National Semiconductor

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LP3883
3A Fast-Response Ultra Low Dropout Linear Regulators

General Description

The LP3883 is a high-current, fast-response regulator which can maintain output voltage regulation with minimum input to output voltage drop. An external bias voltage is used to provide voltage drive for the N-MOS pass transistor. N-MOS design requires minimum external capacitance to maintain stability.

The fast transient response of these devices makes them suitable for use in powering CPU core voltages and terminators. The parts are available in TO-220 and TO-263 packages.

Dropout Voltage: 210 mV (typ) @ 3A load current.

Ground Pin Current: 3 mA (typ) at full load.

Shutdown Current: 60 nA (typ) when S/D pin is low.

Precision Output Voltage: 1.5% room temperature accuracy.

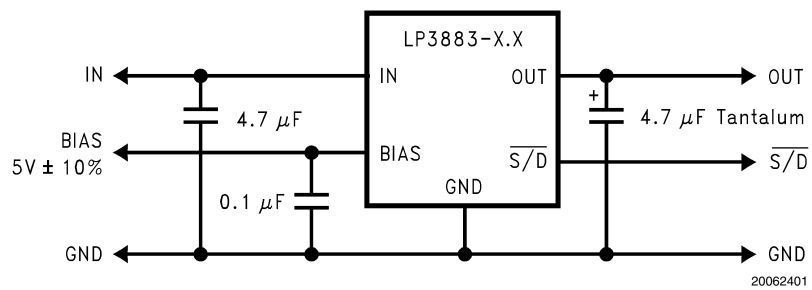
Features

- Ultra low dropout voltage (210 mV @ 3A typ)
- Low ground pin current
- Load regulation of 0.04%/A
- 60 nA typical quiescent current in shutdown
- 1.5% output accuracy (25˚C)
- TO-220, TO-263 packages
- Over temperature/over current protection
- −40˚C to +125˚C junction temperature range

Applications

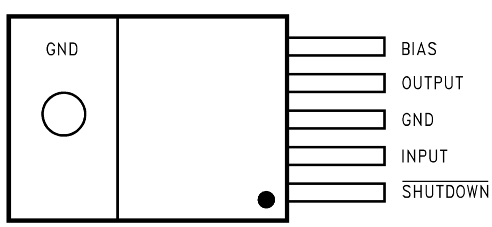
- DSP Power Supplies
- Server Core and I/O Supplies
- Linear Power Supplies for PC Add-in-Cards
- Set-Top Box Power Supplies
- Microprocessor Power Supplies
- High Efficiency Linear Power Supplies
- SMPS Post-Regulators

Typical Application Circuit

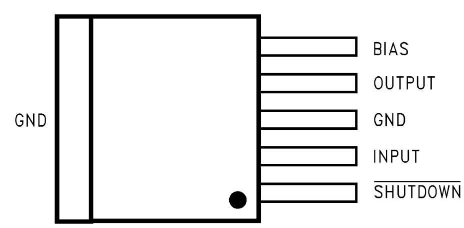


At least 4.7 μF of input and output capacitance is required for stability.

Connection Diagrams



TO-220, Top View



TO-263, Top View

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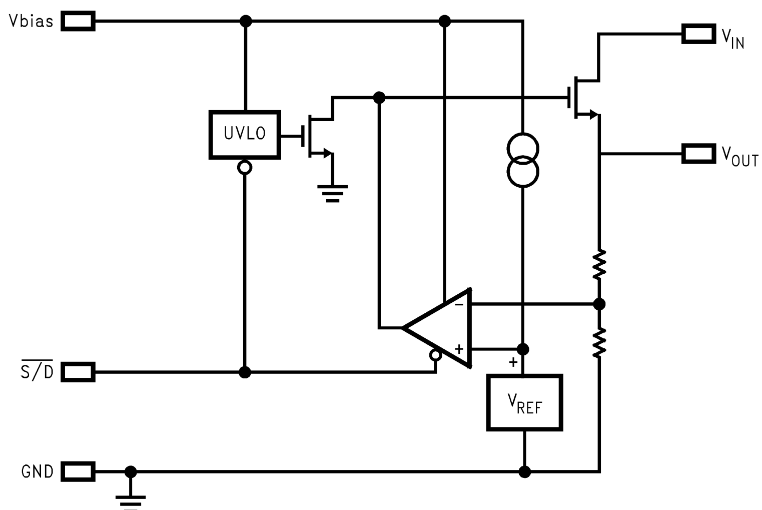
Ordering Information

Order Number	Package Type	Package Drawing	Supplied As
LP3883ES-1.2	TO263-5	TS5B	Rail
LP3883ESX-1.2	TO263-5	TS5B	Tape and Reel
LP3883ET-1.2	TO220-5	T05D	Rail
LP3883ES-1.5	TO263-5	TS5B	Rail
LP3883ESX-1.5	TO263-5	TS5B	Tape and Reel
LP3883ET-1.5	TO220-5	T05D	Rail
LP3883ES-1.8	TO263-5	TS5B	Rail
LP3883ESX-1.8	TO263-5	TS5B	Tape and Reel
LP3883ET-1.8	TO220-5	T05D	Rail

