

## Low Dropout, Low IQ, 500mA CMOS Linear Regulator

Check for Samples: [LP8345](#)

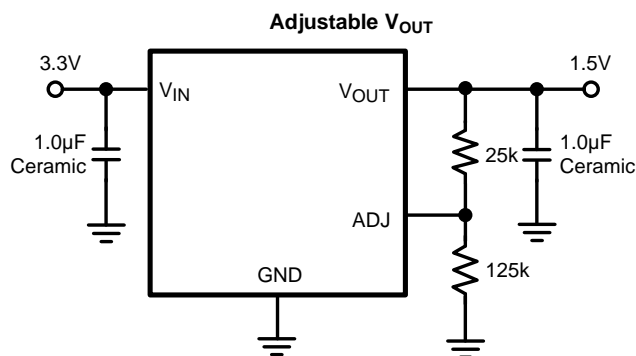
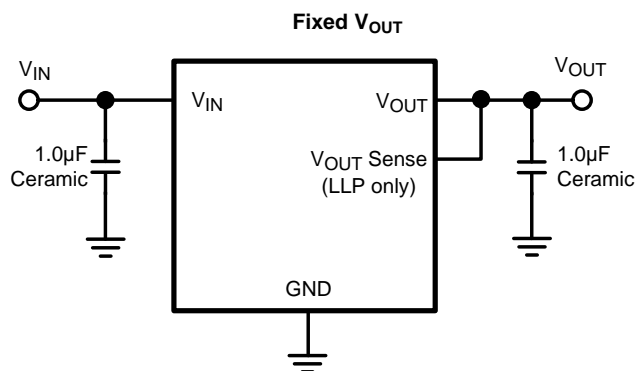
### FEATURES

- $\pm 1.5\%$  Typical  $V_{OUT}$  Tolerance
- 210mV Typical Dropout @ 500mA ( $V_O = 5V$ )
- Wide Operating Range 2.7V to 10V
- Internal 500mA PMOS Output Transistor
- 19 $\mu$ A Typical Quiescent Current
- Thermal Overload Limiting
- Foldback Current Limiting
- Zener Trimmed Bandgap Reference
- Space Saving WSON package
- Temperature Range
  - LP8345C 0°C to 125°C
  - LP8345I –40°C to 125°C

### APPLICATIONS

- Hard Disk Drives
- Notebook Computers
- Battery Powered Electronics
- Portable Instrumentation

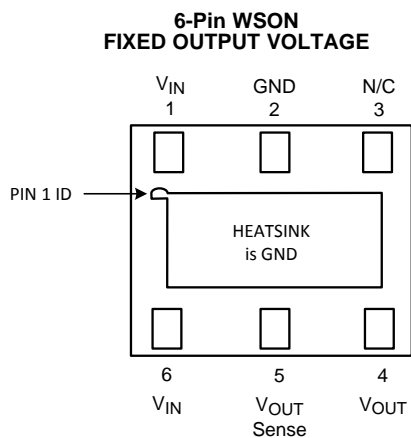
### TYPICAL APPLICATIONS



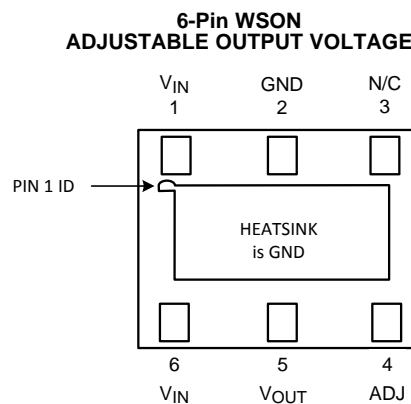
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## CONNECTION DIAGRAMS



**Figure 1. Bottom View**

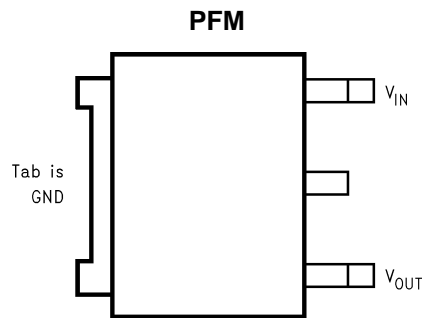


**Figure 2. Bottom View**

### NOTE

$V_{IN}$  Pins (Pin 1 & 6) must be connected together externally for full 500mA operation (250mA max per pin).

$V_{OUT}$  Sense (Pin 5) must be connected to  $V_{OUT}$  (Pin 4).



