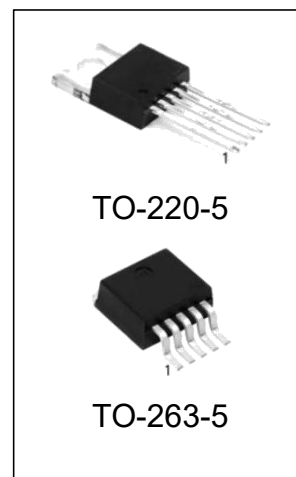


# 1.5A Fast Ultra Low Dropout Linear Regulators

## Features

- Ultra low dropout voltage
- Low ground pin current
- Load regulation of 0.04%
- 15μA quiescent current in shutdown mode
- Guaranteed output current of 1.5A DC
- Available in TO-263 and TO-220 packages
- Output voltage accuracy  $\pm 1.5\%$
- Sense option improves better load regulation
- Extremely low output capacitor requirements
- Overt emperature/overcurrent protection
- $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$  junction temperature range



## Ordering Information

DEVICE	Package Type	MARKING	Packing	Packing Qty
LP3965T-1.8	TO-220-5	LP3965-1.8	TUBE	1000pcs/Box
LP3965T-2.5	TO-220-5	LP3965-2.5	TUBE	1000pcs/Box
LP3965T-3.3	TO-220-5	LP3965-3.3	TUBE	1000pcs/Box
LP3965T-5.0	TO-220-5	LP3965-5.0	TUBE	1000pcs/Box
LP3965T-ADJ	TO-220-5	LP3965-ADJ	TUBE	1000pcs/Box
LP3965S-1.8/TR	TO-263-5	LP3965-1.8	REEL	500pcs/Reel
LP3965S-2.5/TR	TO-263-5	LP3965-2.5	REEL	500pcs/Reel
LP3965S-3.3/TR	TO-263-5	LP3965-3.3	REEL	500pcs/Reel
LP3965S-5.0/TR	TO-263-5	LP3965-5.0	REEL	500pcs/Reel
LP3965S-ADJ/TR	TO-263-5	LP3965-ADJ	REEL	500pcs/Reel

## General Description

The LP3965 series of fast ultra low-dropout linear regulators operate from a +2.5V to +7.0V input supply. Wide range of preset output voltage options are available. These ultra low dropout linear regulators respond very fast to step changes in load which makes them suitable for low voltage microprocessor applications. The LP3965 are developed on a CMOS process which allows low quiescent current operation independent of output load current. This CMOS process also allows the LP3965 to operate under extremely low dropout conditions.

**Dropout Voltage:**

Ultra low dropout voltage; typically 38mV at 150mA load current and 380mV at 1.5A load current.

**Ground Pin Current:**

Typically 5mA at 1.5A load current.

**Shutdown Mode:**

Typically 15 $\mu$ A quiescent current when the shutdown pin is pulled low.

**SENSE:**

Sense pin improves regulation at remote loads.

