150kHz, 3A PWM Buck DC/DC Converter

LM2596-XXE5/F5

Description

The LM2596-XXE5/F5 series of regulators are monolithic ICs that provide all 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 voltage 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-XXE5/F5 series operates at a switching frequency of 150kHz, thus allowing smaller sized filter components than what would be needed with lower frequency switching regulators. Available in standard 5-lead TO-220 and TO-263 packages with several different lead bend options. A standard series of inductors are available from several different manufacturers optimized for use with the LM2596-XXE5/F5 series. This feature greatly simplifies the design of switch-mode power supplies. Other features include a guaranteed ±4% tolerance on output voltage under specified input voltage and output load conditions, and ±15% on the oscillator frequency. External shutdown is included, featuring 80μA 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.

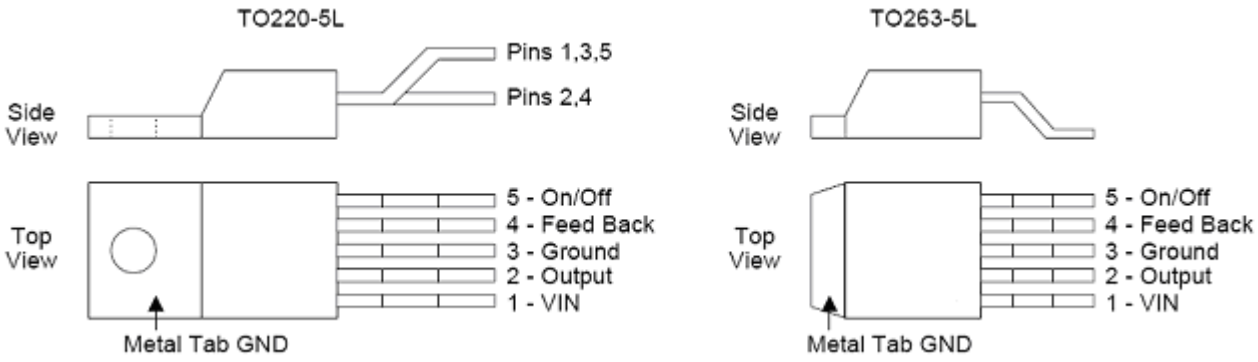
Features

- 3.3V, 5V, 12V, and adjustable output versions
- Adjustable version output voltage range, 1.3V to 37V±4% max over line and load conditions
- 150kHz±15% fixed switching frequency
- TTL shutdown capability
- Operating voltage can be up to 40V
- Output load current:3A
- TO220-5L and TO263-5L packages
- Low power standby mode.
- Thermal shutdown and current limit protection.
- High efficiency
- Built-in switching transistor on chip
- Requires only 4 external components
- Use readily available standard inductors

