

LM333 3-Ampere Adjustable Negative Regulator

Check for Samples: [LM333](#)

FEATURES

- Output Voltage Adjustable from -1.2V to -32V
- 3.0A Output Current Specified, -40°C to $+125^{\circ}\text{C}$
- Line Regulation Typically $0.01\%/V$
- Load Regulation Typically 0.2%
- Excellent Rejection of Thermal Transients
- $50\text{ ppm}/^{\circ}\text{C}$ Temperature Coefficient
- Temperature-Independent Current Limit
- Internal Thermal Overload Protection
- Standard 3-Lead Transistor Package
- Output is Short Circuit Protected

DESCRIPTION

The LM333 is an adjustable 3-terminal negative voltage regulator capable of supplying in excess of -3.0A over an output voltage range of -1.2V to -32V . This regulator is exceptionally easy to apply, requiring only 2 external resistors to set the output voltage and 1 output capacitor for frequency compensation. The circuit design has been optimized for excellent regulation and low thermal transients. Further, the LM333 features internal current limiting, thermal shutdown and safe-area compensation, making them substantially immune to failure from overloads.

The LM333 serves a wide variety of applications including local on-card regulation, programmable-output voltage regulation or precision current regulation. The LM333 is an ideal complement to the LM150/LM350 adjustable positive regulators.

Connection Diagram

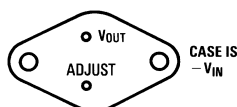


Figure 1. TO-3 Package - Bottom View
Steel TO-3 Package (NDS STEEL)
 See Package Number NDS0002A

Typical Application

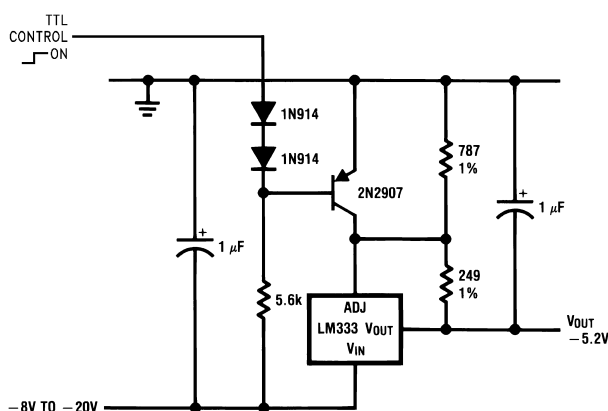


Figure 2. -5.2V Regulator with Electronic Shutdown



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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⁽¹⁾⁽²⁾

Power Dissipation		Internally Limited
Input-Output Voltage Differential		35V
Operating Junction Temperature Range T_{MIN} to T_{MAX}	LM333	-40°C to +125°C
Storage Temperature		-65°C to +150°C
Lead Temperature (Soldering, 10 sec.)	TO-3 Package	300°C
ESD Susceptibility		TBD

(1) Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Electrical specifications do not apply when operating the device outside of its stated operating conditions.

(2) If Military/Aerospace specified devices are required, please contact the TI Sales Office/ Distributors for availability and specifications.

ELECTRICAL CHARACTERISTICS LM333

Specifications with standard typeface are for $T_J = 25^\circ\text{C}$, and those with **boldface type** apply over the full operating temperature range.⁽¹⁾

Parameter	Conditions	Typical	Min ⁽²⁾	Max ⁽²⁾	Units
Reference Voltage	$I_L = 10\text{ mA}$	-1.250	-1.225	-1.275	V
	$3\text{V} \leq V_{IN} - V_{OUT} \leq 35\text{V}$ $10\text{ mA} \leq I_L \leq 3\text{A}$, $P \leq P_{MAX}$	-1.250	-1.213	-1.287	
Line Regulation	$3\text{V} \leq V_{IN} - V_{OUT} \leq 35\text{V}$ $I_{OUT} = 50\text{ mA}$ ⁽³⁾	0.01 0.02		0.04 0.07	% /V
Load Regulation	$10\text{ mA} \leq I_L \leq 3\text{A}$, $P \leq P_{MAX}$ ⁽³⁾⁽⁴⁾	0.2 0.4		1.0 1.5	%
Thermal Regulation	10 ms Pulse	0.002		0.02	% /W
Temperature Stability	$T_{MIN} \leq T_J \leq T_{MAX}$	0.5			%
Long Term Stability	$T_J = 125^\circ\text{C}$, 1000 Hours	0.2			%
Adjust Pin Current		65 70		95 100	μA
Adjust Pin Current Change	$10\text{ mA} \leq I_L \leq 3\text{A}$ $3.0\text{V} \leq V_{IN} - V_{OUT} \leq 35\text{V}$	2.5		8	μA
Minimum Load Current	$ V_{IN} - V_{OUT} \leq 35\text{V}$	2.5		10	mA
	$ V_{IN} - V_{OUT} \leq 10\text{V}$	1.5		5.0	
Current Limit ⁽⁴⁾	$3\text{V} \leq V_{IN} - V_{OUT} \leq 10\text{V}$	3.9	3.0		A
	$ V_{IN} - V_{OUT} = 20\text{V}$	2.4	1.0		
	$ V_{IN} - V_{OUT} = 30\text{V}$	0.4	0.20		
Output Noise (% of V_{OUT})	10 Hz to 10 kHz	0.003			% (rms)