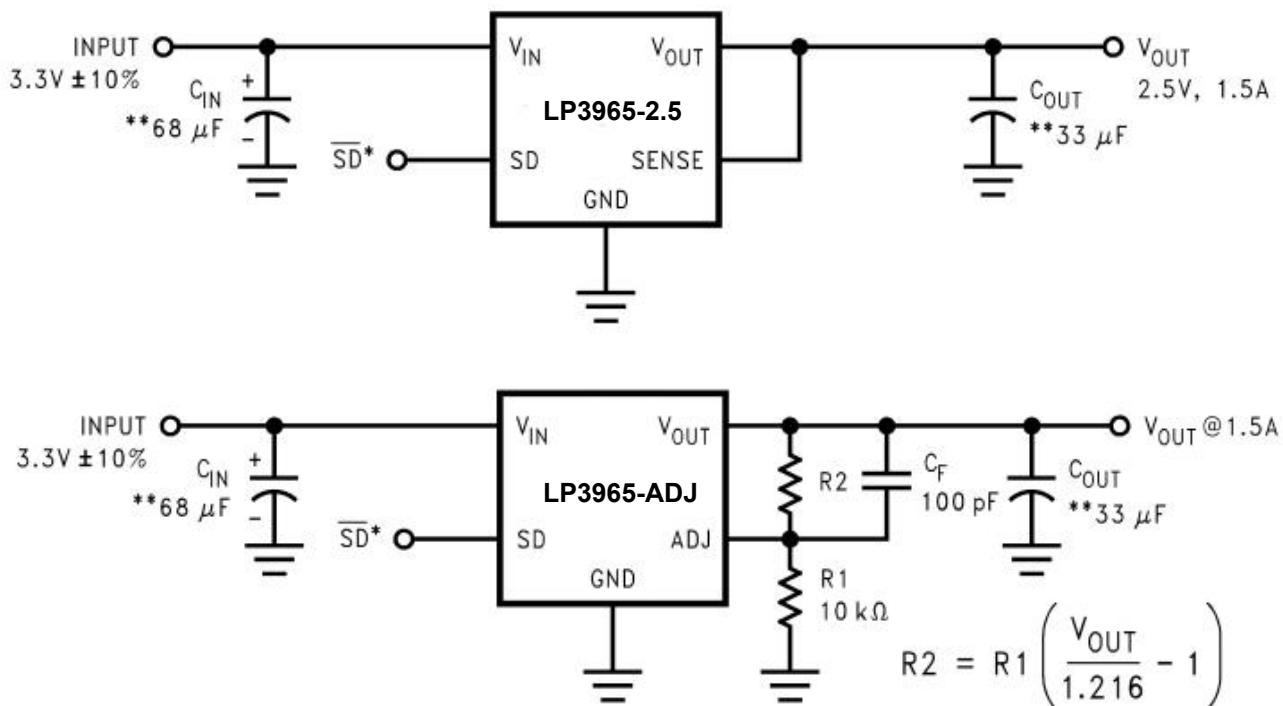
**Precision Output Voltage:**

Multiple output voltage options are available ranging from 1.8V 、 2.5V、 3.3V、 5.0V and adjustable (LP3965), with a guaranteed accuracy of  $\pm 1.5\%$  at room temperature, and  $\pm 3.0\%$  over all conditions (varying line, load, and temperature).

## Applications

- Microprocessor power supplies
- GTL, GTL+, BTL, and SSTL bus terminators
- Power supplies for DSPs
- SCSI terminator
- Post regulators
- High efficiency linear regulators
- Battery chargers
- Other battery powered applications

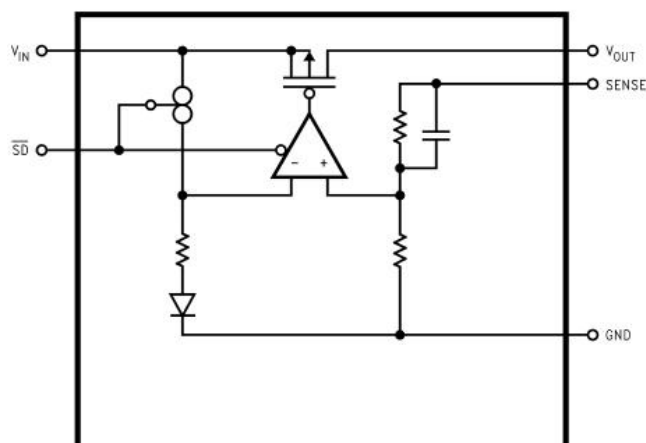
## Typical Application Circuits



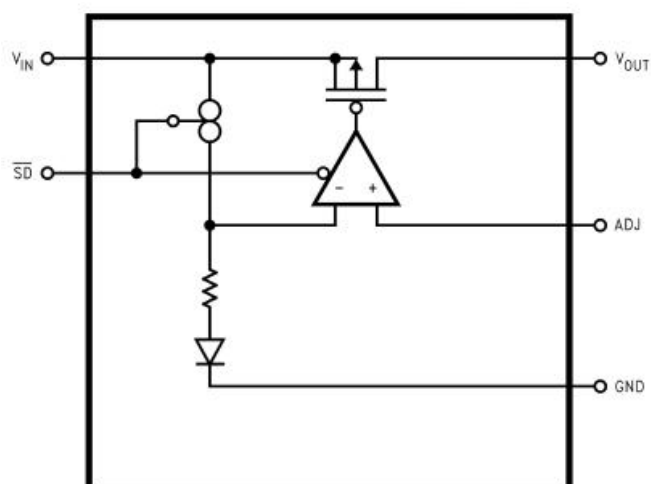
\*SD and ERROR pins must be pulled high through a 10k $\Omega$  pull-up resistor. Connect the ERROR pin to ground if this function is not used. See applications section for more information.