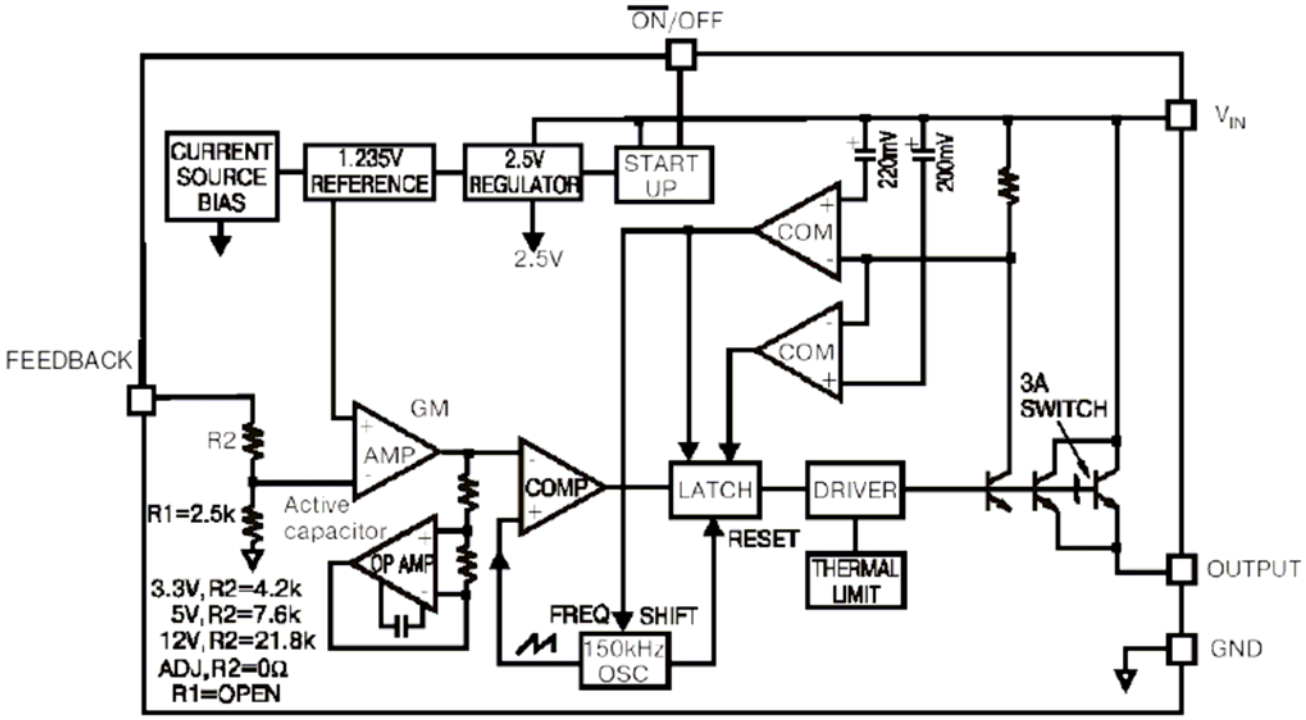
Applications

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

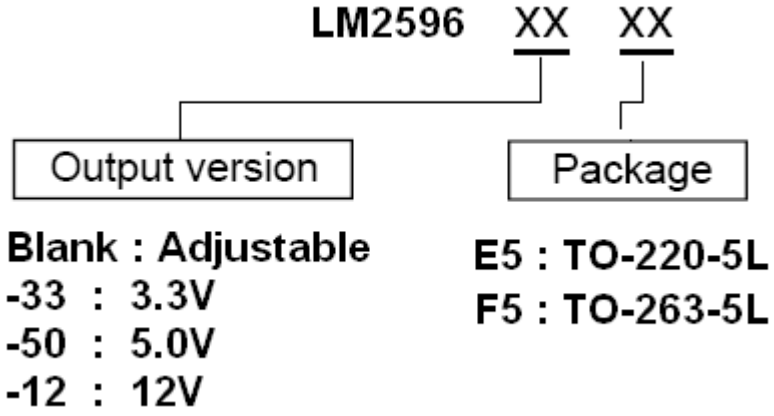
Pin Assignment



Block Diagram



Ordering Information



Absolute Maximum Ratings (Note 1)

Parameter	Symbol	Value	Unit
Supply Voltage	V_{CC}	45	V
On/Off Pin Input Voltage	V_{SD}	-0.3 ~ +25	V
Feedback Pin Voltage	V_{FB}	-0.3 ~ +25	V
Output Voltage to Ground	V_{OUT}	-1	V
Power Dissipation	P_D	Internally Limited	W
Operating Temperature	Topr	-40 ~ +125	℃
Storage Temperature	Tstg	-65 ~ +150	℃
Operating Voltage	V_{OP}	+4.5 ~ +40	V
ESD Susceptibility (Note 2)		2000	V

Electrical Characteristics (All Output Voltage Versions)

Specifications with **boldface type** are for full operating temperature range, the other type are for T_J=25°C. (Unless otherwise specified, V_{IN}=12V for the 3.3V, 5V, and adjustable version and V_{IN}=24V for the 12V version, I_{LOAD}=500mA)

Parameter	Symbol	Test Condition		Min	Typ	Max	Unit
Device parameters							
Feedback Bias Current	Ib	Adjustable Version Only, V_{FB}=1.3V		-	10	50 **100**	nA
Oscillator Frequency	fo	(Note 6)		127 **110**	150	173 **173**	KHz
Saturation Voltage	V_{SAT}	I_{OUT}=3A (Note 7, 8)		-	1.16	1.4 **1.5**	V
Max Duty Cycle (ON)	DC	(Note 8)		-	100	-	%
Min Duty Cycle(OFF)		(Note 9)			0		
Current Limit	I_{CL}	Peak Current (Note 7, 8)		3.6 **3.4**	4.5	6.9 **7.5**	A
Output Leakage Current	I_L	Output=0V (Note 7, 9)		-	-	50	μA
		Output=-1V(Note 10)		-	2	30	mA
Quiescent Current	I_Q	(Note 9)		-	5	10	mA
Standby Quiescent Current	I_{STBY}	ON/OFF pin=5V (Note 10)		-	80	200 **250**	μA
Thermal Resistance	θ_{JC}	TO-220-5L	Junction to Case	-	2	-	℃/W
		TO-263-5L		-	3.5	-	
	θ_{JA} (Note11)	TO-220-5L	Junction to Ambient	-	50	-	℃/W
		TO-263-5L		-	23	-	
ON/OFF Control							
ON/OFF Pin Logic Input Threshold Voltage	V_{IH}	Low (Regulator ON)		-	1.3	0.6	V
	V_{IL}	High (Regulator OFF)		2.0		-	
ON/OFF Pin Input Current	I_{IH}	V_{LOGIC}=2.5V (Regulator OFF)		-	5	15	μA
	I_{IL}	V_{LOGIC}=0.5V (Regulator ON)		-	0.02	5	

Electrical Characteristics (Continued)

Specifications with **boldface type** are for full operating temperature range, the other type are for T_J=25°C.

Part No.	Parameter	Symbol	Conditions	Min	Typ (Note 3)	Max (Note 4)	Units
LM2596-3.3	Output Voltage	V_{OUT}	4.75V≤V_{IN}≤40V, 0.2A≤I_{LOAD}≤3A	3.168 **3.135**	3.3	3.432 **3.465**	V
	Efficiency	η	V_{IN}=12V, I_{LOAD}=3A	-	73	-	%
LM2596-5.0	Output Voltage	V_{OUT}	7V≤V_{IN}≤40V, 0.2A≤I_{LOAD}≤3A	4.800 **4.750**	5.0	5.200 **5.250**	V
	Efficiency	η	V_{IN}=12V, I_{LOAD}=3A	-	80	-	%
LM2596-12	Output Voltage	V_{OUT}	15V≤V_{IN}≤40V, 0.2A≤I_{LOAD}≤3A	11.52 **11.40**	12.0	12.48 **12.60**	V
	Efficiency	η	V_{IN}=25V, I_{LOAD}=3A	-	90	-	%
LM2596-ADJ	Output Feedback	V_{FB}	4.5V≤V_{IN}≤40V, 0.2A≤I_{LOAD}≤3A V_{OUT} programmed for 3V	1.180 **1.168**	1.230	1.280 **1.292**	V
	Efficiency	η	V_{IN}=12V, V_{OUT}=3V, I_{LOAD}=3A	-	77	-	%

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 100pF capacitor discharged through a 1.5K resistor into each pin.

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

Note 4 : All limits guaranteed at room temperature (standard face type) and at temperature extremes(bold face type). 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.

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.