Block Diagram



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Absolute Maximum Ratings (Note 1)

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

Storage Temperature Range	–65˚C to +150˚C
Lead Temp. (Soldering, 5 seconds)	260˚C
ESD Rating	
Human Body Model (Note 3)	2 kV
Machine Model (Note 10)	200V
Power Dissipation (Note 2)	Internally Limited
V_{IN} Supply Voltage (Survival)	–0.3V to +6V
V_{BIAS} Supply Voltage (Survival)	–0.3V to +7V
Shutdown Input Voltage (Survival)	–0.3V to +7V
I_{OUT} (Survival)	Internally Limited
Output Voltage (Survival)	–0.3V to +6V
Junction Temperature	–40˚C to +150˚C

Operating Ratings

V_{IN} Supply Voltage	(V_{OUT} + V_{DO}) to 5.5V
Shutdown Input Voltage	0 to +6V
I_{OUT}	3A
Operating Junction Temperature Range	–40˚C to +125˚C
V_{BIAS} Supply Voltage	4.5V to 6V

Electrical Characteristics

Limits in standard typeface are for T_J = 25˚C, and limits in **boldface type** apply over the full operating temperature range. Unless otherwise specified: V_{IN} = V_O(NOM) + 1V, V_{BIAS} = 4.5V, I_L = 10 mA, C_{IN} = C_{OUT} = 4.7 µF, $V_{S/D}$ = V_{BIAS}.

Symbol	Parameter	Conditions	Typical (Note 4)	MIN (Note 5)	MAX (Note 5)	Units
V_O	Output Voltage Tolerance	10 mA < I_L < 3A V_O(NOM) + 1V ≤ V_{IN} ≤ 5.5V 4.5V ≤ V_{BIAS} ≤ 6V	1.216	1.198 **1.186**	1.234 **1.246**	V
			1.5	1.478 **1.455**	1.522 **1.545**	V
			1.8	1.773 **1.746**	1.827 **1.854**	V
$\Delta V_O/\Delta V_{IN}$	Output Voltage Line Regulation (Note 7)	V_O(NOM) + 1V ≤ V_{IN} ≤ 5.5V	0.01			%/V
$\Delta V_O/\Delta I_L$	Output Voltage Load Regulation (Note 8)	10 mA < I_L < 3A	0.04 **0.06**			%/A
V_{IN}–V_O	Dropout Voltage (Note 9)	I_L = 3A	210		270 **420**	mV
$I_Q(V_{IN})$	Quiescent Current Drawn from V_{IN} Supply	10 mA < I_L < 3A	3		7 **8**	mA
		$V_{\overline{S/D}}$ ≤ 0.3V	0.03		1 **30**	µA
$I_Q(V_{BIAS})$	Quiescent Current Drawn from V_{BIAS} Supply	10 mA < I_L < 3A	1		2 **3**	mA
		$V_{\overline{S/D}}$ ≤ 0.3V	0.03		1 **30**	µA
I_{SC}	Short-Circuit Current	V_{OUT} = 0V	6			A
$T_{S/D}$	Thermal Shutdown Temperature		165			˚C
T_{HYS}	Thermal Shutdown Temperature Hysteresis		20			˚C
Shutdown Input						
V_{SDT}	Output Turn-off Threshold	Output = ON	0.7	**1.3**		V
		Output = OFF	0.7		**0.3**	V
Td (OFF)	Turn-OFF Delay	R_{LOAD} X C_{OUT} << Td (OFF)	20			µs
Td (ON)	Turn-ON Delay	R_{LOAD} X C_{OUT} << Td (ON)	15			µs
$I_{\overline{S/D}}$	$\overline{S/D}$ Input Current	$V_{\overline{S/D}}$ =1.3V	1			µA
		$V_{\overline{S/D}}$ ≤ 0.3V	–1			µA

Electrical Characteristics

Limits in standard typeface are for T_J = 25˚C, and limits in **boldface type** apply over the full operating temperature range. Unless otherwise specified: V_{IN} = V_O(NOM) + 1V, V_{BIAS} = 4.5V, I_L = 10 mA, C_{IN} = C_{OUT} = 4.7 µF, $V_{S/D}$ = V_{BIAS}. (Continued)

Symbol	Parameter	Conditions	Typical (Note 4)	MIN (Note 5)	MAX (Note 5)	Units
AC Parameters						
PSRR (V_{IN})	Ripple Rejection for V_{IN} Input Voltage	V_{IN} = V_{OUT} +1V, f = 120 Hz	80			dB
		V_{IN} = V_{OUT} + 1V, f = 1 kHz	65			
PSRR (V_{BIAS})	Ripple Rejection for V_{BIAS} Voltage	V_{BIAS} = V_{OUT} + 3V, f = 120 Hz	70			
		V_{BIAS} = V_{OUT} + 3V, f = 1 kHz	65			
	Output Noise Density	f = 120 Hz	1			µV/root−Hz
e_n	Output Noise Voltage	BW = 10 Hz – 100 kHz	150			µV (rms)
		BW = 300 Hz – 300 kHz	90			

Note 1: Absolute maximum ratings indicate limits beyond which damage to the component 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, see Electrical Characteristics. Specifications do not apply when operating the device outside of its rated operating conditions.

