National Semiconductor Corporation

LM133/LM333 3-Ampere Adjustable Negative Regulators

General Description

The LM133/LM333 are adjustable 3-terminal negative voltage regulators capable of supplying in excess of −3.0A over an output voltage range of −1.2V to −32V. These regulators are 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 themal transients. Further, the LM133 series features internal current limiting, thermal shutdown and safe-area compensation, making them virtually blowout-proof against overloads.

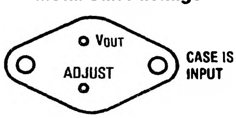
The LM133/LM333 serve a wide variety of applications including local on-card regulation, programmable-output voltage regulation or precision current regulation. The LM133/LM333 are ideal complements to the LM150/LM350 adjustable positive regulators.

Features

- Output voltage adjustable from −1.2V to −32V
- 3.0A output current guaranteed, −55°C to +150°C
- Line regulation typically 0.01%/V
- Load regulation typically 0.1%
- Excellent rejection of thermal transients
- 50 ppm/°C temperature coefficient
- Temperature-independent current limit
- Internal thermal overload protection
- 100% electrical burn-in
- Standard 3-lead transistor package
- Output is short circuit protected

Connection Diagrams

TO-3
Metal Can Package

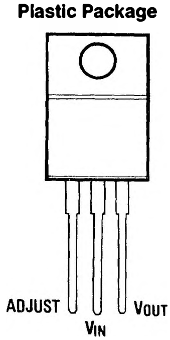


TL/H/9065-1

Bottom View

Steel TO-3 Metal Can Package (K STEEL)
Order Number LM133K STEEL or LM333K STEEL
See NS Package Number K02A

TO-220
Plastic Package



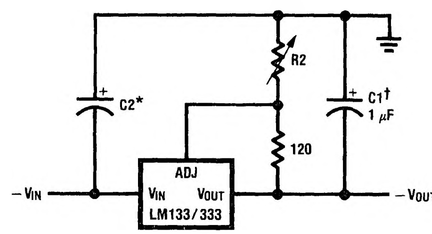
TL/H/9065-2

Bottom View

3-Lead TO-220 Plastic Package (T)
Order Number LM333T
See NS Package Number T03B

Typical Applications

Adjustable Negative Voltage Regulator



TL/H/9065-3

Full output current not available at high input-output voltages.

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

†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 improved output impedance and rejection of transients.

Absolute Maximum Ratings

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

Power Dissipation	Internally Limited
Input-Output Voltage Differential	35V
Operating Junction Temperature Range	T_{MIN} to T_{MAX}
LM133	−55°C to +150°C
LM333	−40°C to +125°C
Storage Temperature	−65°C to +150°C
Lead Temperature (Soldering, 10 sec.)	
TO-3 Package	300°C
TO-220 Package	260°C

Preconditioning

Burn-In In Thermal Limit	100% All Devices

Electrical Characteristics LM133 (Note 1) (Note 5)

