

LM2596

SIMPLE SWITCHER® Power Converter 150 kHz

3A Step-Down Voltage Regulator

General Description

The LM2596 series of regulators are monolithic integrated circuits that provide all the active functions for a step-down (buck) switching regulator, capable of driving a 3A load with excellent line and load regulation. These devices are available in fixed output voltages of 3.3V, 5V, 12V, 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 LM2596 series operates at a switching frequency of 150 kHz thus allowing smaller sized filter components than what would be needed with lower frequency switching regulators. Available in a standard 5-lead TO-220 package with several different lead bend options, and a 5-lead TO-263 surface mount package.

A standard series of inductors are available from several different manufacturers optimized for use with the LM2596 series. This feature greatly simplifies the design of switch-mode power supplies.

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. 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.

Features

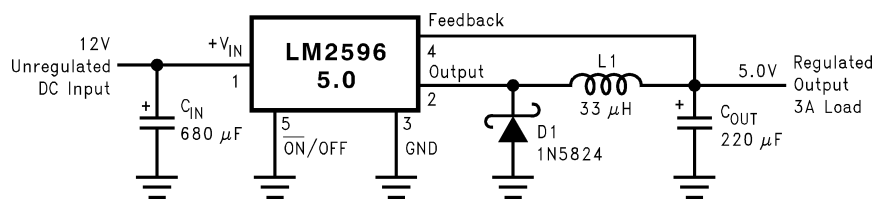
- 3.3V, 5V, 12V, and adjustable output versions
- Adjustable version output voltage range, 1.2V to 37V $\pm 4\%$ max over line and load conditions
- Available in TO-220 and TO-263 packages
- Guaranteed 3A output load current
- Input voltage range up to 40V
- Requires only 4 external components
- Excellent line and load regulation specifications
- 150 kHz fixed frequency internal oscillator
- TTL shutdown capability
- Low power standby mode, I_Q typically 80 μA
- High efficiency
- Uses readily available standard inductors
- Thermal shutdown and current limit protection

Applications

- Simple high-efficiency step-down (buck) regulator
- On-card switching regulators
- Positive to negative converter

Note: †Patent Number 5,382,918.

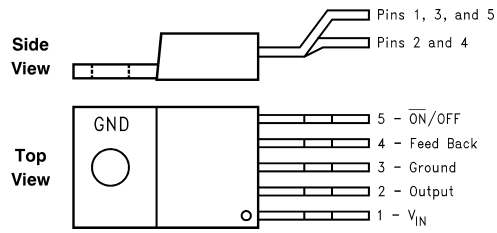
Typical Application (Fixed Output Voltage Versions)



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Connection Diagrams and Ordering Information

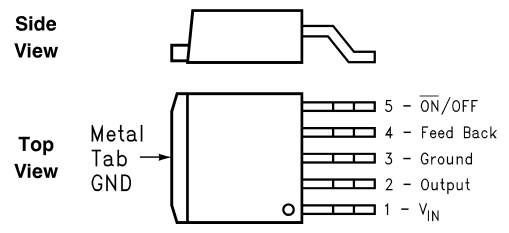
Bent and Staggered Leads, Through Hole Package 5-Lead TO-220 (T)



01258302

Order Number LM2596T-3.3, LM2596T-5.0,
LM2596T-12 or LM2596T-ADJ
See NS Package Number T05D

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



01258303

Order Number LM2596S-3.3, LM2596S-5.0,
LM2596S-12 or LM2596S-ADJ
See NS Package Number TS5B

Absolute Maximum Ratings (Note 1)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

Maximum Supply Voltage	45V
$\overline{\text{ON}}$ /OFF Pin Input Voltage	$-0.3 \leq V \leq +25V$
Feedback Pin Voltage	$-0.3 \leq V \leq +25V$
Output Voltage to Ground (Steady State)	-1V
Power Dissipation	Internally limited
Storage Temperature Range	-65°C to $+150^{\circ}\text{C}$
ESD Susceptibility	

Human Body Model (Note 2)	2 kV
Lead Temperature	
S Package	
Vapor Phase (60 sec.)	$+215^{\circ}\text{C}$
Infrared (10 sec.)	$+245^{\circ}\text{C}$
T Package (Soldering, 10 sec.)	$+260^{\circ}\text{C}$
Maximum Junction Temperature	$+150^{\circ}\text{C}$

Operating Conditions

Temperature Range	$-40^{\circ}\text{C} \leq T_J \leq +125^{\circ}\text{C}$
Supply Voltage	4.5V to 40V

LM2596-3.3
Electrical Characteristics

Specifications with standard type face are for $T_J = 25^{\circ}\text{C}$, and those with **boldface type** apply over **full Operating Temperature Range**