Note 2: At elevated temperatures, device power dissipation must be derated based on package thermal resistance and heatsink thermal values. θ_{J-A} for TO-220 devices is 65˚C/W if no heatsink is used. If the TO-220 device is attached to a heatsink, a θ_{J-S} value of 4˚C/W can be assumed. θ_{J-A} for TO-263 devices is approximately 40˚C/W if soldered down to a copper plane which is at least 1.5 square inches in area. If power dissipation causes the junction temperature to exceed specified limits, the device will go into thermal shutdown.

Note 3: The human body model is a 100 pF capacitor discharged through a 1.5k resistor into each pin.

Note 4: Typical numbers represent the most likely parametric norm for 25˚C operation.

Note 5: Limits are guaranteed through testing, statistical correlation, or design.

Note 6: If used in a dual-supply system where the regulator load is returned to a negative supply, the output pin must be diode clamped to ground.

Note 7: Output voltage line regulation is defined as the change in output voltage from nominal value resulting from a change in input voltage.

Note 8: Output voltage load regulation is defined as the change in output voltage from nominal value as the load current increases from no load to full load.

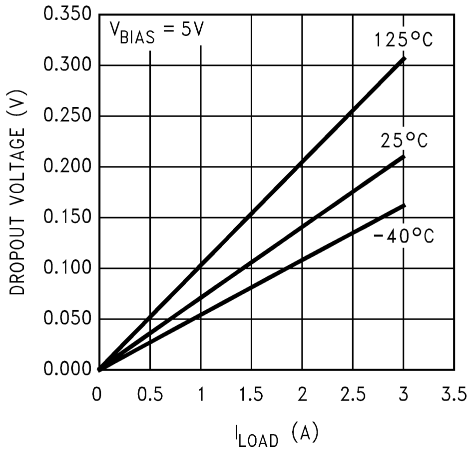
Note 9: Dropout voltage is defined as the minimum input to output differential required to maintain the output with 2% of nominal value.

Note 10: The machine model is a 220 pF capacitor discharged directly into each pin. The machine model ESD rating of pin 5 is 100V.

Typical Performance Characteristics

Unless otherwise specified: T_A = 25˚C, C_{OUT} = 4.7µF, Cin = 4.7µF, $\overline{S/D}$ pin is tied to V_{BIAS}, V_{IN} = 2.2V.

Dropout vs I_L



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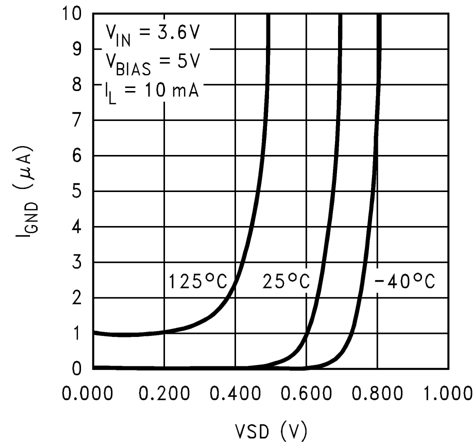
I_{GND} vs VSD



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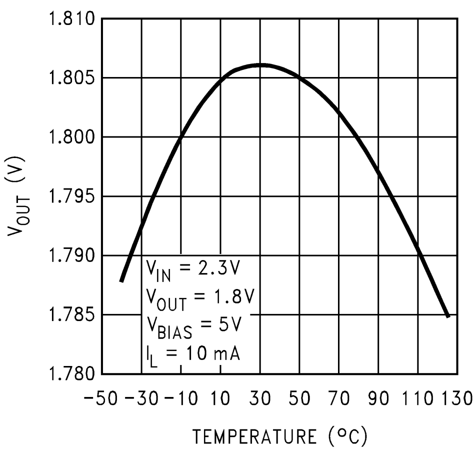
V_{OUT} vs Temperature



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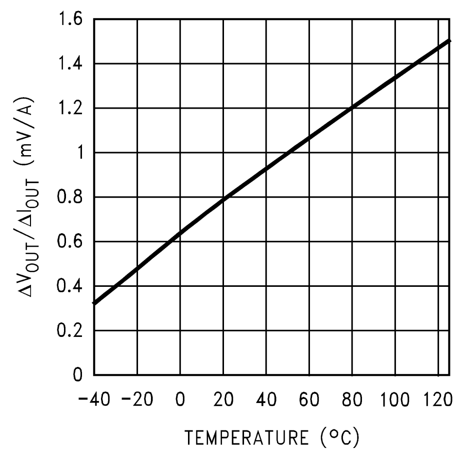
DC Load Regulation