**Figure 3. Top View**



These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

## ABSOLUTE MAXIMUM RATINGS<sup>(1) (2)(3)</sup>

$V_{IN}$ , $V_{OUT}$ , $V_{OUT}$ Sense, ADJ		–0.3V to 12V
Storage Temperature Range		–65°C to 160°C
Junction Temperature ( $T_J$ )		150°C
Power Dissipation		<sup>(4)</sup>
ESD Rating	Human Body Model <sup>(5)</sup>	2kV
	Machine Model	200V

- (1) Absolute Maximum ratings indicate limits beyond which damage may occur. Electrical specifications do not apply when operating the device outside of its rated operating conditions.
- (2) All voltages are with respect to the potential at the ground pin.
- (3) If Military/Aerospace specified devices are required, please contact the Texas Instruments Sales Office/Distributors for availability and specifications.

- (4) Maximum Power dissipation for the device is calculated using the following equations:  $P_D = \frac{T_{J(MAX)} - T_A}{\theta_{JA}}$  where  $T_{J(MAX)}$  is the maximum junction temperature,  $T_A$  is the ambient temperature, and  $\theta_{JA}$  is the junction-to-ambient thermal resistance. The value of the  $\theta_{JA}$  for the WSON package is specifically dependant on the PCB trace area, trace material, and the number of layers and thermal vias. For improved thermal resistance and power dissipation for the WSON package, refer to Application Note AN-1187 (literature number [SNOA401](#)).
- (5) Human body model 1.5k $\Omega$  in series with 100pF.

## OPERATING RATINGS<sup>(1) (2)</sup>

Supply Voltage		2.7 to 10V
Temperature Range	LP8345C	0°C to 125°C
	LP8345I	–40°C to 125°C

- (1) Absolute Maximum ratings indicate limits beyond which damage may occur. Electrical specifications do not apply when operating the device outside of its rated operating conditions.
- (2) All voltages are with respect to the potential at the ground pin.

## LP8345C ELECTRICAL CHARACTERISTICS

Unless otherwise specified all limits specified for  $V_{IN} = V_O + 1V$ ,  $C_{IN} = C_{OUT} = 10\mu F$ ,  $T_J = 25^\circ C$ . **Boldface** limits apply over the full operating temperature range of  $T_J = 0^\circ C$  to  $125^\circ C$

Symbol	Parameter	Conditions	Min <sup>(1)</sup>	Typ <sup>(2)</sup>	Max <sup>(1)</sup>	Units
$V_{IN}$	Input Voltage	LP8345-ADJ, 1.8, 2.5 LP8345-3.3, 5.0	<b>2.7</b>		<b>10</b> <b>10</b>	V
$V_{OUT}$	Output Voltage	LP8345-ADJ, ADJ = OUT $I_{OUT} = 10mA$ , $V_{IN} = 2.7V$ , $T_J = 25^\circ C$ $100\mu A \leq I_{OUT} \leq 500mA$ , $2.7V \leq V_{IN} \leq V_{OUT} + 4V$	1.231 <b>1.213</b>	1.250	1.269 <b>1.288</b>	V
		LP8345-1.8 $I_{OUT} = 10mA$ , $V_{IN} = 2.8V$ , $T_J = 25^\circ C$ $100\mu A \leq I_{OUT} \leq 500mA$ , $2.8V \leq V_{IN} \leq 6V$	1.773 <b>1.746</b>	1.800	1.827 <b>1.854</b>	V
		LP8345-2.5 $I_{OUT} = 10mA$ , $V_{IN} = 3.5V$ , $T_J = 25^\circ C$ $100\mu A \leq I_{OUT} \leq 500mA$ , $3.5V \leq V_{IN} \leq 6.5V$	2.463 <b>2.425</b>	2.500	2.538 <b>2.575</b>	V
		LP8345-3.3 $I_{OUT} = 10mA$ , $V_{IN} = 4.3V$ , $T_J = 25^\circ C$ $100\mu A \leq I_{OUT} \leq 500mA$ , $4.3V \leq V_{IN} \leq 7.5V$	3.250 <b>3.201</b>	3.300	3.350 <b>3.399</b>	V
		LP8345-5.0 $I_{OUT} = 10mA$ , $V_{IN} = 6V$ , $T_J = 25^\circ C$ $100\mu A \leq I_{OUT} \leq 500mA$ , $6V \leq V_{IN} \leq 9V$	4.925 <b>4.850</b>	5.000	5.075 <b>5.150</b>	V

- (1) All limits are specified by testing or statistical analysis.
- (2) Typical Values represent the most likely parametric norm.