Parameter	Conditions	Typical	Tested Limit (Note 3)	Design Limit (Note 4)	Units (Max Unless Noted)
Reference Voltage	$T_J = 25°C$, $I_L = 10$ mA	−1.250	−1.238 −1.262		V(MIN) V(MAX)
	$T_{MIN} \le T_J \le T_{MAX}$, $3V \le \lvert V_{IN} - V_{OUT} \rvert \le 35V$, $10\text{ mA} \le I_L \le 3A$, $P \le P_{MAX}$ LM133 LM133	**−1.250**	**−1.225** **−1.275**		V(MIN) V(MAX)
Line Regulation	$T_J = 25°C$, $3V \le \lvert V_{IN} - V_{OUT} \rvert \le 35V$, $I_{OUT} = 50$ mA (Note 2)	0.01	0.02		% /V
	LM133	**0.02**	**0.05**		% /V
Load Regulation	$T_J = 25°C$, $10\text{ mA} \le I_{OUT} \le 3A$, $P \le P_{MAX}$ (Notes 2 and 6)	0.2	0.5		%
	LM133	**0.4**	**1.0**		%
Thermal Regulation	$T_J = 25°C$, 10 ms Pulse	0.002	0.01		% /W
Temperature Stability	$T_{MIN} \le T_J \le T_{MAX}$	0.4			%
Long Term Stability	$T_J = 125°C$, 1000 Hours	0.15		0.8	%
Adjust Pin Current	$T_J = 25°C$ LM133 LM133	65 **70**	90 **100**		μA μA
Adjust Pin Current Change	$T_J = 25°C$, $10\text{ mA} \le I_L \le 3A$ $T_J = 25°C$, $3.0V \le \lvert V_{IN} - V_{OUT} \rvert \le 35V$	2 2	5 5	**6** **6**	μA μA
Minimum Load Current	$\lvert V_{IN} - V_{OUT} \rvert \le 35V$, $T_J = 25°C$ LM133	**2.5**	**5.0**		mA
	$\lvert V_{IN} - V_{OUT} \rvert \le 10V$, $T_J = 25°C$ LM133	**1.2**	**2.5**		mA
Current Limit (Note 6)	$3V \le \lvert V_{IN} - V_{OUT} \rvert \le 10V$, $T_J = 25°C$ LM133	**3.9**	**3.0**		A(MIN)
	$\lvert V_{IN} - V_{OUT} \rvert = 20V$, $T_J = 25°C$ LM133	**2.4**	**1.25**		A(MIN)
	$\lvert V_{IN} - V_{OUT} \rvert = 30V$, $T_J = 25°C$ LM133	0.4	**0.3**		A(MIN)
Output Noise (% of V_{OUT})	10 Hz to 10 kHz, $T_J = 25°C$	0.003		0.010	% (rms)
Ripple Rejection	$V_{OUT} = 10V$, $f = 120$ Hz, $T_J = 25°C$ $C_{ADJ} = 0$ μF $C_{ADJ} = 10$ μF	60 77		55 70	dB dB
Thermal Resistance	TO-3 Package (K STEEL) TO-220 Package (T)	1.2 3		1.8 4	°C/W °C/W
Thermal Shutdown Temperature	LM133 LM133	163	150	 190	°C(MIN) °C(MAX)

Electrical Characteristics LM133 (Note 1) **(Note 5)**

Parameter	Conditions	Typical	Tested Limit (Note 3)	Design Limit (Note 4)	Units (Max Unless Noted)
Reference Voltage	$T_J = 25°C$, $I_L = 10$ mA	−1.250	−1.225 −1.275		V(MIN) V(MAX)
	$T_{MIN} \le T_J \le T_{MAX}$, $3V \le \lvert V_{IN} - V_{OUT} \rvert \le 35V$, $10\ mA \le I_L \le 3A$, $P \le P_{MAX}$	**−1.250**		**−1.213** **−1.287**	V(MIN) V(MAX)
Line Regulation	$T_J = 25°C$, $3V \le \lvert V_{IN} - V_{OUT} \rvert \le 35V$, $I_{OUT} = 50$ mA (Note 2)	0.001 **0.02**	0.004	 **0.07**	% /V % /V
Load Regulation	$T_J = 25°C$, $10\ mA \le I_{OUT} \le 3A$, $P \le P_{MAX}$ (Notes 2 and 6)	0.2 **0.4**	1.0	 **1.5**	% %
Thermal Regulation	$T_J = 25°C$, 10 ms Pulse	0.002	0.02		% /W
Temperature Stability	$T_{MIN} \le T_J \le T_{MAX}$	0.5			%
Long Term Stability	$T_J = 125°C$, 1000 Hours	0.2		0.8	%
Adjust Pin Current	$T_J = 25°C$	65 **70**	95	 **100**	μA μA
Adjust Pin Current Change	$T_J = 25°C$, $10\ mA \le I_L \le 3A$ $T_J = 25°C$, $3.0V \le \lvert V_{IN} \le \le 35V$	2.5 2.5	7 7	**8** **8**	μA μA
Minimum Load Current	$\lvert V_{IN} - V_{OUT} \rvert \le 35V$, $T_J = 25°C$ $\lvert V_{IN} - V_{OUT} \rvert \le 10V$, $T_J = 25°C$	**2.5** **1.5**	10 5.0	**10** 5.0	mA mA
Current Limit (Note 6)	$3V \le \lvert V_{IN} - V_{OUT} \rvert \le 10V$, $T_J = 25°C$ $\lvert V_{IN} - V_{OUT} \rvert = 20V$, $T_J = 25°C$ $\lvert V_{IN} - V_{OUT} \rvert = 30V$, $T_J = 25°C$	**3.9** **2.4** 0.4	2.0 1.0 0.20	**3.0** **1.0** **0.2**	A(MIN) A(MIN) A(MIN)
Output Noise (% of V_{OUT})	10 Hz to 10 kHz, $T_J = 25°C$	0.003		0.010	% (rms)
Ripple Rejection	$V_{OUT} = 10V$, $f = 120$ Hz, $T_J = 25°C$ $C_{ADJ} = 0\ \mu F$ $C_{ADJ} = 10\ \mu F$	 60 77		 50 66	 dB dB
Thermal Resistance Junction to Case	TO-3 Package (K STEEL) TO-220 Package (T)	1.2 3		1.8 4	°C/W °C/W
Thermal Shutdown Temperature		163		150 190	°C(MIN) °C(MAX)
Thermal Resistance Junction to Ambient (No Heatsink)	K Package T Package	35 50			°C/W °C/W