\*\* See Application Hints.

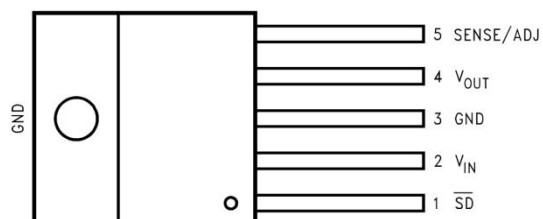
### Block Diagram LP3965



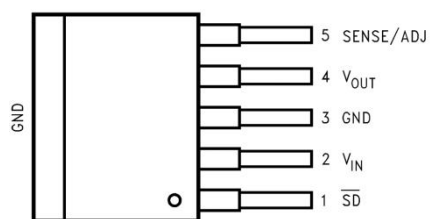
### Block Diagram LP3965-ADJ



## Connection Diagrams



Top View  
TO-220-5 Package



Top View  
TO-263-5 Package

## Pin Description for TO220-5 and TO263-5 Packages

Pin #	LP3965	
	Name	Function
1	$\overline{SD}$	Shutdown
2	$V_{IN}$	Input Supply
3	GND	Ground
4	$V_{OUT}$	Output Voltage
5	SENSE/ADJ	Remote Sense Pin or Output Adjust Pin

**Absolute Maximum Ratings (Note 1)**

Condition	Min	Max
Storage Temperature Range	-65°C	+150°C
Lead Temperature(Soldering, 10 sec.)	-	245°C
ESD Rating (Note 3)	-	2kV
Power Dissipation (Note 2)	Internally Limited	
Input Supply Voltage (Survival)	-0.3V	+7.5V
Shutdown Input Voltage (Survival)	-0.3V	V <sub>IN</sub> +0.3V
Output Voltage (Survival), (Note 6), (Note 7)	-0.3V	+7.5V
IOUT (Survival)	Short Circuit Protected	
Maximum Voltage for SENSE Pin	-	V <sub>OUT</sub> +0.3V

**Operating Ratings**

Condition	Min	Max
Input Supply Voltage (Operating)(Note 12)	2.5V	7.0V
Shutdown Input Voltage (Operating)	-0.3V	+0.3V
Maximum Operating Current (DC)	-	1.5A
Operating Junction Temp. Range	-40°C	+125°C

## Electrical Characteristics

Limits in standard typeface are for  $T_J = 25^{\circ}\text{C}$ , and limits in **boldface type** apply over the **full operating temperature range**. Unless otherwise specified:  $V_{IN} = V_{O(NOM)} + 1\text{V}$ ,  $I_L = 10\text{ mA}$ ,  $C_{OUT} = 33\mu\text{F}$ ,  $V_{SD} = V_{IN} - 0.3\text{V}$ .

Symbol	Parameter	Conditions	Typ (Note 4)	LP3965 (Note 5)		Units
				Min	Max	
$V_O$	Output Voltage Tolerance (Note 8)	$10\text{ mA} \leq I_L \leq 1.5\text{A}$ $V_{OUT} + 1 \leq V_{IN} \leq 7.0\text{V}$	0	-1.5 <b>-3.0</b>	+1.5 <b>+3.0</b>	%
$V_{ADJ}$	Adjust Pin Voltage (ADJ version)	$10\text{ mA} \leq I_L \leq 1.5\text{A}$ $V_{OUT} + 1.5\text{V} \leq V_{IN} \leq 7.0\text{V}$	1.216	1.198 <b>1.180</b>	1.234 <b>1.253</b>	V
$\Delta V_{OL}$	Output Voltage Line Regulation (Note 8)	$V_{OUT} + 1\text{V} < V_{IN} < 7.0\text{V}$ ,	0.02 0.06			%
$\Delta V_O / \Delta I_{OUT}$	Output Voltage Load Regulation (Note 8)	$10\text{ mA} < I_L < 1.5\text{ A}$	0.04 0.09			%
$V_{IN} - V_{OUT}$	Dropout Voltage (Note 10)	$I_L = 150\text{ mA}$	38		45 <b>55</b>	mV
		$I_L = 1.5\text{ A}$	380		450 <b>550</b>	
$I_{GND}$	Ground Pin Current In Normal Operation Mode	$I_L = 150\text{ mA}$	4		9 <b>10</b>	mA
		$I_L = 1.5\text{ A}$	5		14 <b>15</b>	
$I_{GND}$	Ground Pin Current In Shutdown Mode (Note 11)	$V_{SD} \leq 0.2\text{V}$	15		25 <b>75</b>	$\mu\text{A}$
$I_{O(PK)}$	Peak Output Current	(Note 2)	2.5	2.0 <b>1.7</b>		A
<b>SHORT CIRCUIT PROTECTION</b>						
$I_{SC}$	Short Circuit Current		4.5			A
<b>OVER TEMPERATURE PROTECTION</b>						
$T_{sh}(t)$	Shutdown Threshold		165			$^{\circ}\text{C}$
$T_{sh}(h)$	Thermal Shutdown Hysteresis		10			$^{\circ}\text{C}$
<b>SHUTDOWN INPUT</b>						
$V_{SDT}$	Shutdown Threshold	Output = High	$V_{IN}$	<b><math>V_{IN} - 0.3</math></b>		V
		Output = Low	0		<b>0.2</b>	