## LP8345C ELECTRICAL CHARACTERISTICS (continued)

Unless otherwise specified all limits specified for  $V_{IN} = V_O + 1V$ ,  $C_{IN} = C_{OUT} = 10\mu F$ ,  $T_J = 25^\circ C$ . **Boldface** limits apply over the full operating temperature range of  $T_J = 0^\circ C$  to  $125^\circ C$

Symbol	Parameter	Conditions	Min <sup>(1)</sup>	Typ <sup>(2)</sup>	Max <sup>(1)</sup>	Units
$\Delta V_O$	Load Regulation	LP8345-ADJ, ADJ=OUT $I_{OUT} = 1mA$ to $500mA$ , $V_{IN} = 2.7V$		6	<b>20</b>	mV
		LP8345-1.8 $I_{OUT} = 1mA$ to $500mA$ , $V_{IN} = 2.8V$		7	<b>20</b>	
		LP8345-2.5 $I_{OUT} = 1mA$ to $500mA$ , $V_{IN} = 3.5V$		9	<b>30</b>	
		LP8345-3.3 $I_{OUT} = 1mA$ to $500mA$ , $V_{IN} = 4.3V$		12	<b>35</b>	
		LP8345-5.0 $I_{OUT} = 1mA$ to $500mA$ , $V_{IN} = 6V$		14	<b>40</b>	
$\Delta V_O$	Line Regulation	$V_{OUT} + 0.5V \leq V_{IN} \leq 10V$ , $I_{OUT} = 25mA$ <sup>(3)</sup>		4	<b>15</b>	mV
$V_{IN} - V_O$	Dropout Voltage <sup>(3) (4)</sup>	LP8345-2.5 $I_{OUT} = 500mA$		335	<b>650</b>	mV
		LP8345-3.3 LP8345-ADJ, $V_{OUT} = 3.3V$ , $I_{OUT} = 500mA$		270	<b>500</b>	
		LP8345-5.0 $I_{OUT} = 500mA$		210	<b>400</b>	
$I_Q$	Quiescent Current	$V_{IN} \leq 10V$		19	<b>50</b>	$\mu A$
	Minimum Load Current	$V_{IN} - V_{OUT} \leq 4V$			<b>100</b>	$\mu A$
$I_{LIMIT}$	Foldback Current Limit	$V_{IN} - V_{OUT} > 5V$		450		mA
		$V_{IN} - V_{OUT} < 4V$		1200		
	Ripple Rejection Ratio	$V_{IN} (dc) = V_{OUT} + 2V$ $V_{IN} (ac) = 1V_{P-P}$ @ 120Hz	<b>48</b>	55		dB
$T_{SD}$	Thermal Shutdown Temp.			160		$^\circ C$
	Thermal Shutdown Hyst.			10		
	ADJ Input Leakage Current	$V_{ADJ} = 1.5V$ or $0V$		$\pm 0.01$	$\pm 100$	nA
	$V_{OUT}$ Leakage Current	LP8345-ADJ ADJ = OUT, $V_{OUT} = 2V$ , $V_{IN} = 10V$			10	$\mu A$
		LP8345-1.8, $V_{OUT} = 2.5V$ , $V_{IN} = 10V$			10	
		LP8345-2.5, $V_{OUT} = 3.5V$ , $V_{IN} = 10V$			10	
		LP8345-3.3, $V_{OUT} = 4V$ , $V_{IN} = 10V$			10	
		LP8345-5.0, $V_{OUT} = 6V$ , $V_{IN} = 10V$			10	
$e_n$	Output Noise	10Hz to 10kHz, $R_L = 1k\Omega$ , $C_{OUT} = 10\mu F$		250		$\mu V_{rms}$

(3) Condition does not apply to input voltages below 2.7V since this is the minimum input operating voltage.

(4) Dropout voltage is measured by reducing  $V_{IN}$  until  $V_O$  drops 100mV from its normal value.

## LP8345I ELECTRICAL CHARACTERISTICS

Unless otherwise specified all limits specified for  $V_{IN} = V_O + 1V$ ,  $C_{IN} = C_{OUT} = 10\mu F$ ,  $T_J = 25^\circ C$ . **Boldface** limits apply over the full operating temperature range of  $T_J = -40^\circ C$  to  $125^\circ C$

Symbol	Parameter	Conditions	Min <sup>(1)</sup>	Typ <sup>(2)</sup>	Max <sup>(1)</sup>	Units
$V_{IN}$	Input Voltage	LP8345-ADJ, 1.8, 2.5 LP8345-3.3, 5.0	<b>2.7</b>		<b>10</b> <b>10</b>	V

(1) All limits are specified by testing or statistical analysis.

(2) Typical Values represent the most likely parametric norm.