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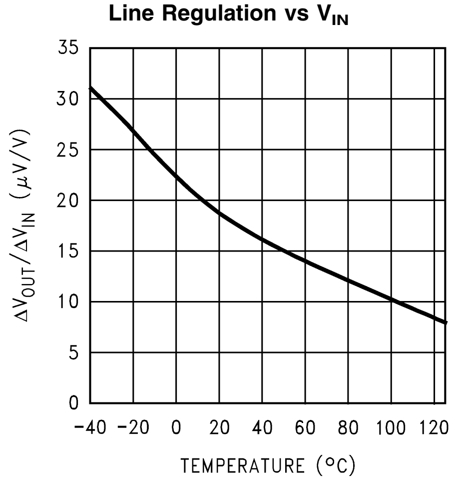
Line Regulation vs V_{IN}



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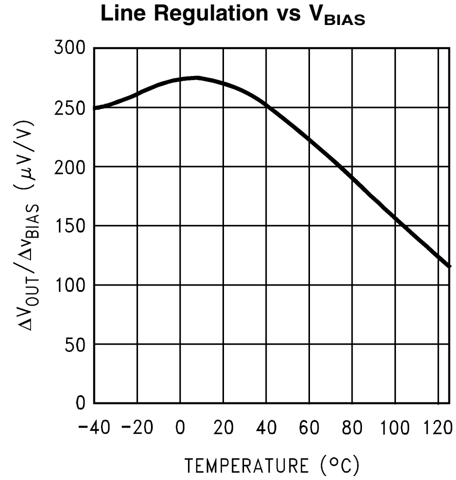
Line Regulation vs V_{BIAS}



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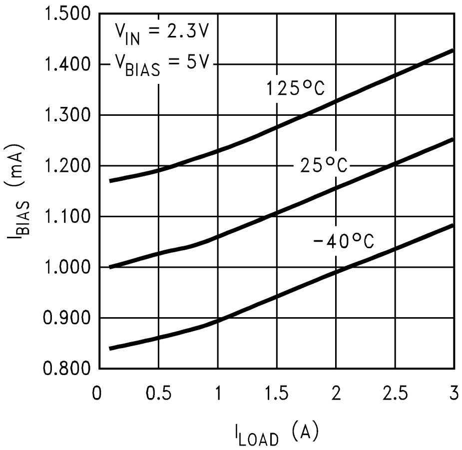
Typical Performance Characteristics Unless otherwise specified: T_A = 25˚C, C_{OUT} = 4.7µF, Cin = 4.7µF, $\overline{S/D}$ pin is tied to V_{BIAS}, V_{IN} = 2.2V. (Continued)

I_{BIAS} vs I_L



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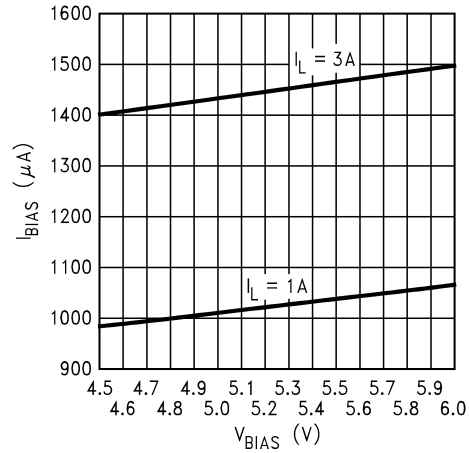
I_{BIAS} vs V_{BIAS}



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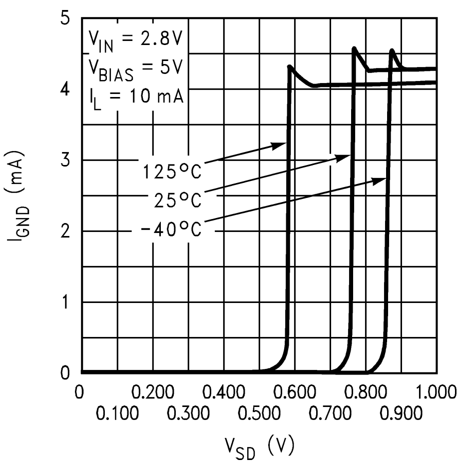
I_{GND} vs VSD



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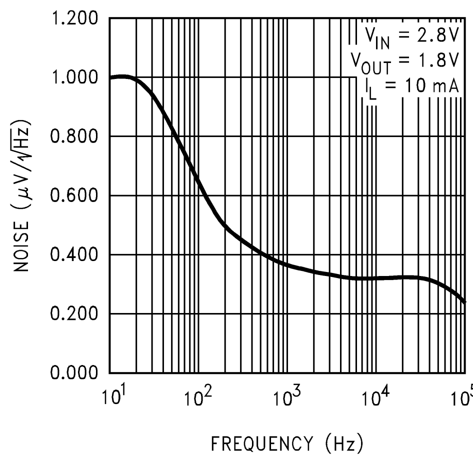
Noise Measurement