(1) Unless otherwise specified: $|V_{IN} - V_{OUT}| = 5\text{V}$, $I_{OUT} = 0.5\text{A}$, $P_{DISS} \leq 30\text{W}$.

(2) All limits are specified at either room temperature (standard type face) or at **temperature extremes (bold typeface)** by production testing or correlation techniques using standard Statistical Quality Control (SQC) methods.

(3) Load and line regulation are measured at constant junction temperature, using low duty cycle pulse testing (output voltage changes due to heating effects are covered by the Thermal Regulation specification). For the TO-3 package, load regulation is measured on the output pin, $\frac{1}{8}$ " below the base of the package.

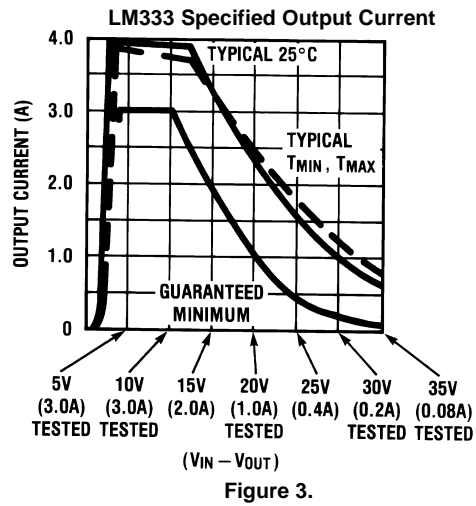
(4) The output current of the LM333 is ensured to be $\geq 3\text{A}$ in the range $3\text{V} \leq |V_{IN} - V_{OUT}| \leq 10\text{V}$. For the range $10\text{V} \leq |V_{IN} - V_{OUT}| \leq 15\text{V}$, the ensured minimum output current is equal to: $30 / (V_{IN} - V_{OUT})$. Refer to [TYPICAL PERFORMANCE CHARACTERISTICS](#) for ensured output currents at other voltages.

ELECTRICAL CHARACTERISTICS LM333 (continued)

Specifications with standard typeface are for $T_J = 25^{\circ}\text{C}$, and those with **boldface type** apply over the full operating temperature range.⁽¹⁾

Parameter	Conditions	Typical	Min ⁽²⁾	Max ⁽²⁾	Units
Ripple Rejection	$V_{OUT} = 10\text{V}$, $f = 120\text{ Hz}$				
	$C_{ADJ} = 0\text{ }\mu\text{F}$	60			dB
	$C_{ADJ} = 10\text{ }\mu\text{F}$	77			
Thermal Shutdown Temperature		163			$^{\circ}\text{C}$
Thermal Resistance Junction to Case (θ_{JC})	TO-3 Package (K Steel)	1.2		1.8	$^{\circ}\text{C/W}$
Thermal Resistance Junction to Ambient (θ_{JA}) (No Heatsink)	TO-3 Package (K Steel)	35			$^{\circ}\text{C/W}$