**LP8345 ELECTRICAL CHARACTERISTICS (continued)**

Unless otherwise specified all limits specified for  $V_{IN} = V_O + 1V$ ,  $C_{IN} = C_{OUT} = 10\mu F$ ,  $T_J = 25^\circ C$ . **Boldface** limits apply over the full operating temperature range of  $T_J = -40^\circ C$  to  $125^\circ C$

Symbol	Parameter	Conditions	Min <sup>(1)</sup>	Typ <sup>(2)</sup>	Max <sup>(1)</sup>	Units
$V_{OUT}$	Output Voltage	LP8345-ADJ, ADJ = OUT $I_{OUT} = 10mA$ , $V_{IN} = 2.7V$ , $T_J = 25^\circ C$ $100\mu A \leq I_{OUT} \leq 500mA$ , $2.7V \leq V_{IN} \leq V_{OUT} + 4V$	1.231 <b>1.213</b>	1.250	1.269 <b>1.288</b>	V
		LP8345-1.8 $I_{OUT} = 10mA$ , $V_{IN} = 2.8V$ , $T_J = 25^\circ C$ $100\mu A \leq I_{OUT} \leq 500mA$ , $2.8V \leq V_{IN} \leq 6V$	1.773 <b>1.746</b>	1.800	1.827 <b>1.854</b>	V
		LP8345-2.5 $I_{OUT} = 10mA$ , $V_{IN} = 3.5V$ , $T_J = 25^\circ C$ $100\mu A \leq I_{OUT} \leq 500mA$ , $3.5V \leq V_{IN} \leq 6.5V$	2.463 <b>2.425</b>	2.500	2.538 <b>2.575</b>	V
		LP8345-3.3 $I_{OUT} = 10mA$ , $V_{IN} = 4.3V$ , $T_J = 25^\circ C$ $100\mu A \leq I_{OUT} \leq 500mA$ , $4.3V \leq V_{IN} \leq 7.5V$	3.250 <b>3.201</b>	3.300	3.350 <b>3.399</b>	V
		LP8345-5.0 $I_{OUT} = 10mA$ , $V_{IN} = 6V$ , $T_J = 25^\circ C$ $100\mu A \leq I_{OUT} \leq 500mA$ , $6V \leq V_{IN} \leq 9V$	4.925 <b>4.850</b>	5.000	5.075 <b>5.150</b>	V
$\Delta V_O$	Load Regulation	LP8345-ADJ, ADJ=OUT $I_{OUT} = 1mA$ to $500mA$ , $V_{IN} = 2.7V$		6	<b>20</b>	mV
		LP8345-1.8 $I_{OUT} = 1mA$ to $500mA$ , $V_{IN} = 2.8V$		7	<b>20</b>	
		LP8345-2.5 $I_{OUT} = 1mA$ to $500mA$ , $V_{IN} = 3.5V$		9	<b>30</b>	
		LP8345-3.3 $I_{OUT} = 1mA$ to $500mA$ , $V_{IN} = 4.3V$		12	<b>35</b>	
		LP8345-5.0 $I_{OUT} = 1mA$ to $500mA$ , $V_{IN} = 6V$		14	<b>40</b>	
$\Delta V_O$	Line Regulation	$V_{OUT} + 0.5V \leq V_{IN} \leq 10V$ , $I_{OUT} = 25mA$ (3)		4	<b>15</b>	mV
$V_{IN} - V_O$	Dropout Voltage (3) (4)	LP8345-2.5 $I_{OUT} = 500mA$		335	<b>650</b>	mV
		LP8345-3.3 LP8345-ADJ, $V_{OUT} = 3.3V$ , $I_{OUT} = 500mA$		270	<b>500</b>	
		LP8345-5.0 $I_{OUT} = 500mA$		210	<b>400</b>	
$I_Q$	Quiescent Current	$V_{IN} \leq 10V$		19	<b>50</b>	$\mu A$
	Minimum Load Current	$V_{IN} - V_{OUT} \leq 4V$			<b>100</b>	$\mu A$
$I_{LIMIT}$	Foldback Current Limit	$V_{IN} - V_{OUT} > 5V$		450		mA
		$V_{IN} - V_{OUT} < 4V$		1200		
	Ripple Rejection Ratio	$V_{IN} (dc) = V_{OUT} + 2V$ $V_{IN} (ac) = 1V_{P-P}$ @ 120Hz	<b>48</b>	55		dB
$T_{SD}$	Thermal Shutdown Temp. Thermal Shutdown Hyst.			160 10		$^\circ C$
	ADJ Input Leakage Current	$V_{ADJ} = 1.5V$ or $0V$		$\pm 0.01$	$\pm 100$	nA
	$V_{OUT}$ Leakage Current	LP8345-ADJ ADJ = OUT, $V_{OUT} = 2V$ , $V_{IN} = 10V$			10	$\mu A$
		LP8345-1.8, $V_{OUT} = 2.5V$ , $V_{IN} = 10V$			10	
		LP8345-2.5, $V_{OUT} = 3.5V$ , $V_{IN} = 10V$			10	
		LP8345-3.3, $V_{OUT} = 4V$ , $V_{IN} = 10V$			10	
		LP8345-5.0, $V_{OUT} = 6V$ , $V_{IN} = 10V$			10	
$e_n$	Output Noise	10Hz to 10kHz, $R_L = 1k\Omega$ , $C_{OUT} = 10\mu F$		250		$\mu V_{rms}$

(3) Condition does not apply to input voltages below 2.7V since this is the minimum input operating voltage.