## Electrical Characteristics

Limits in standard typeface are for  $T_J = 25^\circ\text{C}$ , and limits in **boldface type** apply over the **full operating temperature range**. Unless otherwise specified:  $V_{IN} = V_{O(NOM)} + 1\text{V}$ ,  $I_L = 10\text{ mA}$ ,  $C_{OUT} = 33\mu\text{F}$ ,  $V_{SD} = V_{IN} - 0.3\text{V}$ .

Symbol	Parameter	Conditions	Typ (Note 4)	LP3965 (Note 5)		Units
				Min	Max	
$T_{dOFF}$	Turn-off delay	$I_L = 1.5\text{ A}$	20			$\mu\text{s}$
$T_{dON}$	Turn-on delay	$I_L = 1.5\text{ A}$	25			$\mu\text{s}$
$I_{SD}$	SD Input Current	$V_{SD} = V_{IN}$	1			nA
AC PARAMETERS						
PSRR	Ripple Rejection	$V_{IN} = V_{OUT} + 1.5\text{V}$ $C_{OUT} = 100\mu\text{F}$ $V_{OUT} = 3.3\text{V}$	60			dB
		$V_{IN} = V_{OUT} + 0.3\text{V}$ $C_{OUT} = 100\mu\text{F}$ $V_{OUT} = 3.3\text{V}$	40			
$p_n(f)$	Output Noise Density	$f = 120\text{Hz}$	0.8			$\mu\text{V}$
$e_n$	Output Noise Voltage	$\text{BW} = 10\text{Hz} - 100\text{kHz}$	150			$\mu\text{V (rms)}$
	(rms)	$\text{BW} = 300\text{Hz} - 300\text{kHz}$	100			

**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 does not guarantee specific performance limits. For guaranteed specifications and test conditions, see Electrical Characteristics. The guaranteed specifications apply only for the test conditions listed. Some performance characteristics may degrade when the device is not operated under the listed test conditions.

**Note 2:** At elevated temperatures, devices must be derated based on package thermal resistance. The devices in TO220 package must be derated at  $\theta_{JA} = 50^\circ\text{C/W}$  (with  $0.5\text{in}^2$ , 1oz. copper area), junction-to-ambient (with no heat sink). The devices in the TO263 surface-mount package must be derated at  $\theta_{JA} = 60^\circ\text{C/W}$  (with  $0.5\text{in}^2$ , 1oz. copper area), junction-to-ambient. The devices in SOT223 package must be derated at  $\theta_{JA} = 90^\circ\text{C/W}$  (with  $0.5\text{in}^2$ , 1oz. copper area), junction-to-ambient.

**Note 3:** The human body model is a  $100\text{pF}$  capacitor discharged through a  $1.5\text{k}\Omega$  resistor into each pin.

**Note 4:** Typical numbers are at  $25^\circ\text{C}$  and represent the most likely parametric norm.

**Note 5:** Limits are 100% production tested at  $25^\circ\text{C}$ . Limits over the operating temperature range are guaranteed through correlation using Statistical Quality Control (SQC) methods. The limits are used to calculate National's Average Outgoing Quality Level (AOQL).

**Note 6:** If used in a dual-supply system where the regulator load is returned to a negative supply, the LP396X output must be diode-clamped to ground.