TYPICAL PERFORMANCE CHARACTERISTICS



TYPICAL APPLICATIONS

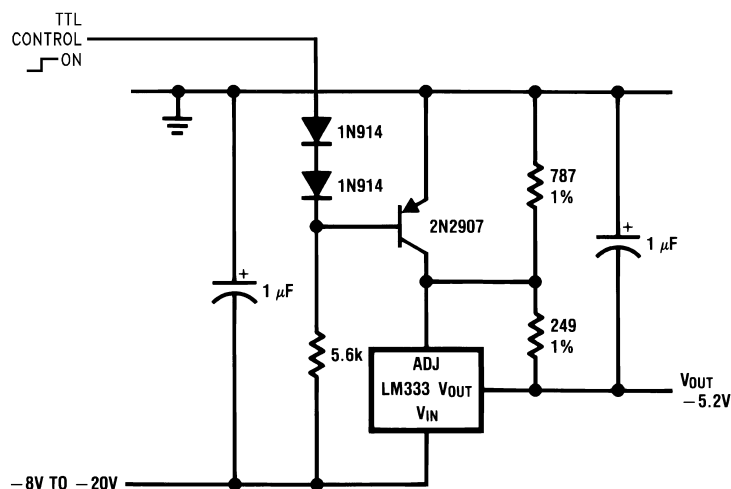
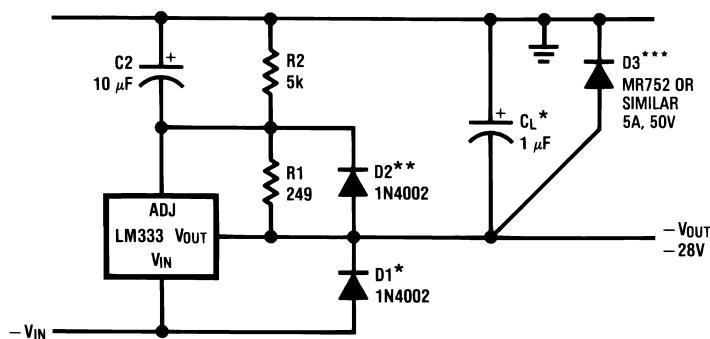


Figure 4. -5.2V Regulator with Electronic Shutdown



* When C_L is larger than 20 μF , D1 protects the LM333 in case the input supply is shorted.

** When C_2 is larger than 10 μF and $-V_{OUT}$ is larger than -25V, D2 protects the LM333 in case the output is shorted.

*** In case V_{OUT} is shorted to a positive supply, D3 protects the LM333 from over-voltage, and protects the load from reversed voltage.

