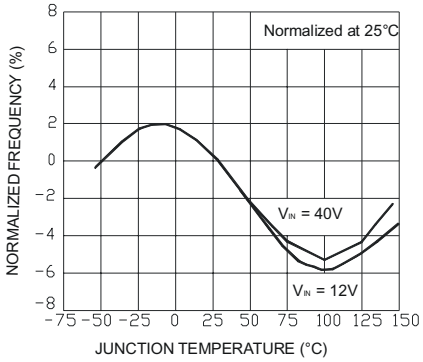
Switch Saturation Voltage



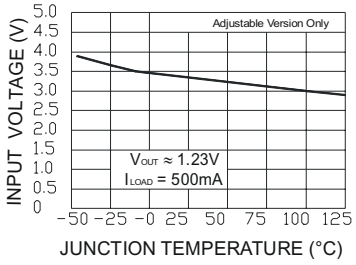
Efficiency



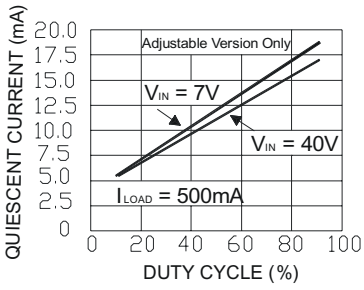
Oscillator Frequency



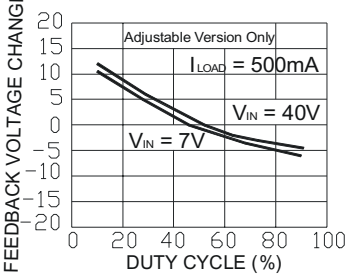
Minimum Operating Voltage



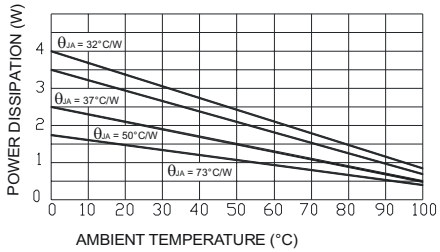
Quiescent Current vs Duty Cycle



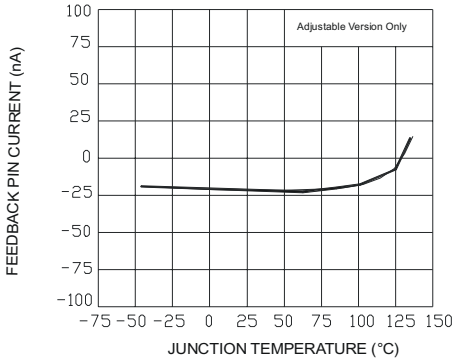
Feedback Voltage vs Duty Cycle



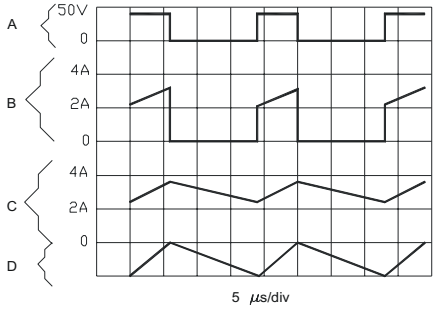
Maximum Power Dissipation (TO-263) (See Note 10)



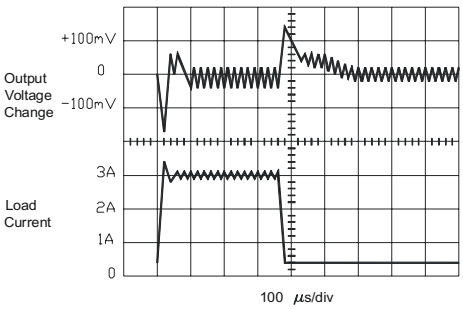
Feedback Pin Current



Switching Waveforms



Load Transient Response



V_{OUT} =15V

A: Output Pin Voltage, 50V/div

B: Output Pin Current, 2A/div

C: Inductor Current, 2A/div

D: Output Ripple Voltage, 50mV/div,

AC-Coupled

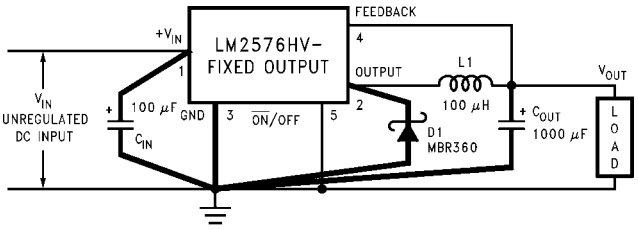
Horizontal Time Base: 5µs/div

TEST CIRCUIT AND LAYOUT GUIDELINES

As in any switching regulator, layout is very important. Rapidly switching currents associated with wiring inductance generate voltage transients which can cause problems. For minimal inductance and ground loops, the length of the leads indicated by heavy lines should be kept as short as possible.

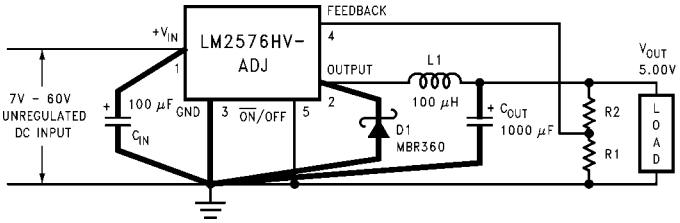
Single-point grounding (as indicated) or ground plane construction should be used for best results. When using the Adjustable version, physically locate the programming resistors near the regulator, to keep the sensitive feedback wiring short.

Fixed Output Voltage Versions



C_{IN} — 100 µF, 75V, Aluminum Electrolytic
C_{OUT} — 1000 µF, 25V, Aluminum Electrolytic
D_1 — Schottky, MBR360
L_1 — 100 µH, Pulse Eng. PE-92108
R_1 — 2k, 0.1%
R_2 — 6.12k, 0.1%

Adjustable Output Voltage Version



$$V_{OUT} = V_{REF}\left(1 + \frac{R_2}{R_1}\right)$$

$$R_2 = R_1\left(\frac{V_{OUT}}{V_{REF}} - 1\right)$$

where V_{REF} = 1.23V, R1 between 1k and 5k.

FIGURE 2.