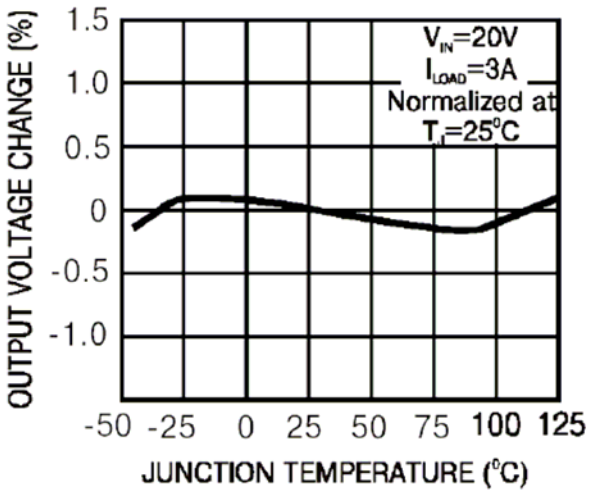
Note 8 : Feedback pin removed from output and connected to 0V to force the output transistor switch ON.

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

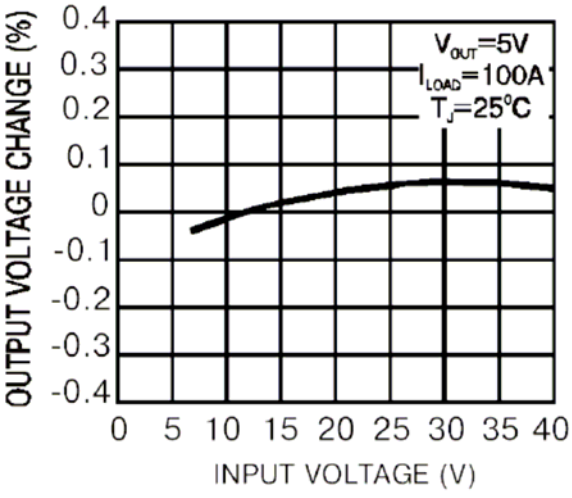
Note 10 : V_{IN}=40V.

Note 11 : Junction to Ambient thermal resistance. (With copper area of approximately 3 in^2)

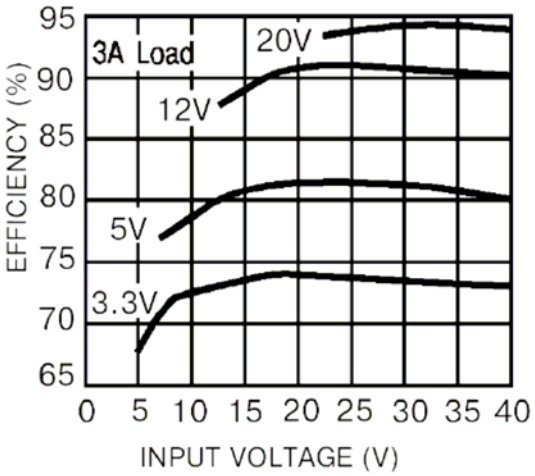
Typical Performance Characteristics (circuit of Figure 2)