**Note 7:** The output PMOS structure contains a diode between the  $V_{IN}$  and  $V_{OUT}$  terminals. This diode is normally reverse biased. This diode will get forward biased if the voltage at the output terminal is forced to be higher than the voltage at the input terminal. This diode can typically withstand  $200\text{mA}$  of DC current and  $1\text{Amp}$  of peak current.

**Note 8:** Output voltage line regulation is defined as the change in output voltage from the nominal value due to change in the input line voltage. Output voltage load regulation is defined as the change in output voltage from the nominal value due to change in load current. The line and load regulation specification contains only the typical number. However, the limits for line and load regulation are included in the output voltage tolerance specification.

**Note 9:** Dropout voltage is defined as the minimum input to output differential voltage at which the output drops 2% below the nominal value. Dropout voltage specification applies only to output voltages of  $2.5\text{V}$  and above. For output voltages below  $2.5\text{V}$ , the drop-out voltage is nothing but the input to output differential, since the minimum input voltage is  $2.5\text{V}$ .

**Note 10:** This specification has been tested for  $-40^\circ\text{C} \leq T_J \leq 85^\circ\text{C}$  since the temperature rise of the device is negligible under shutdown conditions.

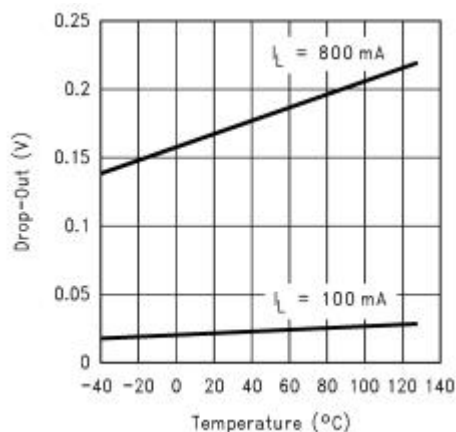
**Note 12:** The minimum operating value for  $V_{IN}$  is equal to either  $[V_{OUT(NOM)} + V_{DROPOUT}]$  or  $2.5\text{V}$ , whichever is greater.



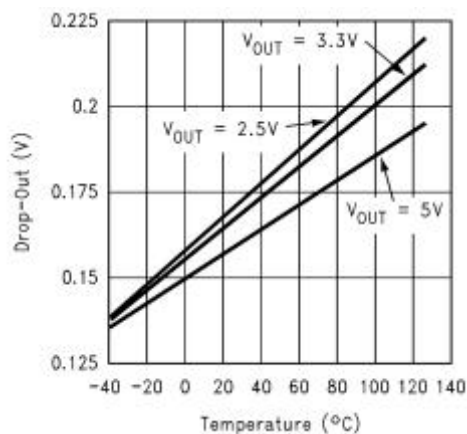
## Typical Performance Characteristics

Unless otherwise specified,  $V_{IN} = V_{O(NOM)} + 1V$ ,  $V_{OUT} = 2.5V$ ,  $C_{OUT} = 33\mu F$ ,  $I_{OUT} = 10mA$ ,  $C_{IN} = 68\mu F$ ,  $V_{SD} = V_{IN}$ , and  $T_A = 25^\circ C$ .

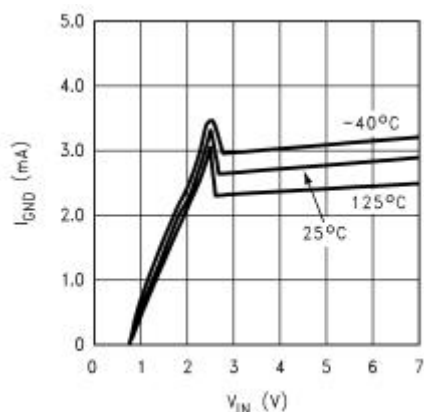
Drop-Out Voltage vs Temperature for Different Load Currents



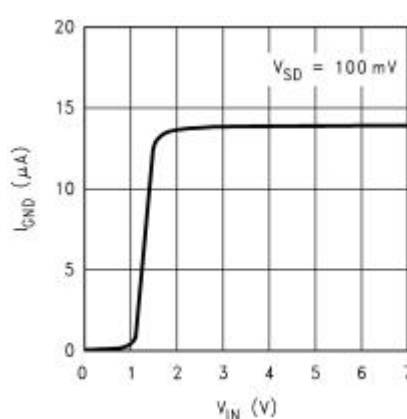
Drop-Out Voltage vs Temperature for Different Output Voltages ( $I_{OUT} = 800mA$ )