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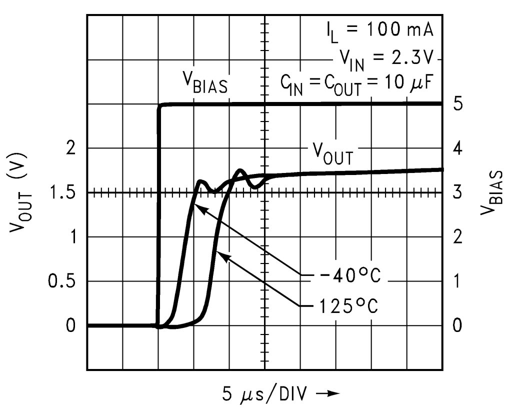
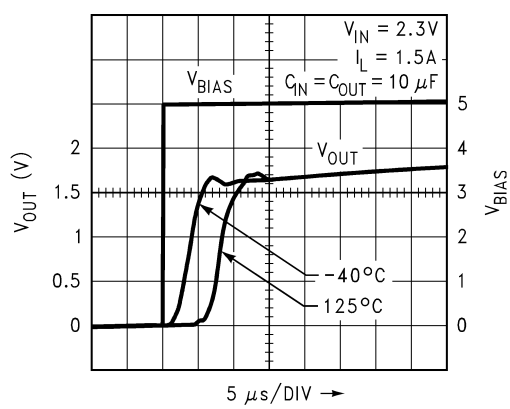
V_{OUT}Startup Waveform



20062415

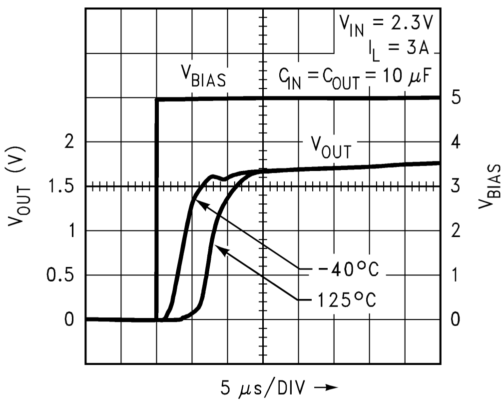
V_{OUT}Startup Waveform



20062416

Typical Performance Characteristics Unless otherwise specified: $T_A = 25°C$, $C_{OUT} = 4.7\mu F$, Cin = 4.7µF, $\overline{S/D}$ pin is tied to V_{BIAS}, $V_{IN} = 2.2V$. (Continued)

V_{OUT} Startup Waveform



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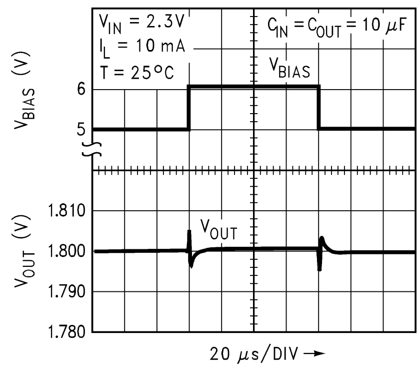
Line Regulation vs V_{BIAS}



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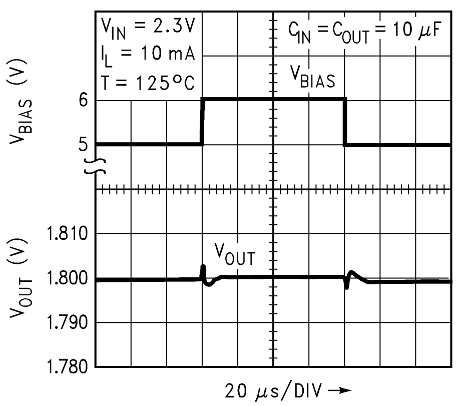
Line Regulation vs V_{BIAS}



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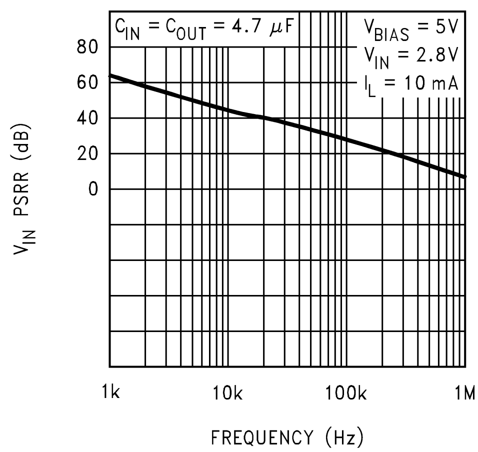
V_{IN} PSRR