Figure 5. Negative Regulator with Protection Diodes

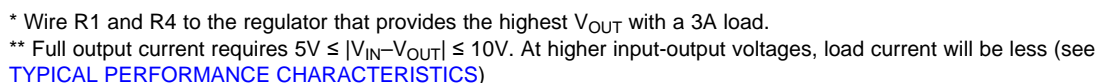


Figure 7. Current Regulator

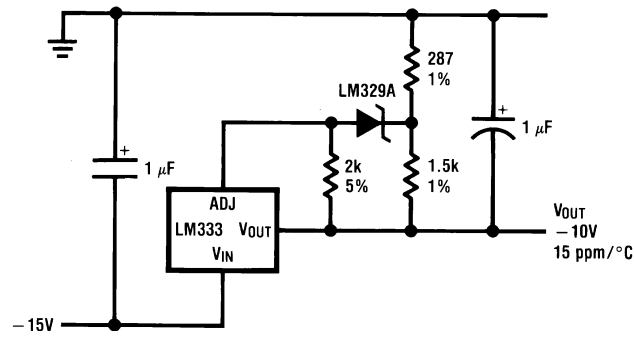
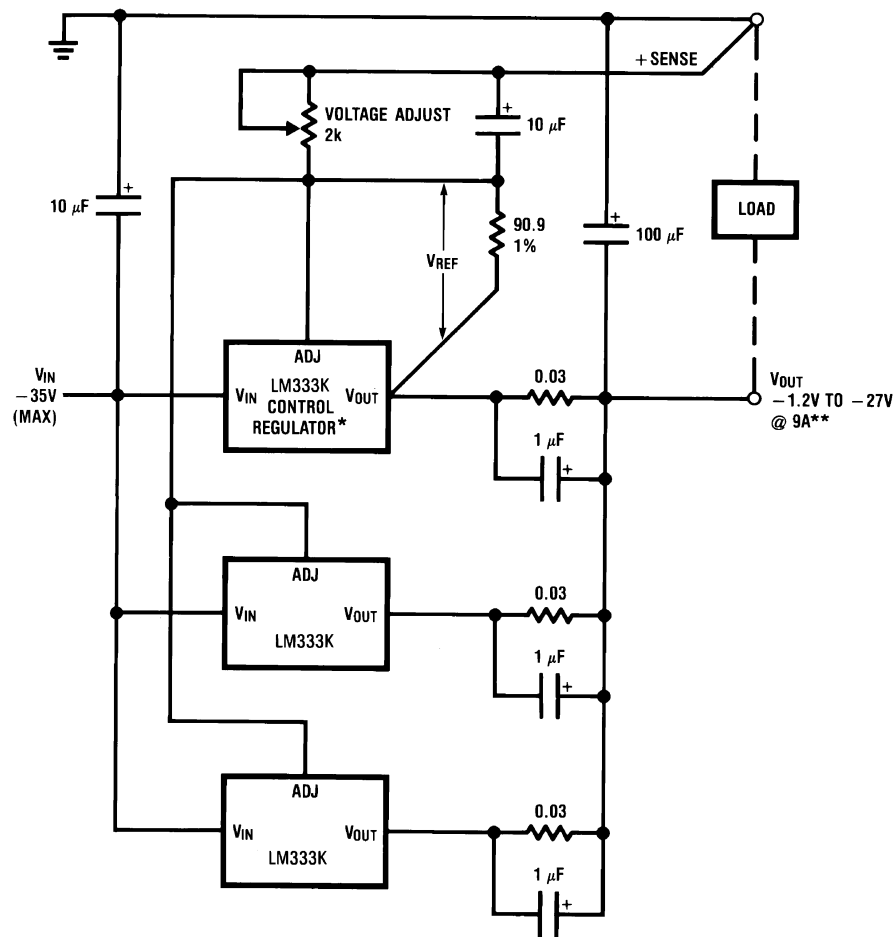


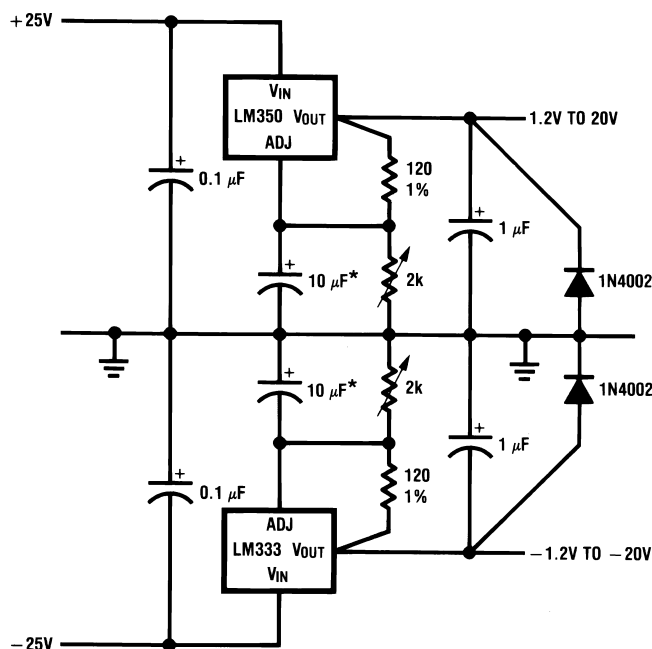
Figure 8. High Stability 10V Regulator



* Control regulator must have the largest V_{REF}

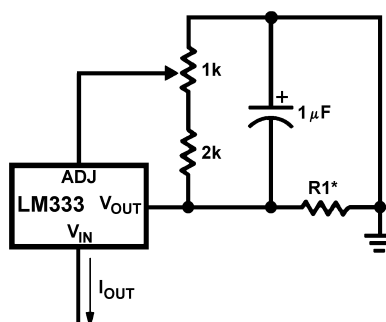
** Full output current requires $5V \leq |V_{IN}-V_{OUT}| \leq 10V$. At higher input-output voltages, load current will be less (see [TYPICAL PERFORMANCE CHARACTERISTICS](#))

Figure 9. High-Current Adjustable Regulator



* The 10 μF capacitors are optional to improve ripple rejection.