(4) Dropout voltage is measured by reducing  $V_{IN}$  until  $V_O$  drops 100mV from its normal value.

## TYPICAL PERFORMANCE CHARACTERISTICS

Unless otherwise specified,  $V_{IN} = V_O + 1.5V$ ,  $C_{IN} = C_{OUT} = 10\mu F$  X7R ceramic,  $T_J = 25^\circ C$

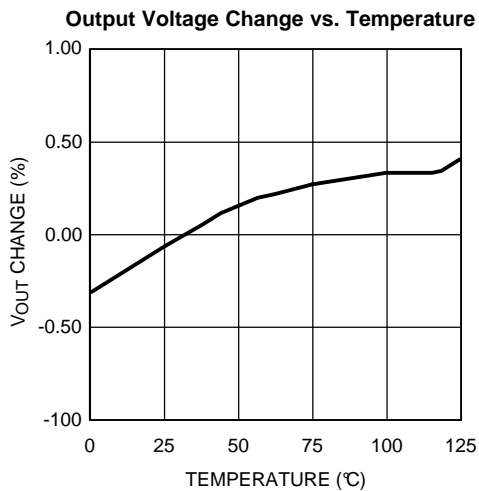


Figure 4.

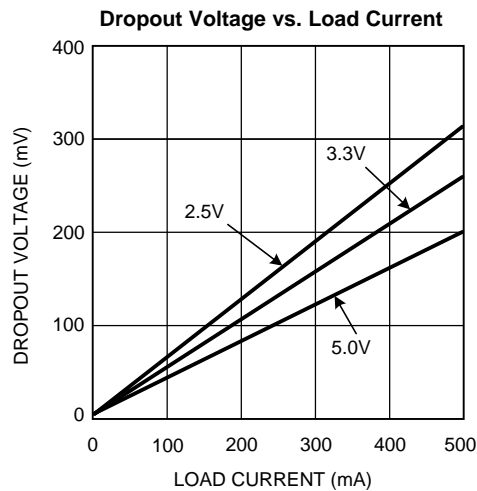


Figure 5.

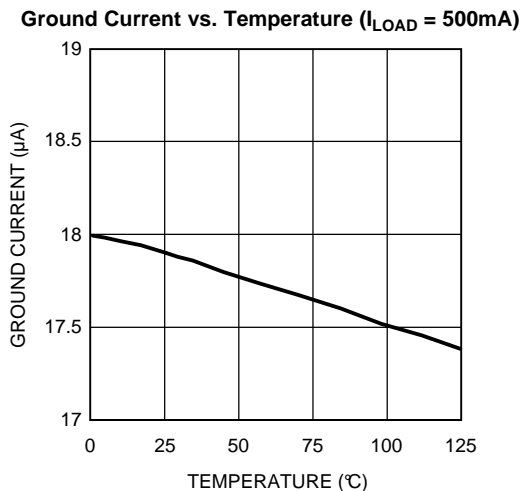


Figure 6.

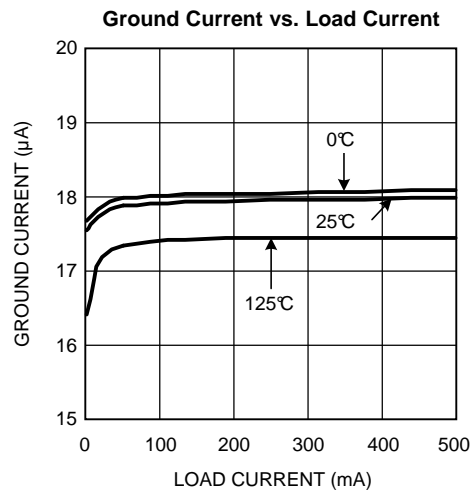


Figure 7.

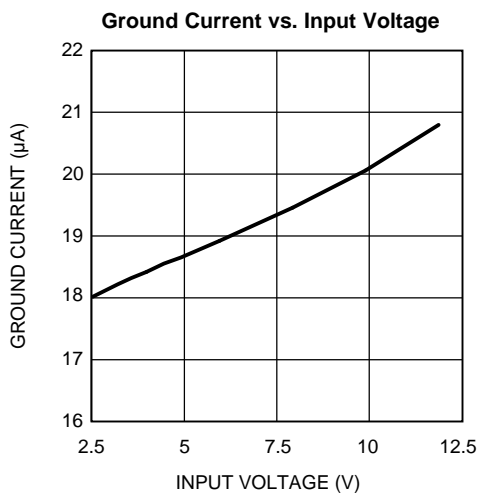


Figure 8.