Ground Pin Current vs Input Voltage ( $V_{SD} = V_{IN}$ )



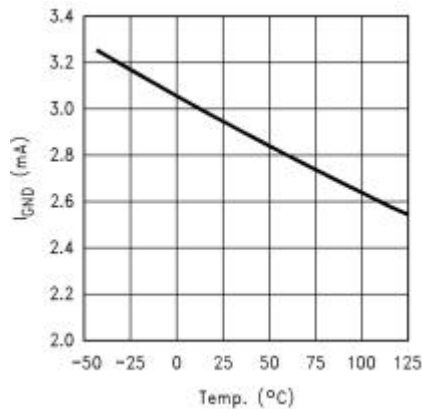
Ground Pin Current vs Input Voltage ( $V_{SD} = 100mV$ )



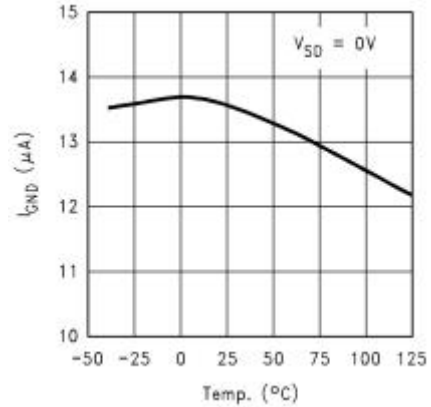
## Typical Performance Characteristics

Unless otherwise specified,  $V_{IN} = V_{O(NOM)} + 1V$ ,  $V_{OUT} = 2.5V$ ,  $C_{OUT} = 33\mu F$ ,  $I_{OUT} = 10mA$ ,  $C_{IN} = 68\mu F$ ,  $V_{SD} = V_{IN}$ , and  $T_A = 25^\circ C$ . (Continued)

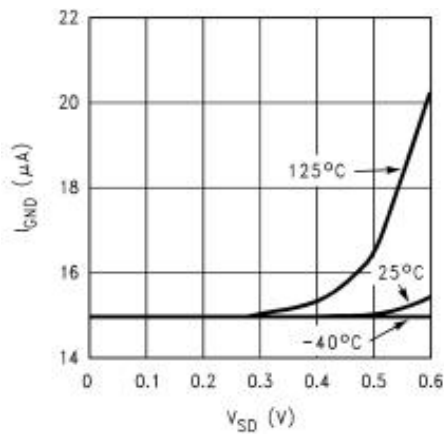
Ground Current vs Temperature ( $V_{SD} = V_{IN}$ )



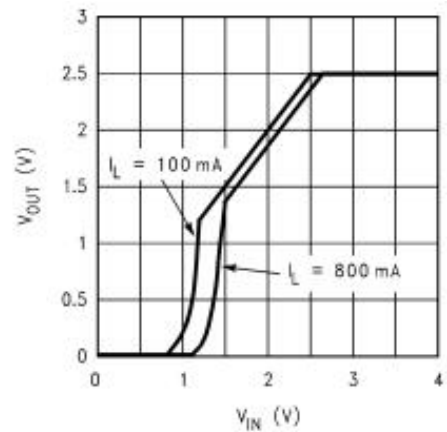
Ground Current vs Temperature ( $V_{SD} = 0V$ )



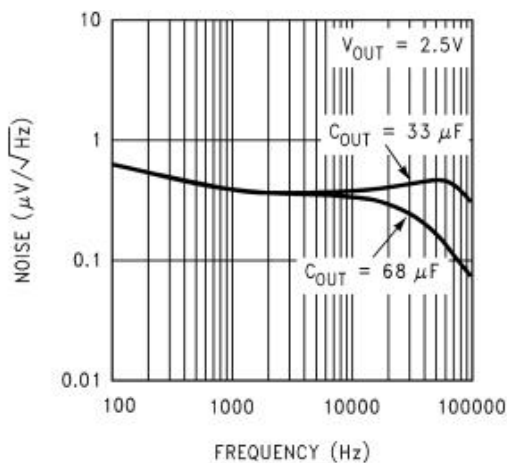
Ground Pin Current vs Shutdown Pin Voltag