Note 1: Unless otherwise specified, these specifications apply: $-55°C \le T_J \le +150°C$ for the LM133; and $-40°C \le T_J + 125°C$ for the LM333; $\lvert V_{IN} - V_{OUT} \rvert = 5V$; and $I_{OUT} = 0.5A$. Although power dissipation is internally limited, these specifications are applicable for power dissipations up to 30W.

Note 2: Regulation is measured at constant junction temperature, using pulse testing with a low duty cycle. Changes in output voltage due to heating effects are covered under the specification for thermal regulation. Load regulation is measured on the output pin at a point 1/8" below the base of the TO-3 package.

Note 3: Testing limits are guaranteed and 100% tested in production.

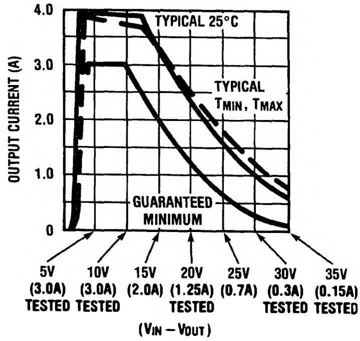
Note 4: Design limits are guaranteed (but not 100% production tested) over the indicated temperature and supply voltage ranges. These limits are not used to calculate outgoing quality levels.

Note 5: Specifcations in **boldface** apply over the full rated temperature range.

Note 6: The output capability of the LM333 is guaranteed at 3A in the range of $3V \le \lvert V_{IN} - V_{OUT} \rvert \le 10V$. At voltages above 10V, the available output current decreases, but in the range $10V \le \lvert V_{IN} - V_{OUT} \rvert \le 15V$, the available current is $30W - \lvert V_{IN} - V_{OUT} \rvert$. At voltages higher than 15V, refer to graphs for actual guaranteed output current available.

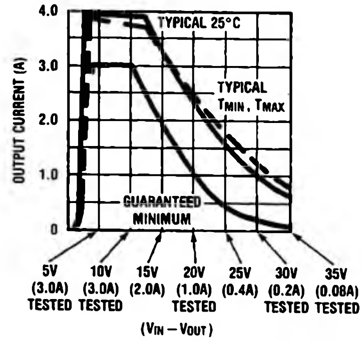
Guaranteed Performance Characteristics

LM133 Guaranteed Output Current



TL/H/9065-4

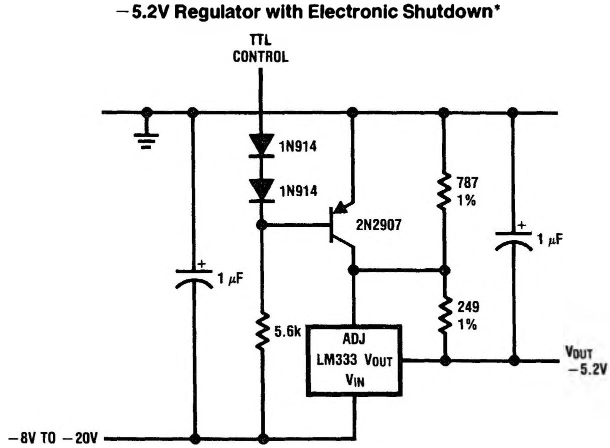
LM333 Guaranteed Output Current



TL/H/9065-5

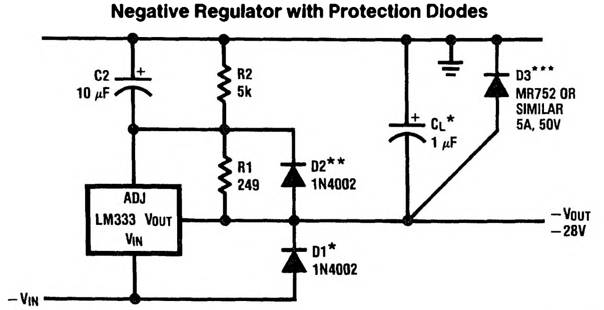
Typical Applications (Continued)