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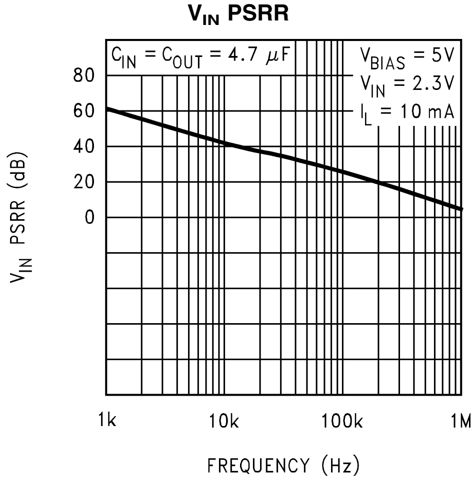
V_{IN} PSRR



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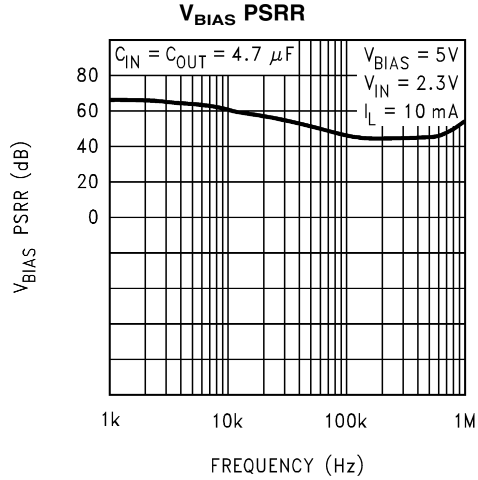
V_{BIAS} PSRR



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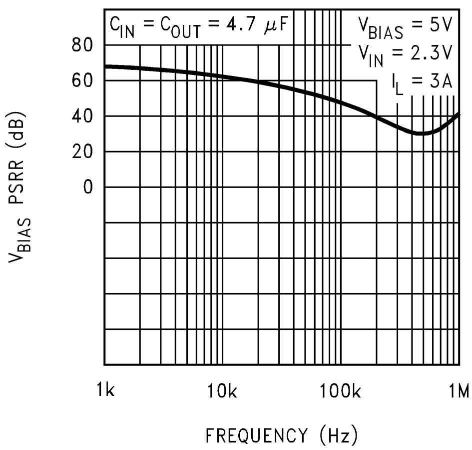
Typical Performance Characteristics

Unless otherwise specified: T_A = 25˚C, C_{OUT} = 4.7µF, Cin = 4.7µF, $\overline{S/D}$ pin is tied to V_{BIAS}, V_{IN} = 2.2V. (Continued)

V_{BIAS} PSRR



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Application Hints

EXTERNAL CAPACITORS

To assure regular stability, input and output capacitors are required as shown in the Typical Application Circuit.

OUTPUT CAPACITOR

A Tantalum capacitor with a minimum of 4.7µF is required on the output for stability. The amount of capacitance can be increased without limit.

Because the ESR of a ceramic capacitance is a few milliohms, they can cause oscillations if placed on the output (depending on how much Tantalum capacitance is present).

INPUT CAPACITOR

An input capacitor of at least 4.7µF is required. This can be either Tantalum or ceramic. The amount of capacitance can be increased without limit.

SHUTDOWN OPERATION

Pulling down the shutdown ($\overline{S/D}$) pin will turn-off the regulator. Pin $\overline{S/D}$ must be actively terminated through a pull-up resistor (10 kΩ to 100 kΩ) for a proper operation. If this pin is driven from a source that actively pulls high and low (such as a CMOS rail to rail comparator), the pull-up resistor is not required. This pin must be tied to Vin if not used.

POWER DISSIPATION/HEATSINKING

A heatsink may be required depending on the maximum power dissipation and maximum ambient temperature of the application. Under all possible conditions, the junction temperature must be within the range specified under operating conditions. The total power dissipation of the device is given by:

$P_D = (V_{IN}-V_{OUT})I_{OUT} + (V_{IN})I_{GND}$

where I_{GND} is the operating ground current of the device.

The maximum allowable temperature rise (T_{Rmax}) depends on the maximum ambient temperature (T_{Amax}) of the application, and the maximum allowable junction temperature (T_{Jmax}):

$T_{Rmax} = T_{Jmax} - T_{Amax}$

The maximum allowable value for junction to ambient Thermal Resistance, θ_{JA}, can be calculated using the formula:

$\theta_{JA} = T_{Rmax} / P_D$

These parts are available in TO-220 and TO-263 packages. The thermal resistance depends on amount of copper area or heat sink, and on air flow. If the maximum allowable value of θ_{JA} calculated above is ≥ 60 ˚C/W for TO-220 package and ≥ 60 ˚C/W for TO-263 package no heatsink is needed since the package can dissipate enough heat to satisfy these requirements. If the value for allowable θ_{JA} falls below these limits, a heat sink is required.