Symbol	Parameter	Conditions	LM2596-3.3		Units (Limits)
			Typ (Note 3)	Limit (Note 4)	
SYSTEM PARAMETERS (Note 5) Test Circuit <i>Figure 1</i>					
V_{OUT}	Output Voltage	$4.75V \leq V_{\text{IN}} \leq 40V, 0.2A \leq I_{\text{LOAD}} \leq 3A$	3.3	3.168/ 3.135 3.432/ 3.465	V V(min) V(max)
η	Efficiency	$V_{\text{IN}} = 12V, I_{\text{LOAD}} = 3A$	73		%

LM2596-5.0
Electrical Characteristics

Specifications with standard type face are for $T_J = 25^{\circ}\text{C}$, and those with **boldface type** apply over **full Operating Temperature Range**

Symbol	Parameter	Conditions	LM2596-5.0		Units (Limits)
			Typ (Note 3)	Limit (Note 4)	
SYSTEM PARAMETERS (Note 5) Test Circuit <i>Figure 1</i>					
V_{OUT}	Output Voltage	$7V \leq V_{\text{IN}} \leq 40V, 0.2A \leq I_{\text{LOAD}} \leq 3A$	5.0	4.800/ 4.750 5.200/ 5.250	V V(min) V(max)
η	Efficiency	$V_{\text{IN}} = 12V, I_{\text{LOAD}} = 3A$	80		%

LM2596-12
Electrical Characteristics

Specifications with standard type face are for $T_J = 25^{\circ}\text{C}$, and those with **boldface type** apply over **full Operating Temperature Range**

Symbol	Parameter	Conditions	LM2596-12		Units (Limits)
			Typ (Note 3)	Limit (Note 4)	
SYSTEM PARAMETERS (Note 5) Test Circuit <i>Figure 1</i>					
V_{OUT}	Output Voltage	$15V \leq V_{\text{IN}} \leq 40V, 0.2A \leq I_{\text{LOAD}} \leq 3A$	12.0	11.52/ 11.40 12.48/ 12.60	V V(min) V(max)
η	Efficiency	$V_{\text{IN}} = 25V, I_{\text{LOAD}} = 3A$	90		%

LM2596-ADJ Electrical Characteristics

Specifications with standard type face are for $T_J = 25^\circ\text{C}$, and those with **boldface type** apply over **full Operating Temperature Range**

Symbol	Parameter	Conditions	LM2596-ADJ		Units (Limits)
			Typ (Note 3)	Limit (Note 4)	
SYSTEM PARAMETERS (Note 5) Test Circuit <i>Figure 1</i>					
V_{FB}	Feedback Voltage	$4.5\text{V} \leq V_{IN} \leq 40\text{V}$, $0.2\text{A} \leq I_{LOAD} \leq 3\text{A}$ V_{OUT} programmed for 3V. Circuit of <i>Figure 1</i>	1.230	1.193/ 1.180 1.267/ 1.280	V V(min) V(max)
η	Efficiency	$V_{IN} = 12\text{V}$, $V_{OUT} = 3\text{V}$, $I_{LOAD} = 3\text{A}$	73		%

All Output Voltage Versions Electrical Characteristics

Specifications with standard type face are for $T_J = 25^\circ\text{C}$, and those with **boldface type** apply over **full Operating Temperature Range**. Unless otherwise specified, $V_{IN} = 12\text{V}$ for the 3.3V, 5V, and Adjustable version and $V_{IN} = 24\text{V}$ for the 12V version. $I_{LOAD} = 500\text{mA}$

Symbol	Parameter	Conditions	LM2596-XX		Units (Limits)
			Typ (Note 3)	Limit (Note 4)	
DEVICE PARAMETERS					
I_b	Feedback Bias Current	Adjustable Version Only, $V_{FB} = 1.3\text{V}$	10	50/ 100	nA nA (max)
f_O	Oscillator Frequency	(Note 6)	150	127/ 110 173/ 173	kHz kHz(min) kHz(max)
V_{SAT}	Saturation Voltage	$I_{OUT} = 3\text{A}$ (Notes 7, 8)	1.16	1.4/ 1.5	V V(max)
DC	Max Duty Cycle (ON) Min Duty Cycle (OFF)	(Note 8) (Note 9)	100 0		%
I_{CL}	Current Limit	Peak Current (Notes 7, 8)	4.5	3.6/ 3.4 6.9/ 7.5	A A(min) A(max)
I_L	Output Leakage Current	Output = 0V (Notes 7, 9)		50	μA (max)
		Output = -1V (Note 10)	2	30	mA mA (max)
I_Q	Quiescent Current	(Note 9)	5	10	mA mA (max)
				200/ 250	μA μA (max)
I_{STBY}	Standby Quiescent Current	ON/OFF pin = 5V (OFF) (Note 10)	80		μA μA (max)
θ_{JC}	Thermal Resistance	TO-220 or TO-263 Package, Junction to Case	2		$^\circ\text{C}/\text{W}$
θ_{JA}		TO-220 Package, Junction to Ambient (Note 11)	50		$^\circ\text{C}/\text{W}$
θ_{JA}		TO-263 Package, Junction to Ambient (Note 12)	50		$^\circ\text{C}/\text{W}$
θ_{JA}		TO-263 Package, Junction to Ambient (Note 13)	30		$^\circ\text{C}/\text{W}$
θ_{JA}		TO-263 Package, Junction to Ambient (Note 14)	20		$^\circ\text{C}/\text{W}$
ON/OFF CONTROL Test Circuit <i>Figure 1</i>					
V_{IH}	$\overline{\text{ON}}$ /OFF Pin Logic Input Threshold Voltage	Low (Regulator ON)	1.3	0.6	V V(max)
V_{IL}		High (Regulator OFF)		2.0	V V(min)