Figure 10. Adjustable Lab Voltage Regulator



$$I_{OUT} = (1.5V / R1) \pm 15\% \text{ adjustable}$$

$$* 0.5\Omega \leq R1 \leq 24\Omega$$

Figure 11. Adjustable Current Regulator

THERMAL REGULATION

When power is dissipated in an IC, a temperature gradient occurs across the IC chip affecting the individual IC circuit components. With an IC regulator, this gradient can be especially severe since the power dissipation is large. Thermal regulation is the effect of these temperature gradients on output voltage (in percentage output change) per watt of power change in a specified time. Thermal regulation error is independent of electrical regulation or temperature coefficient, and occurs within 5 ms to 50ms after a change in power dissipation. Thermal regulation depends on IC layout as well as electrical design. The thermal regulation of a voltage regulator is defined as the percentage change of V_{OUT} , per watt, within the first 10 ms after a step of power is applied. The LM333's specification is 0.01%/W, max.

In [Figure 12](#), a typical LM333's output drifts only 2mV (or 0.02% of $V_{OUT} = -10V$) when a 20W pulse is applied for 10 ms. This performance is thus well inside the specification limit of $0.01\%/W \times 20W = 0.2\%$ max. When the 20W pulse is ended, the thermal regulation again shows a 2 mV step as the LM333 chip cools off. Note that the load regulation error of about 1 mV (0.01%) is additional to the thermal regulation error. In [Figure 13](#), when the 20W pulse is applied for 100 ms, the output drifts only slightly beyond the drift in the first 10ms, and the thermal error stays well within 0.1% (10mV).

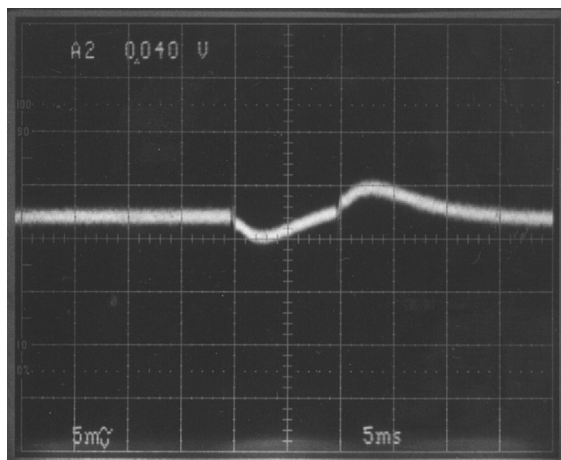


Figure 12.

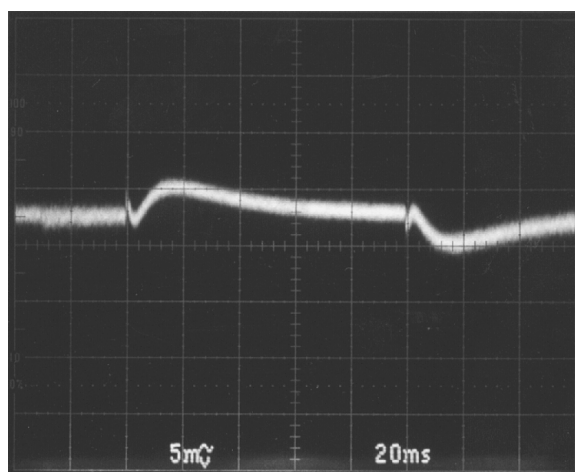
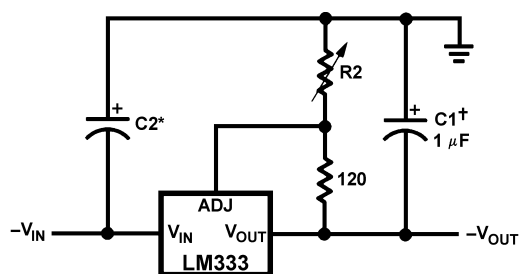


Figure 13.



$$-V_{OUT} = -1.25V \left(1 + \frac{R2}{120\Omega} \right) + (-I_{ADJ} \times R2)$$

† C1 = 1 μF solid tantalum or 10 μF aluminum electrolytic required for stability.

* C2 = 1 μF solid tantalum is required only if regulator is more than 4" from power supply filter capacitor.

Output capacitors in the range of 1 μF to 1000 μF of aluminum or tantalum electrolytic are commonly used to provide lower output impedance and improved transient response.

Figure 14. Adjustable Negative Voltage Regulator

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