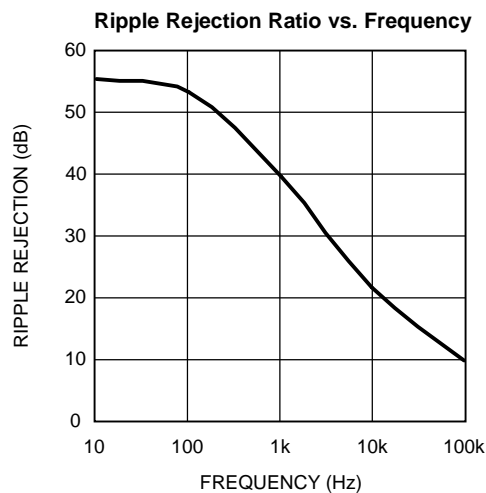
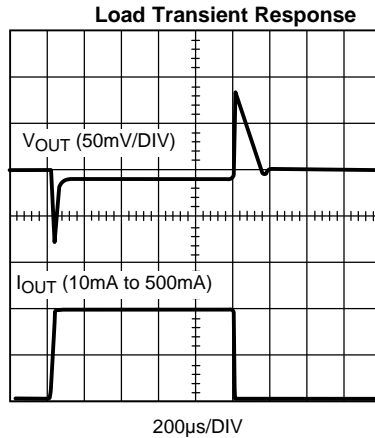


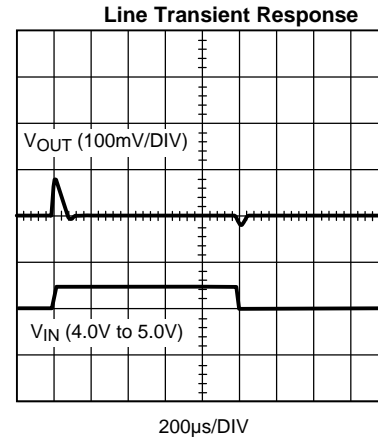
Figure 9.

## TYPICAL PERFORMANCE CHARACTERISTICS (continued)

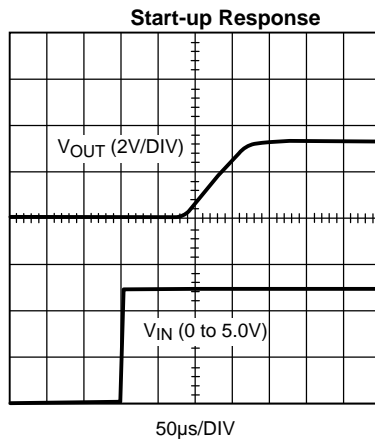
Unless otherwise specified,  $V_{IN} = V_O + 1.5V$ ,  $C_{IN} = C_{OUT} = 10\mu F$  X7R ceramic,  $T_J = 25^\circ C$