All Output Voltage Versions

Electrical Characteristics (Continued)

Specifications with standard type face are for $T_J = 25^\circ\text{C}$, and those with **boldface type** apply over **full Operating Temperature Range**. Unless otherwise specified, $V_{IN} = 12\text{V}$ for the 3.3V, 5V, and Adjustable version and $V_{IN} = 24\text{V}$ for the 12V version. $I_{LOAD} = 500\text{ mA}$

Symbol	Parameter	Conditions	LM2596-XX		Units (Limits)
			Typ (Note 3)	Limit (Note 4)	
I_H	ON /OFF Pin Input Current	$V_{LOGIC} = 2.5\text{V}$ (Regulator OFF)	5	15	μA $\mu\text{A(max)}$
		$V_{LOGIC} = 0.5\text{V}$ (Regulator ON)	0.02	5	μA $\mu\text{A(max)}$

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: The human body model is a 100 pF capacitor discharged through a 1.5k resistor into each pin.

Note 3: Typical numbers are at 25°C and represent the most likely norm.

Note 4: All limits guaranteed at room temperature (standard type face) and at temperature extremes (bold type face). All room temperature limits are 100% production tested. All limits at temperature extremes are guaranteed via correlation using standard Statistical Quality Control (SQC) methods. All limits are used to calculate Average Outgoing Quality Level (AOQL).

Note 5: External components such as the catch diode, inductor, input and output capacitors, and voltage programming resistors 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 of Electrical Characteristics.

Note 6: The switching frequency is reduced when the second stage current limit is activated.

Note 7: No diode, inductor or capacitor connected to output pin.

Note 8: Feedback pin removed from output and connected to 0V to force the output transistor switch ON.

Note 9: Feedback pin removed from output and connected to 12V for the 3.3V, 5V, and the ADJ. version, and 15V for the 12V version, to force the output transistor switch OFF.

Note 10: $V_{IN} = 40\text{V}$.

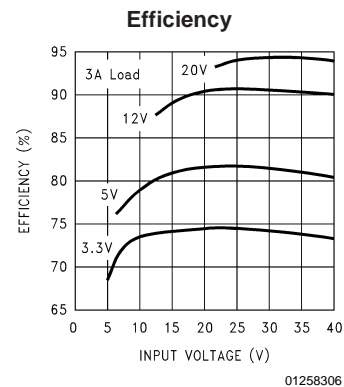
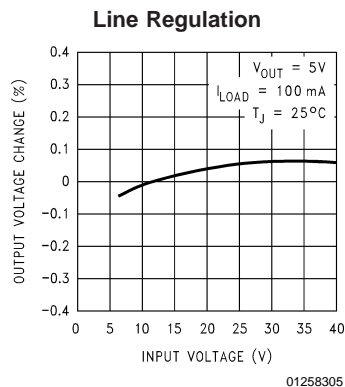
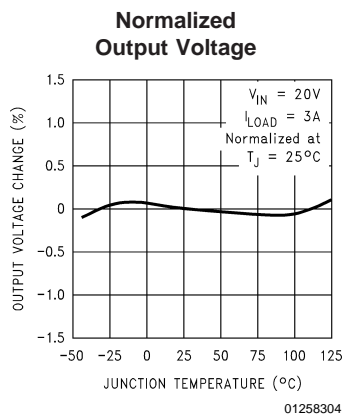
Note 11: Junction to ambient thermal resistance (no external heat sink) for the TO-220 package mounted vertically, with the leads soldered to a printed circuit board with (1 oz.) copper area of approximately 1 in^2 .

Note 12: Junction to ambient thermal resistance with the TO-263 package tab soldered to a single printed circuit board with 0.5 in^2 of (1 oz.) copper area.