HEATSINKING TO-220 PACKAGE

The thermal resistance of a TO220 package can be reduced by attaching it to a heat sink or a copper plane on a PC board. If a copper plane is to be used, the values of θ_{JA} will be same as shown in next section for TO263 package.

The heatsink to be used in the application should have a heatsink to ambient thermal resistance,

$\theta_{HA} \leq \theta_{JA} - \theta_{CH} - \theta_{JC}$.

In this equation, θ_{CH} is the thermal resistance from the case to the surface of the heat sink and θ_{JC} is the thermal resistance from the junction to the surface of the case. θ_{JC} is about 3˚C/W for a TO220 package. The value for θ_{CH} depends on method of attachment, insulator, etc. θ_{CH} varies between 1.5˚C/W to 2.5˚C/W. If the exact value is unknown, 2˚C/W can be assumed.

HEATSINKING TO-263 PACKAGE

The TO-263 package uses the copper plane on the PCB as a heatsink. The tab of these packages are soldered to the copper plane for heat sinking. The graph below shows a curve for the θ_{JA} of TO-263 package for different copper area sizes, using a typical PCB with 1 ounce copper and no solder mask over the copper area for heat sinking.

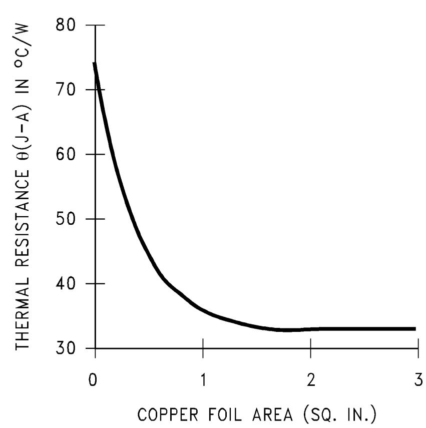

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FIGURE 1. θ_{JA} vs Copper (1 Ounce) Area for TO-263 package

Application Hints (Continued)

As shown in the graph below, increasing the copper area beyond 1 square inch produces very little improvement. The minimum value for θ_{JA} for the TO-263 package mounted to a PCB is 32˚C/W.

Figure 2 shows the maximum allowable power dissipation for TO-263 packages for different ambient temperatures, assuming θ_{JA} is 35˚C/W and the maximum junction temperature is 125˚C.

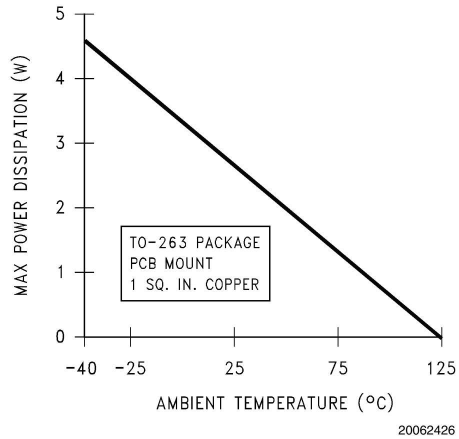
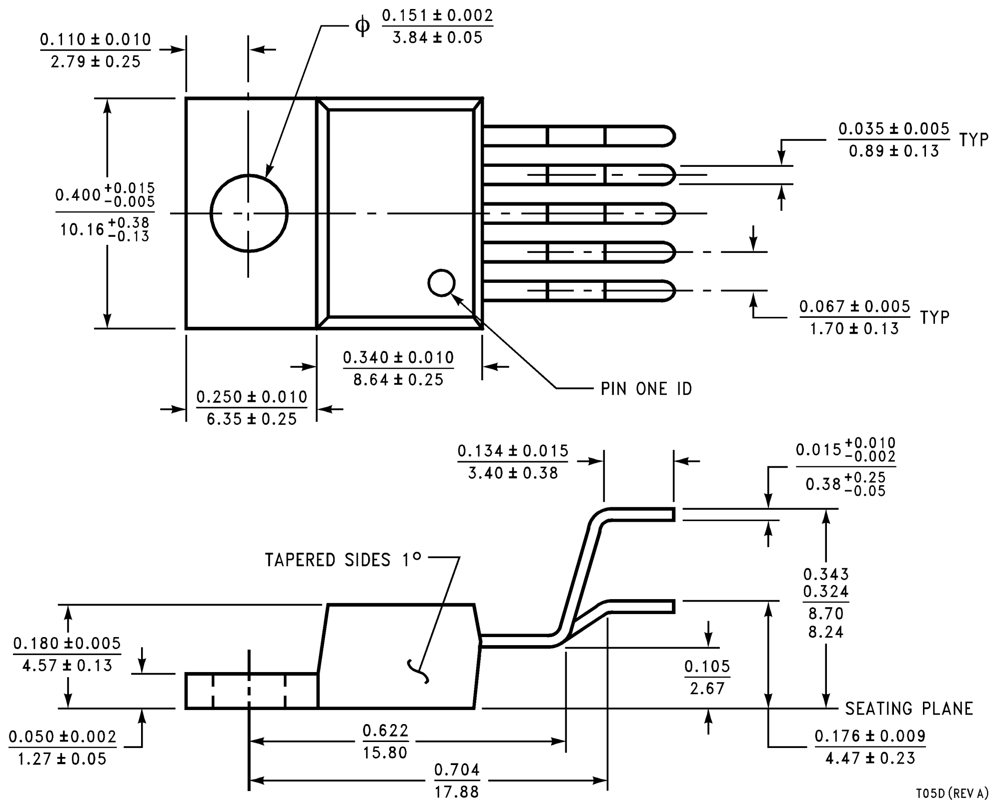