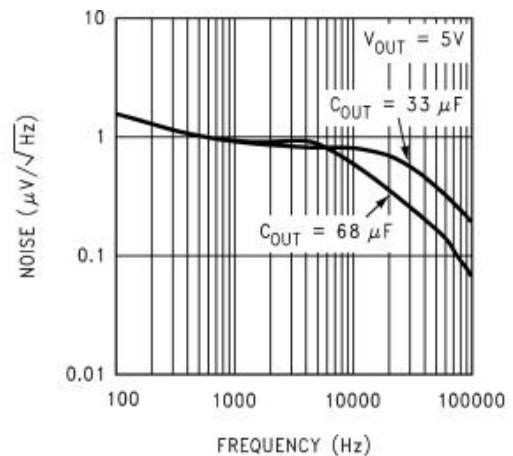
Input Voltage vs Output Voltage



Output Noise Density,  $V_{OUT} = 2.5V$



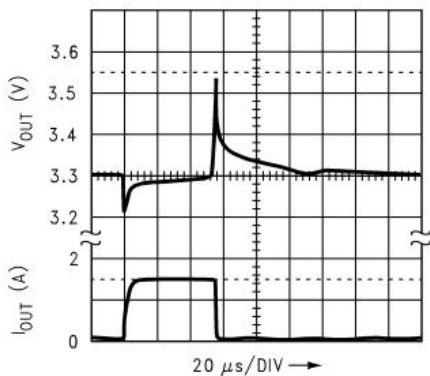
Output Noise Density,  $V_{OUT} = 5V$



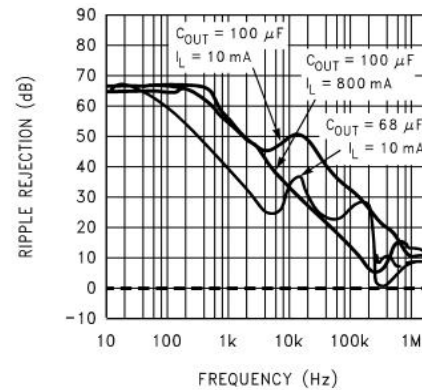
## Typical Performance Characteristics

Unless otherwise specified,  $V_{IN} = V_{O(NOM)} + 1V$ ,  $V_{OUT} = 2.5V$ ,  $C_{OUT} = 33\mu F$ ,  $I_{OUT} = 10mA$ ,  $C_{IN} = 68\mu F$ ,  $V_{SD} = V_{IN}$ , and  $T_A = 25^\circ C$ . (Continued)