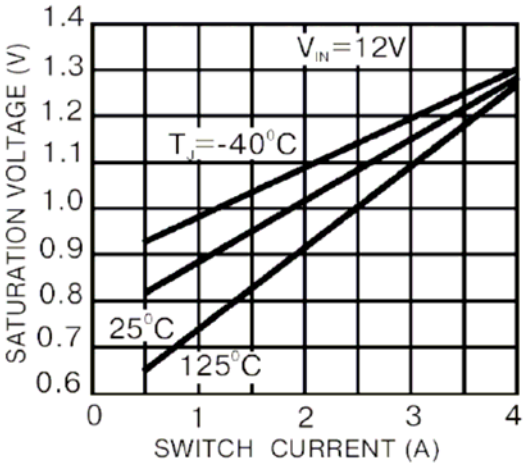
Normalized Output Voltage



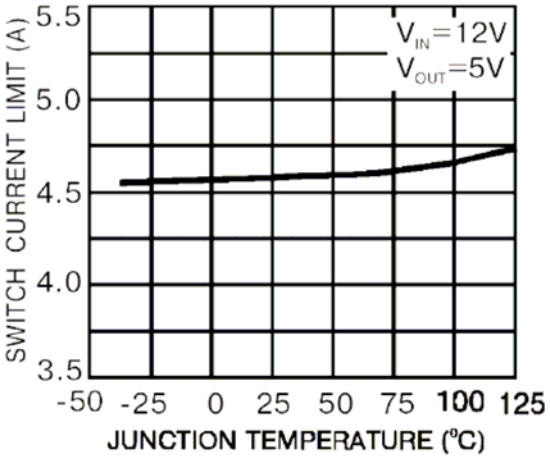
Line Regulator



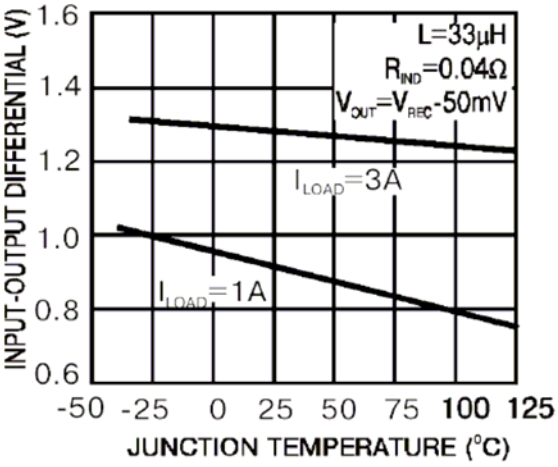
Efficiency



Switch Saturation Voltage

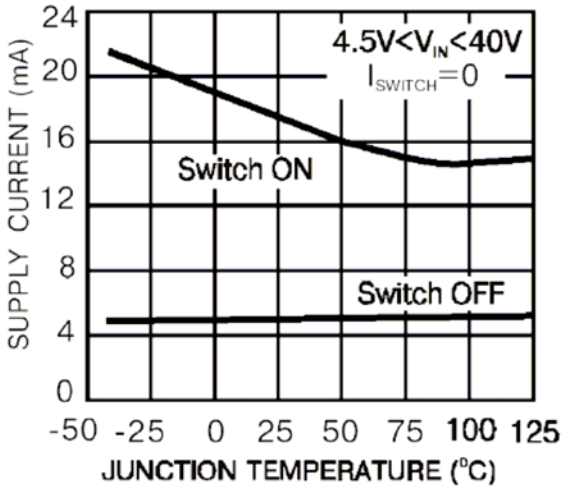


Switch Current Limit

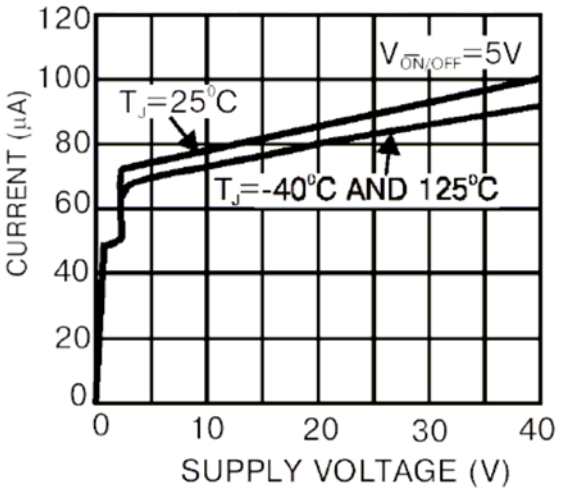


Dropout Voltage

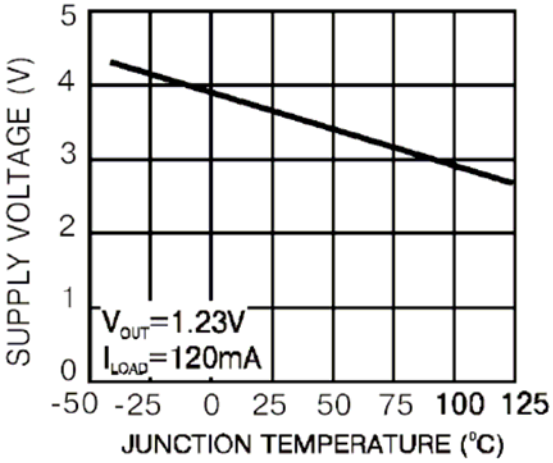
Typical Performance Characteristics(Cont.)



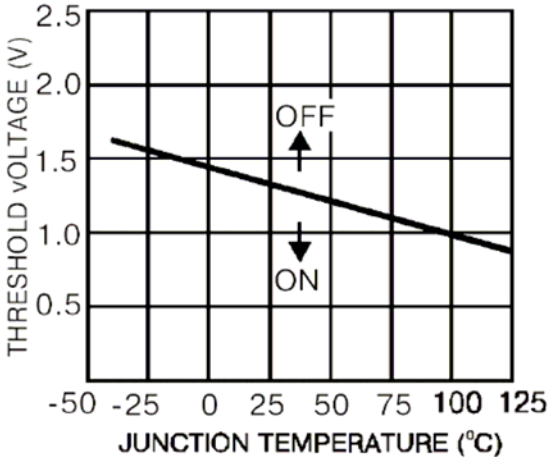
Operating Quiescent Current



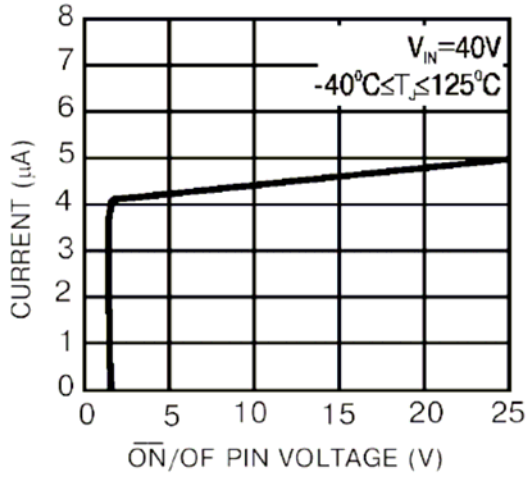
Shutdown Quiescent Current



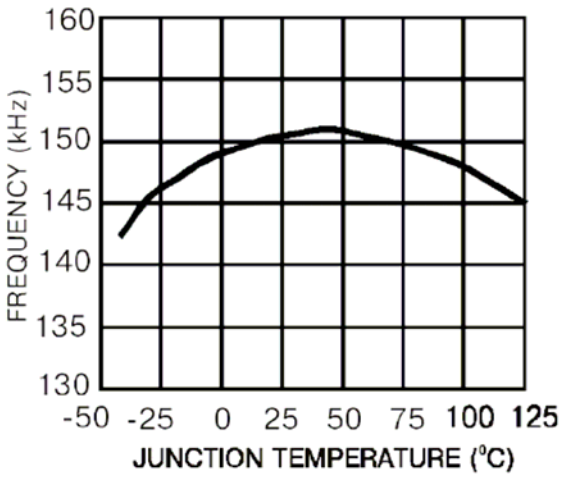
Minimum Operating Supply Voltage



ON/OFF Threshold Voltage

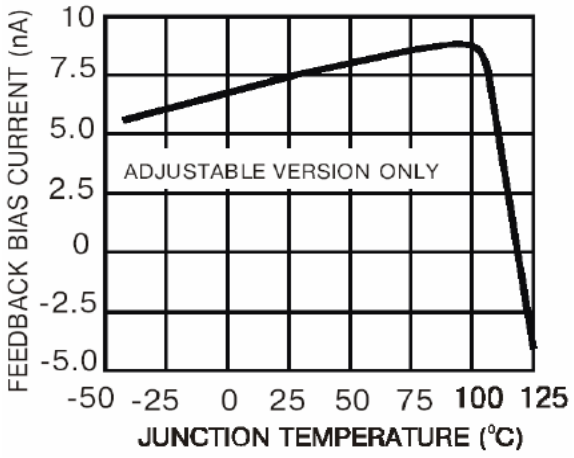


ON/OFF Pin Current (Sinking)