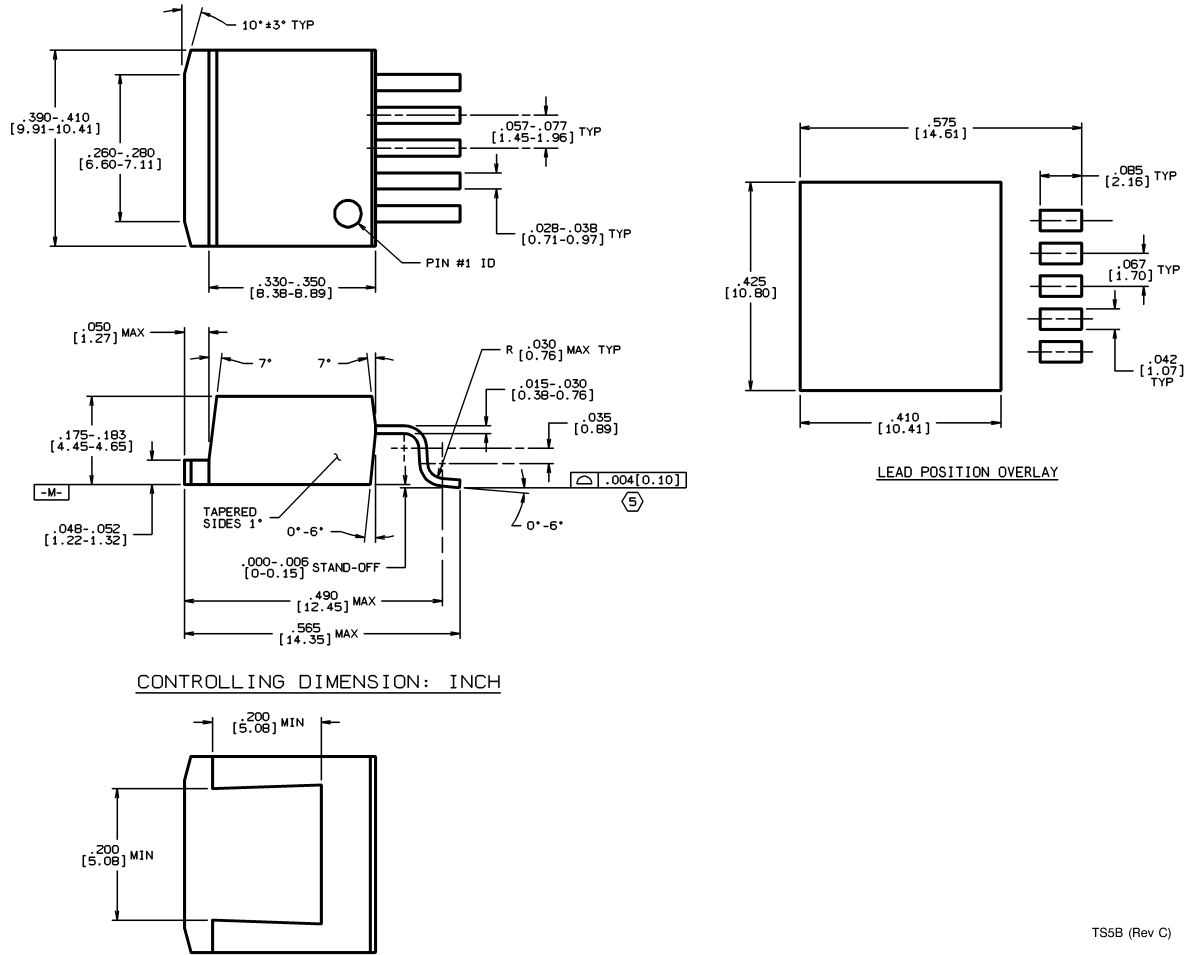
Note 13: Junction to ambient thermal resistance with the TO-263 package tab soldered to a single sided printed circuit board with 2.5 in^2 of (1 oz.) copper area.

Note 14: Junction to ambient thermal resistance with the TO-263 package tab soldered to a double sided printed circuit board with 3 in^2 of (1 oz.) copper area on the LM2596S side of the board, and approximately 16 in^2 of copper on the other side of the p-c board. See Application Information in this data sheet and the thermal model in Switchers Made Simple™ version 4.3 software.

Typical Performance Characteristics (Circuit of Figure 1)



Physical Dimensions inches (millimeters) unless otherwise noted (Continued)



5-Lead TO-263 Surface Mount Package (S)
Order Number LM2596S-3.3, LM2596S-5.0,
LM2596S-12 or LM2596S-ADJ
NS Package Number TS5B

TS5B (Rev C)

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