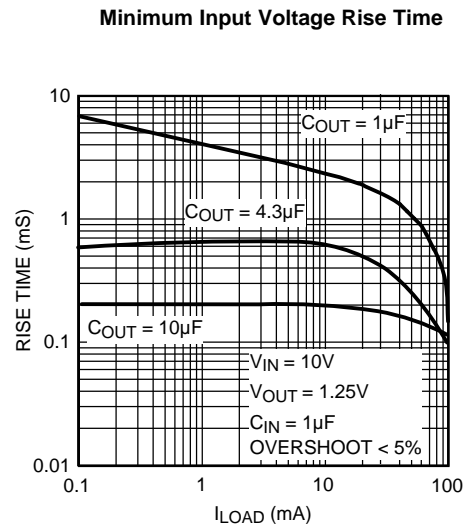
**Figure 10.**



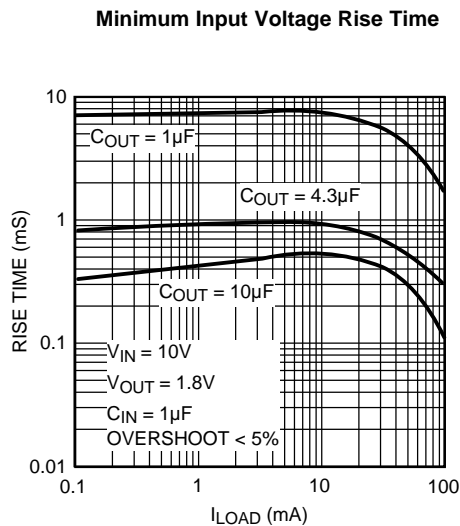
**Figure 11.**



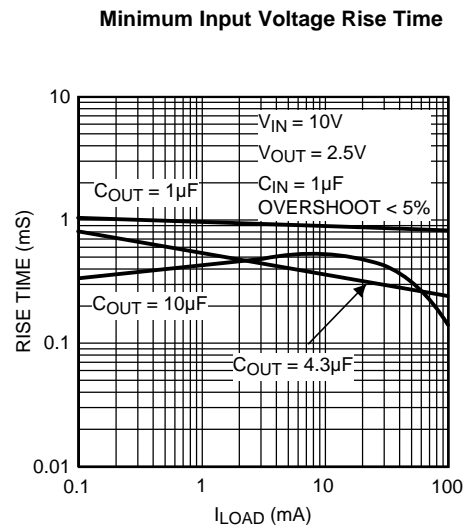
**Figure 12.**



**Figure 13.**



**Figure 14.**

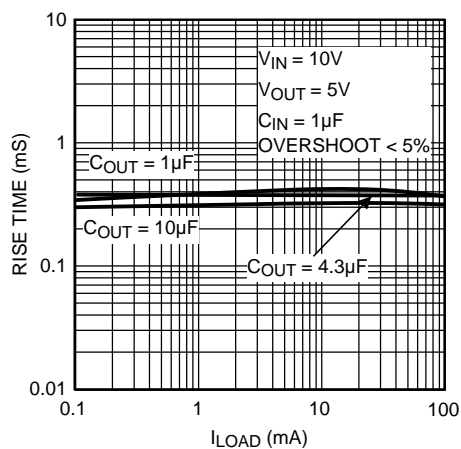


**Figure 15.**

## TYPICAL PERFORMANCE CHARACTERISTICS (continued)

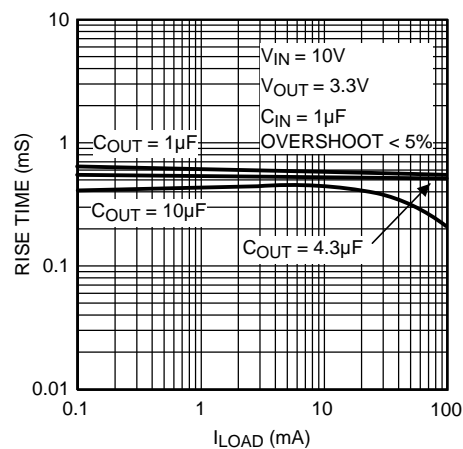
Unless otherwise specified,  $V_{IN} = V_O + 1.5V$ ,  $C_{IN} = C_{OUT} = 10\mu F$  X7R ceramic,  $T_J = 25^\circ C$

**Minimum Input Voltage Rise Time**



**Figure 16.**

**Minimum Input Voltage Rise Time**



**Figure 17.**



## APPLICATIONS SECTION

### GENERAL INFORMATION

The LP8345 is a low-dropout, low quiescent current linear regulator. As shown in Figure 18 it consists of a 1.25V reference, error amplifier, MOSFET driver, PMOS pass transistor and for the fixed output versions, an internal feedback network ( $R_1/R_2$ ). In addition, the device is protected from overload by a thermal shutdown circuit and a foldback current limit circuit.

The 1.25V reference is connected to the inverting input of the error amplifier. Regulation of the output voltage is achieved by means of negative feedback to the non-inverting input of the error amplifier. Feedback resistors  $R_1$  and  $R_2$  are either internal or external to the device, depending on whether it is a fixed voltage version or the adjustable version. The negative feedback and high open loop gain of the error amplifier cause the two inputs of the error amp to be virtually equal in voltage. If the output voltage changes due to load changes, the error amplifier and MOSFET driver provide the appropriate drive to the pass transistor to maintain the error amplifier's inputs as virtually equal.