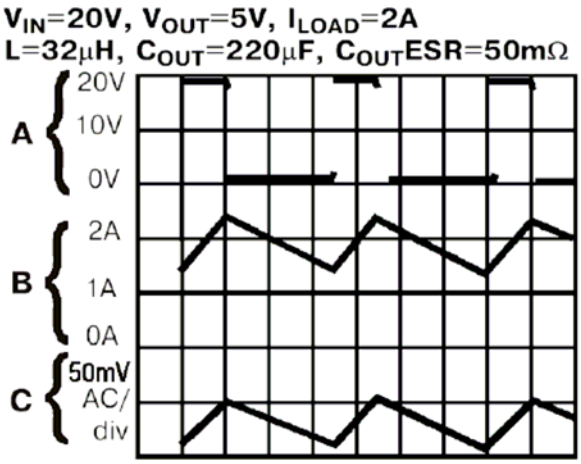


Switching Frequency

Typical Performance Characteristics(Cont.)

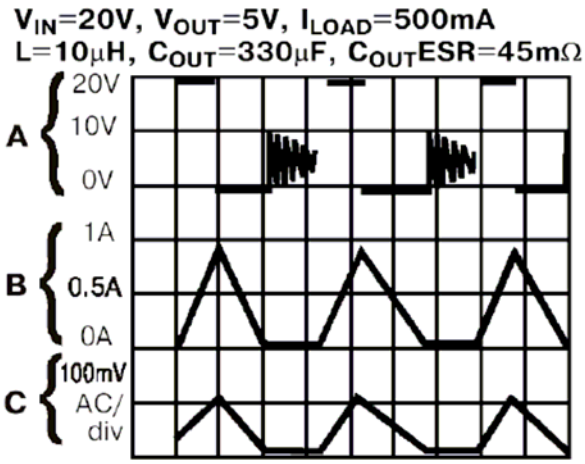


Feedback Pin Bias Current



A: Output Pin Voltage, 10V/div
B: Inductor Current 1A/div
C: Output Ripple Voltage, 50mV/div
Horizontal Time Base: 2μs/div

Continuous Mode Switching Waveforms

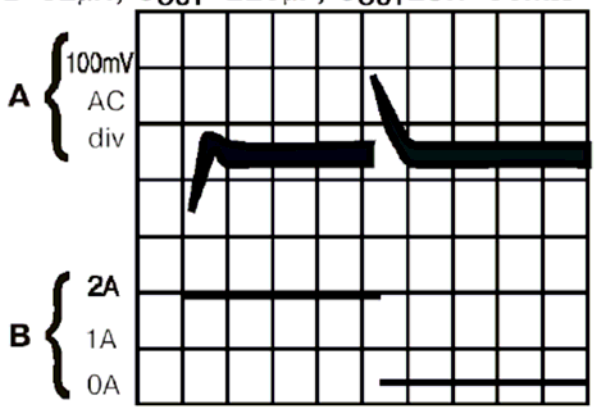


A: Output Pin Voltage, 10V/div
B: Inductor Current 1A/div
C: Output Ripple Voltage, 100mV/div
Horizontal Time Base: 2μs/div

Discontinuous Mode Switching Waveforms

Typical Performance Characteristics(Cont.)