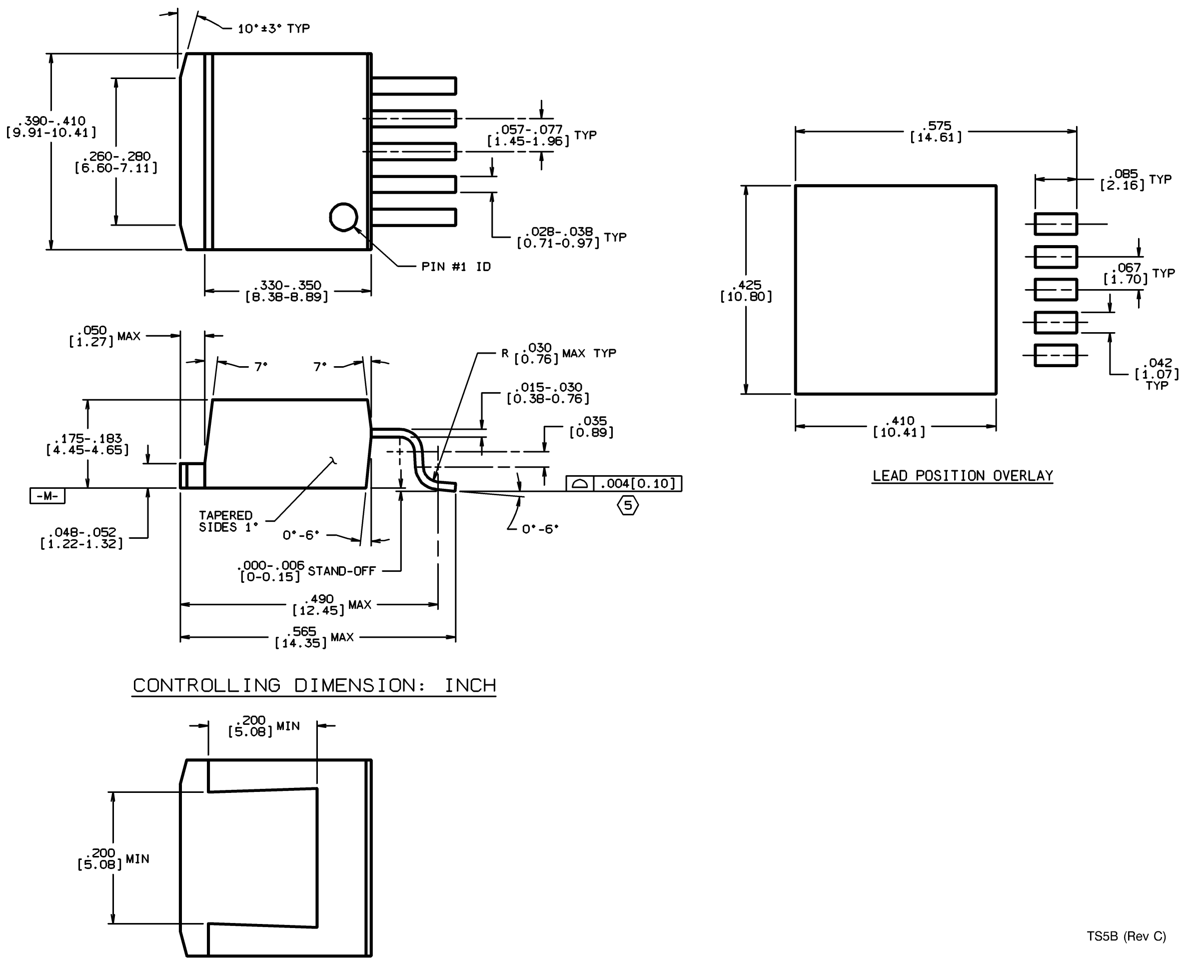
FIGURE 2. Maximum power dissipation vs ambient temperature for TO-263 package

Physical Dimensions inches (millimeters) unless otherwise noted



TO220 5-lead, Molded, Stagger Bend Package (TO220-5)
NS Package Number T05D

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



TS5B (Rev C)

TO263 5-Lead, Molded, Surface Mount Package (TO263-5)
NS Package Number TS5B

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2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

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