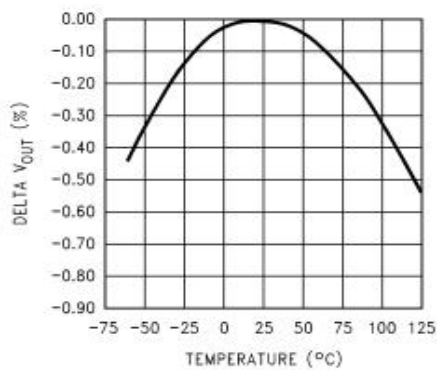
Load Transient Response



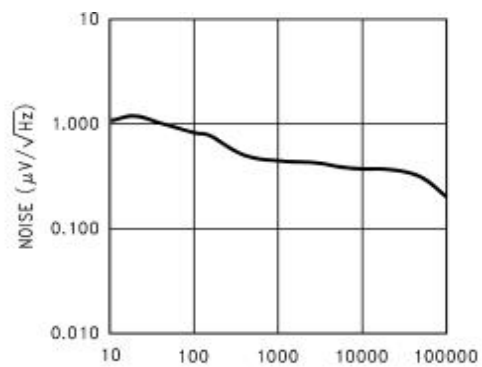
Ripple Rejection vs Frequency



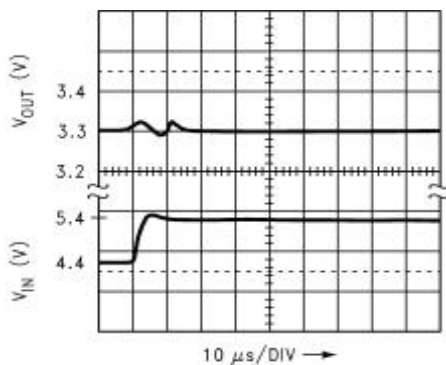
$\Delta V_{OUT}$  vs Temperature



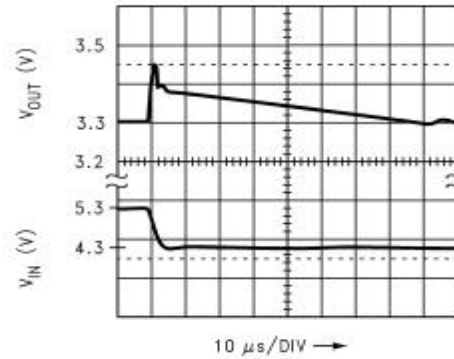
Noise Density  $V_{IN} = 3.5V$ ,  $V_{OUT} = 2.5V$ ,  $I_L = 10mA$



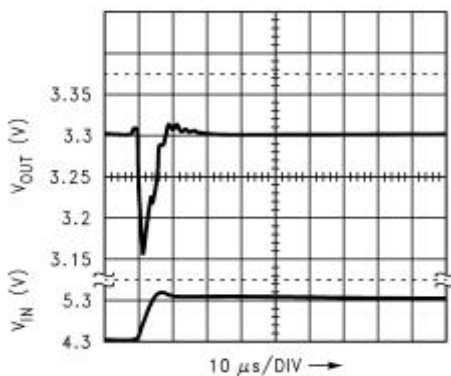
Line Transient Response



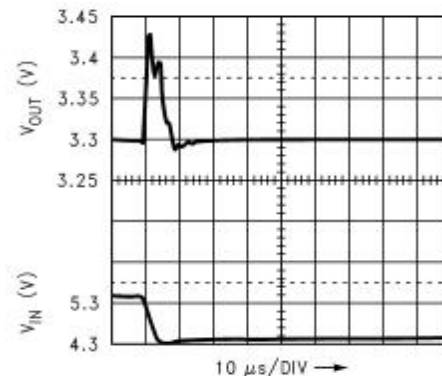
Line Transient Response



Line Transient Response ( $I_{OUT} = 1.5A$ )

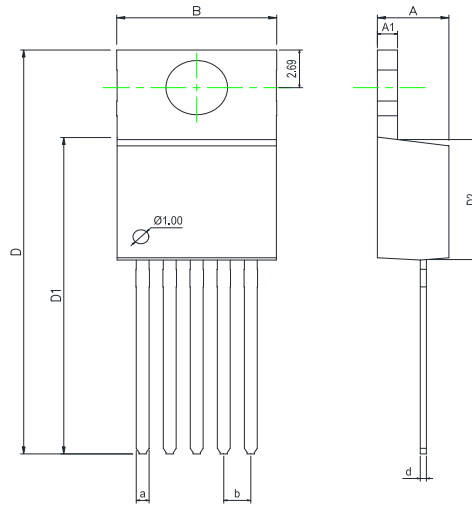


Line Transient Response ( $I_{OUT} = 1.5A$ )



## Physical Dimensions

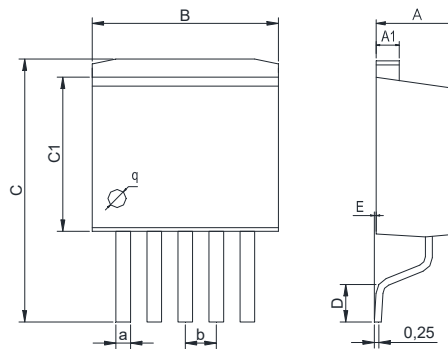
### TO-220-5



**Dimensions In Millimeters(TO-220-5)**

Symbol:	A	A1	B	D	D1	D2	a	d	b
Min:	4.52	1.25	10	28.2	22.4	8.69	0.71	0.33	1.70BSC
Max:	4.62	1.29	10.3	28.9	22.6	8.79	0.97	0.42	

### TO-263-5



**Dimensions In Millimeters(TO-263-5)**

Symbol:	A	A1	B	C	C1	D	E	a	b
Min:	4.45	1.22	10	13.7	8.40	1.90	0	0.71	1.70BSC
Max:	4.62	1.32	10.4	14.6	8.90	2.10	0.20	0.97	

## Revision History

DATE	REVISION	PAGE
2014-6-10	New	1-14
2023-7-24	Modify the package dimension diagram TO-220-5、 Update encapsulation type 、 Update Lead Temperature	12、 1、 6

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