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

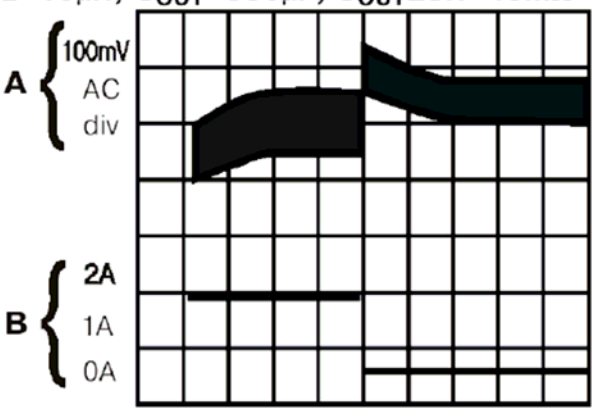


A: Output Voltage, 100mV/div.(AC)
B: 500mA to 2A Load Pulse

Horizontal Time Base: 100μs/div

Load Transient Response
for Continuous Mode

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



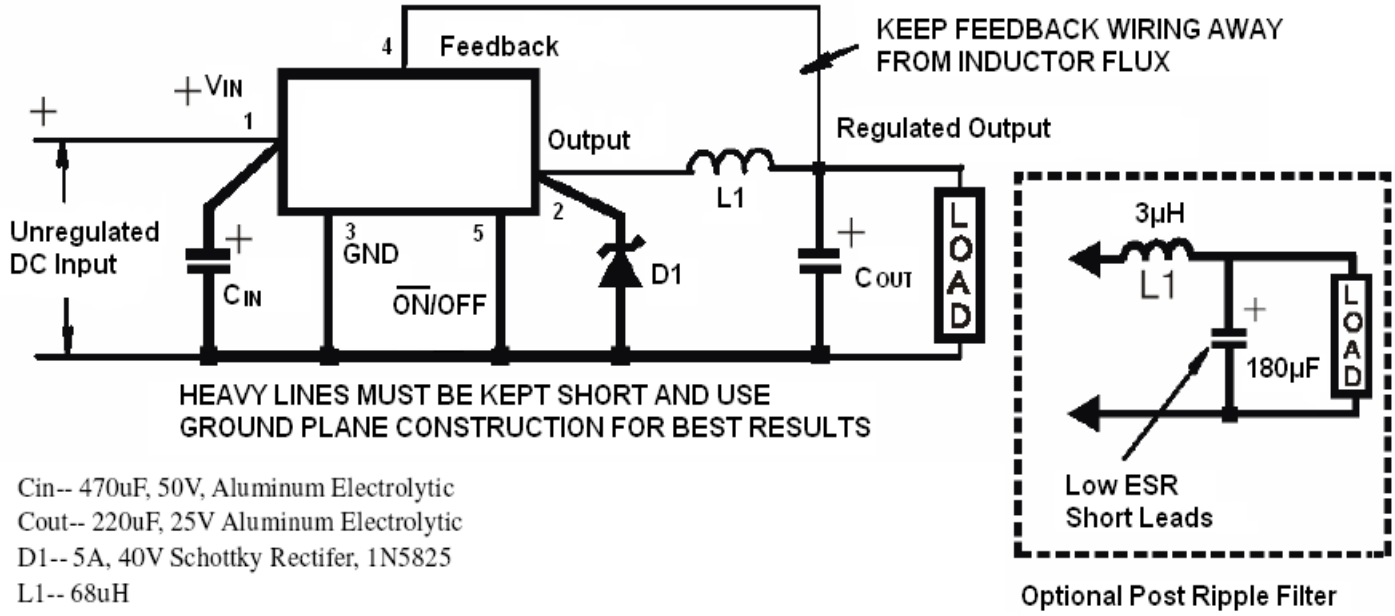
A: Output Voltage, 100mV/div. (AC)
B: 500mA to 2A Load Pulse

Horizontal Time Base: 200μs/div

Load Transient Response
for Discontinuous Mode

Typical Application Circuit

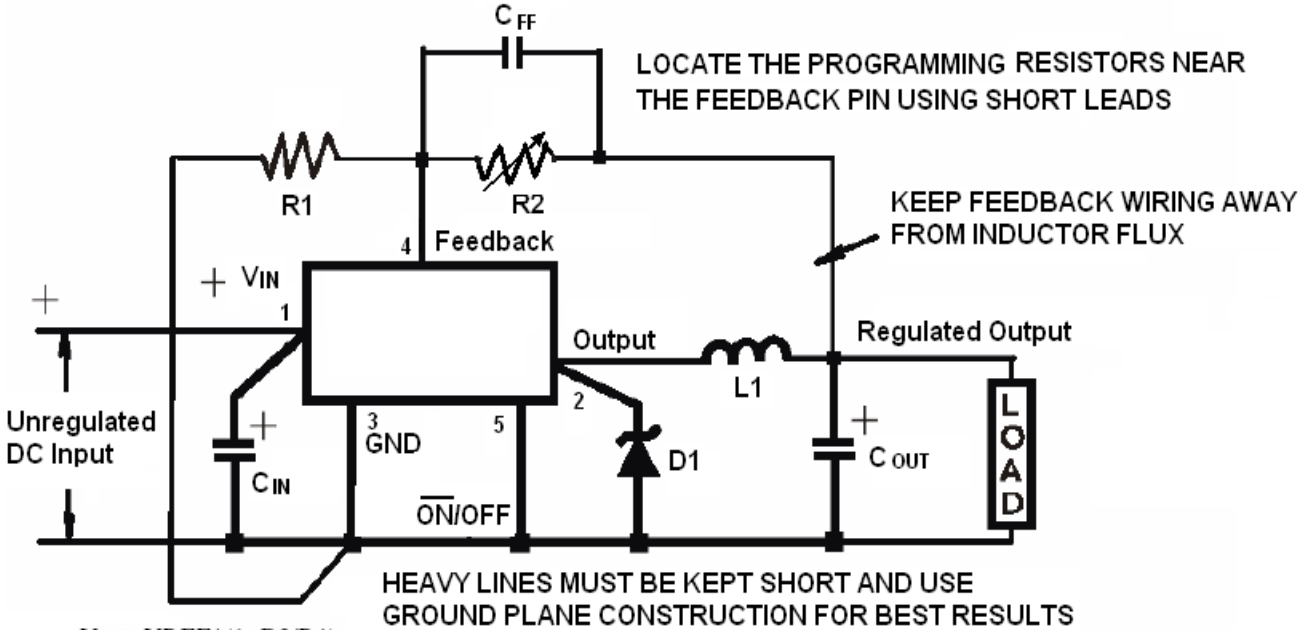
Fixed Output Voltage Versions



Cin-- 470uF, 50V, Aluminum Electrolytic
Cout-- 220uF, 25V Aluminum Electrolytic
D1-- 5A, 40V Schottky Rectifer, 1N5825
L1-- 68uH