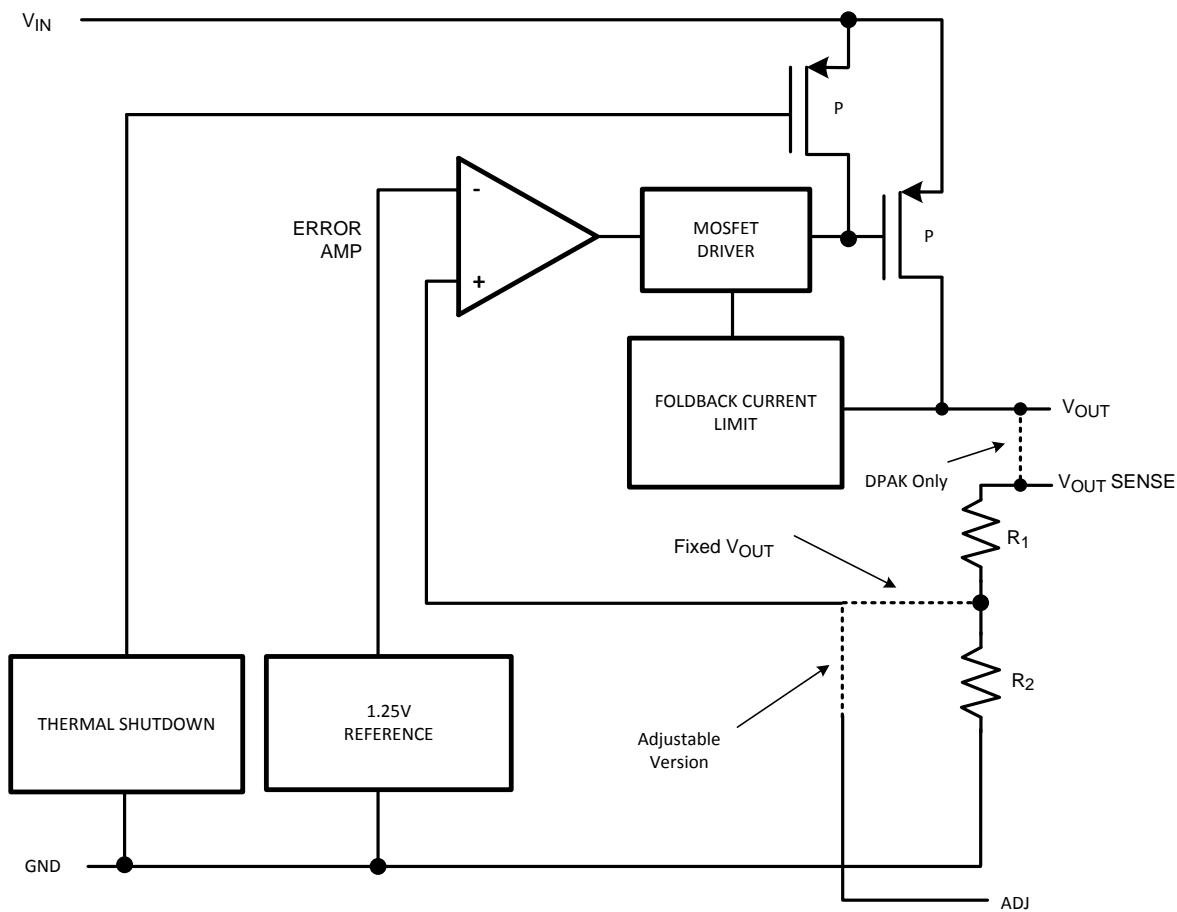


Figure 18. LP8345 Functional Block Diagram

### EXTERNAL CAPACITOR

An input capacitor of 1 $\mu$ F or greater is required between the LP8345  $V_{IN}$  pin and ground. While 1 $\mu$ F will provide adequate bypassing of the  $V_{IN}$  supply larger values of input capacitor (i.e. 10 $\mu$ F) can provide improved bypassing of power supply noise.

Stable operation can be achieved with an output capacitor of 1µF or greater, either ceramic X7R dielectric or aluminum/tantalum electrolytic. While the minimum capacitor value is 1µF, the typical output capacitor values selected range from 1µF to 10µF. The larger values provide improved load-transient response, power supply rejection and stability.

## OUTPUT VOLTAGE SETTING (ADJ VERSION ONLY)

The output voltage is set according to the amount of negative feedback (Note that the pass transistor inverts the feedback signal). This feedback is determined by  $R_1$  and  $R_2$  with the resulting output voltage represented by the following equation:

$$V_O = V_{REF} \left[ \frac{R_1}{R_2} + 1 \right] \quad (1)$$

Use the following equation to determine the values of  $R_1$  and  $R_2$  for a desired  $V_{OUT}$  ( $R_2 = 100k\Omega$  is recommended).

$$R_1 = R_2 \left[ \frac{V_O}{1.25} - 1 \right] \quad (2)$$

## MINIMUM LOAD CURRENT

A minimum load of 100µA is required for regulation and stability over the entire operating temperature range. If actual load current fall below 100µA it is recommended that a resistor of value  $R_L = V_O/100\mu A$  be placed between  $V_O$  and ground.

## START UP CONSIDERATIONS

Under certain operating conditions, overshoot of  $V_{OUT}$  at start-up can occur. The observed overshoot is a function of rise time of  $V_{IN}$  waveform,  $C_{OUT}$ , start-up load current, and  $V_{IN}-V_{OUT}$  differential. The relationship between these conditions is shown in the Typical Performance Characteristics curves (Minimum Input Voltage Rise Time).  $V_{IN}$  rise times above the curve result in <5% overshoot.

Customers are encouraged to check the suitability of LP8345 in their specific application.

## REVISION HISTORY

### Changes from Revision E (April 2013) to Revision F

**Page**

- Changed layout of National Data Sheet to TI format ..... [10](#)

## IMPORTANT NOTICE

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