Optional Post Ripple Filter

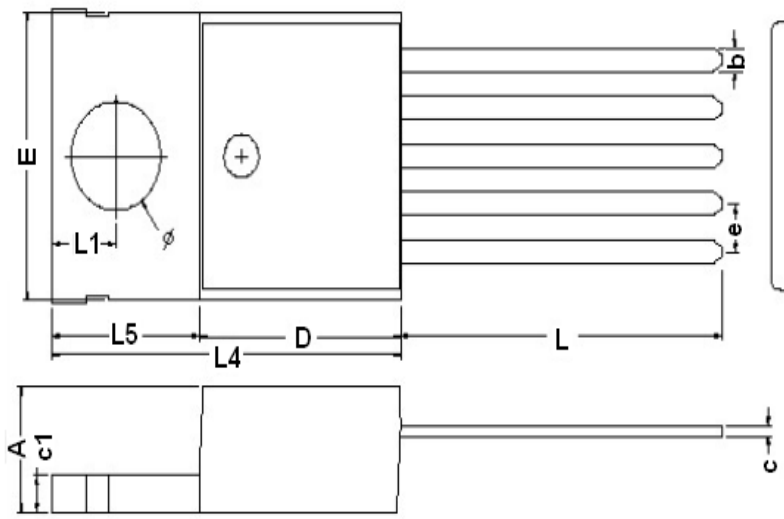
Adjustable Output Voltage Versions

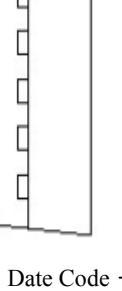


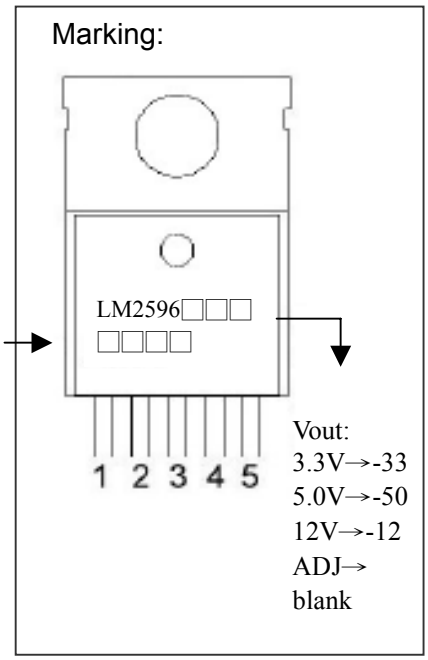
Vout=VREF*(1+R2/R1)
Where VREF=1.23V
R2=R1*(Vout/VREF-1)
Select R1 to be approximately 1kΩ, use a 1% resistor for best stability.
Cin-- 470uF, 50V, Aluminum Electrolytic
Cout-- 220uF, 35V Aluminum Electrolytic
D1-- 5A, 40V Schottky Rectifer, 1N5825
L1-- 68uH

Figure 2 Standard Test Circuits and Layout

TO-263-5L Dimension







5-Lead TO-220-5L Plastic Package
CYStek Package Code: E5

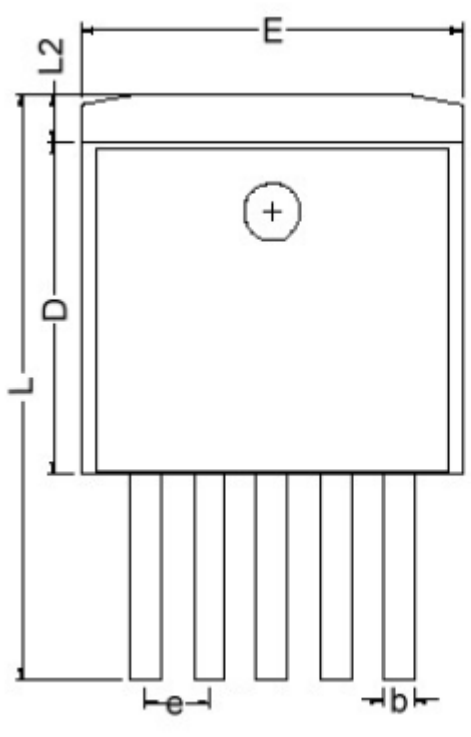
Style: Pin 1.Vin 2.Vout 3.GND
4.Feedback 5.ON/OFF

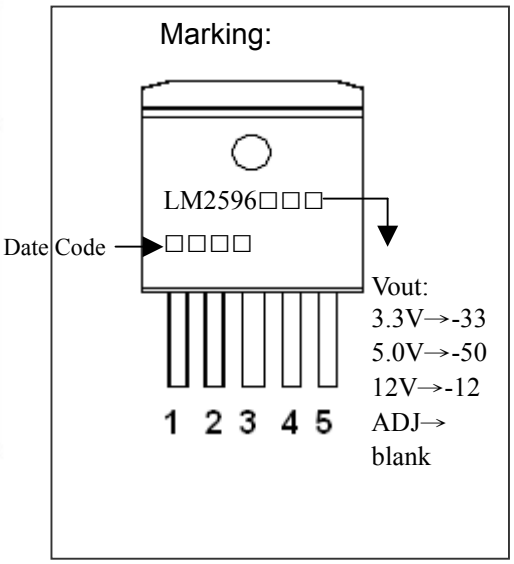
DIM	Inches		Millimeters		DIM	Inches		Millimeters	
	Min.	Max.	Min.	Max.		Min.	Max.	Min.	Max.
A	0.173	0.189	4.40	4.80	L5	0.244	0.260	6.20	6.60
b	0.030	0.039	0.76	1.00	c1	0.049	0.057	1.25	1.45
c	0.014	0.020	0.36	0.50	L	0.522	0.561	13.25	14.25
D	0.339	0.354	8.60	9.00	e	0.067 REF		1.70 REF	
E	0.386	0.409	9.80	10.4	L1	0.102	0.114	2.60	2.89
L4	0.579	0.602	14.7	15.3	φ	0.146	0.156	3.71	3.96

Notes: 1.Controlling dimension: millimeter
2.Maximum lead thickness includes lead finish thickness, and minimum lead thickness is the minimum thickness of base material.
3.If there is any question with packing specification or packing method, please contact your local CYStek sales office.

Material:
• Mold Compound: Epoxy resin family, flammability solid burning class: UL94V-0

TO-263-5L Dimension





Style: Pin 1.Vin 2.Vout 3.GND
4.Feedback 5.ON/OFF

5-Lead TO-263-5L Plastic Package
CYStek Package Code: F5

DIM	Inches		Millimeters		DIM	Inches		Millimeters	
	Min.	Max.	Min.	Max.		Min.	Max.	Min.	Max.
A	0.173	0.189	4.40	4.80	c2	0.049	0.057	1.25	1.45
b	0.026	0.036	0.66	0.91	L2	0.050 REF		1.27 REF	
L4	0.000	0.012	0.00	0.30	D	0.339	0.354	8.60	9.00
c	0.014	0.020	0.36	0.50	e	0.067 REF		1.70 REF	
L1	0.090	0.110	2.29	2.79	L	0.575	0.622	14.6	15.8
E	0.386	0.409	9.80	10.4	θ	0°	8°	0°	8°

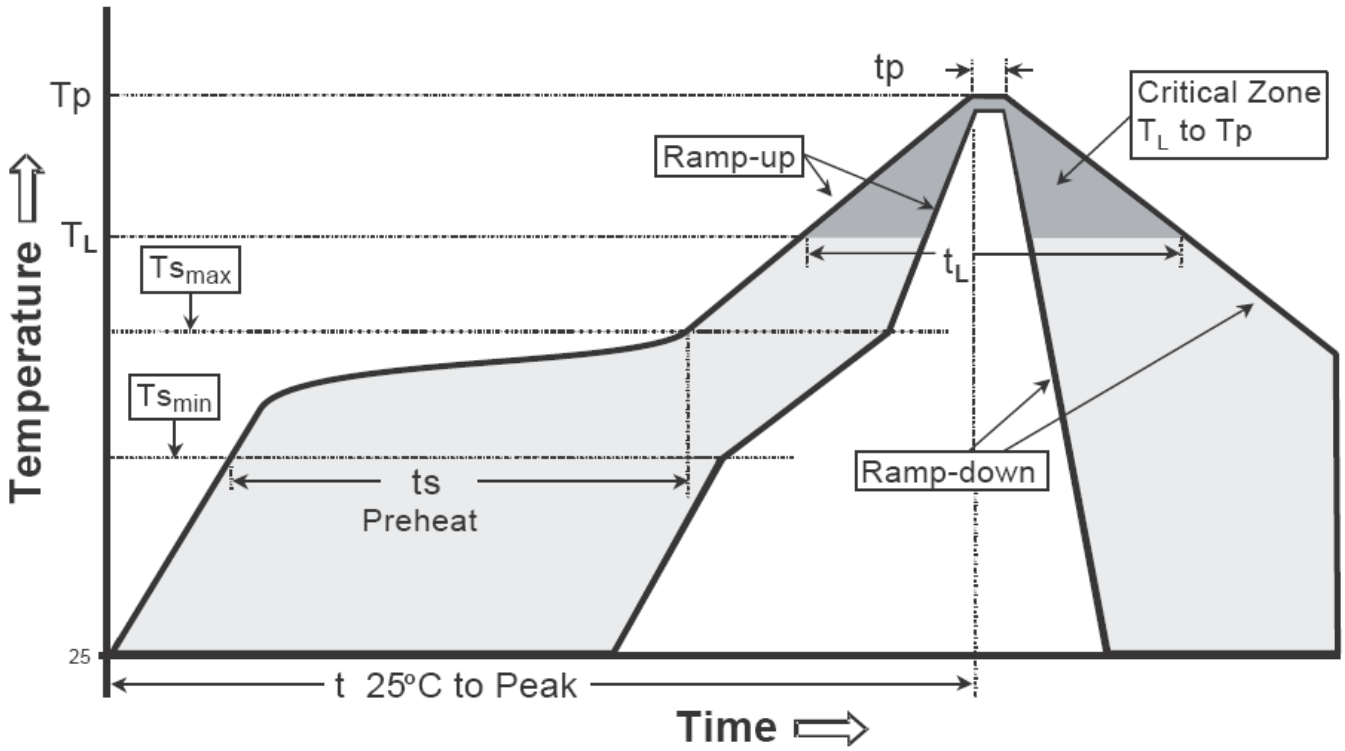
Notes: 1.Controlling dimension :millimeter
2.Maximum lead thickness includes lead finish thickness, and minimum lead thickness is the minimum thickness of base material.
3.If there is any question with packing specification or packing method, please contact your local CYStek sales office.

Material:
• Mold Compound: Epoxy resin family, flammability solid burning class: UL94V-0

Recommended wave soldering condition

Product	Peak Temperature	Soldering Time
Pb-free devices	260 +0/-5 °C	5 +1/-1 seconds

Recommended temperature profile for IR reflow



Profile feature	Sn-Pb eutectic Assembly	Pb-free Assembly
Average ramp-up rate (Tsmax to Tp)	3°C/second max.	3°C/second max.
Preheat −Temperature Min(T_S min) −Temperature Max(T_S max) −Time($t_{s\ min}$ to $t_{s\ max}$)	 100°C 150°C 60-120 seconds	 150°C 200°C 60-180 seconds
Time maintained above: −Temperature (T_L) − Time (t_L)	 183°C 60-150 seconds	 217°C 60-150 seconds
Peak Temperature(T_P)	240 +0/-5 °C	260 +0/-5 °C
Time within 5°C of actual peak temperature(tp)	10-30 seconds	20-40 seconds
Ramp down rate	6°C/second max.	6°C/second max.
Time 25 °C to peak temperature	6 minutes max.	8 minutes max.

Note : All temperatures refer to topside of the package, measured on the package body surface.