−5.2V Regulator with Electronic Shutdown*



TL/H/9065-6

Negative Regulator with Protection Diodes



TL/H/9065-7

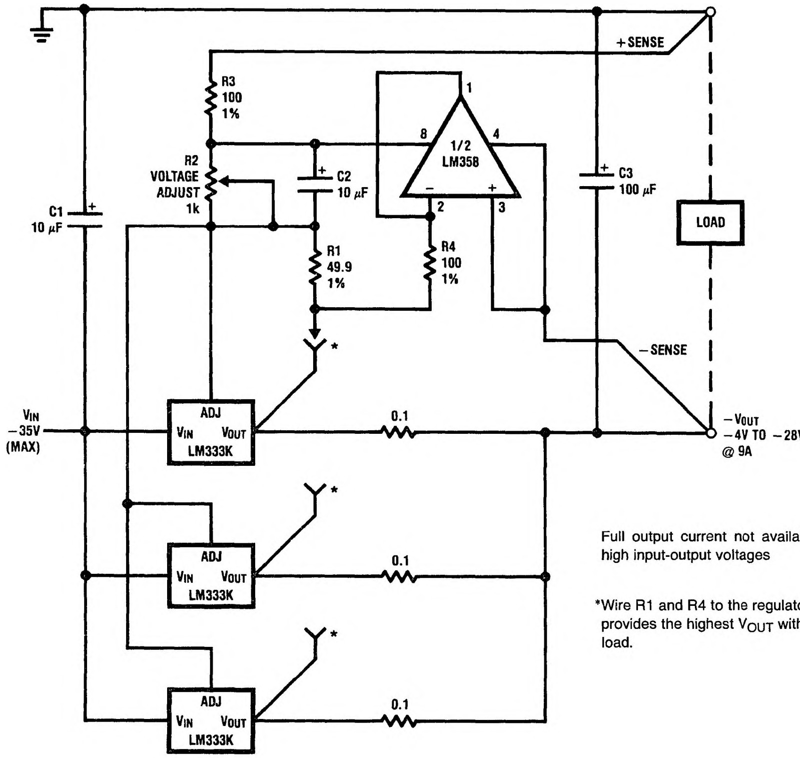
*When C_L is larger than 20 μF, D1 protects the LM133 in case the input supply is shorted.

**When C2 is larger than 10 μF and $-V_{OUT}$ is larger than −25V, D2 protect the LM133 in case the output is shorted.

***In case V_{OUT} is shorted to a positive supply, D3 protects the LM133 from overvoltage, and protects the load from reversed voltage.

Typical Applications (Continued)

High-Performance 9-Ampere Adjustable Regulator

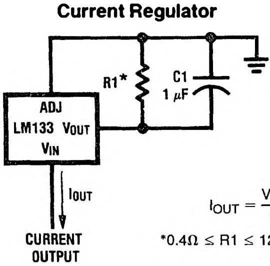


Full output current not available at high input-output voltages

*Wire R1 and R4 to the regulator that provides the highest V_{OUT} with a 3A load.

TL/H/9065–8

Current Regulator

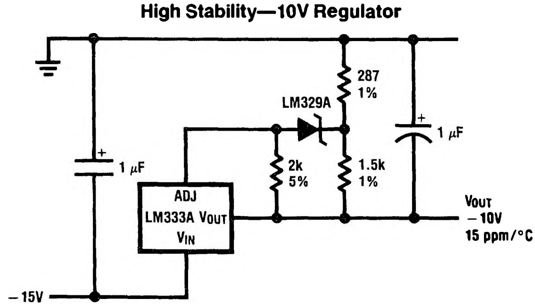


$$I_{OUT} = \frac{V_{REF}}{R1}$$

$*0.4\Omega \le R1 \le 120\Omega$

TL/H/9065–9

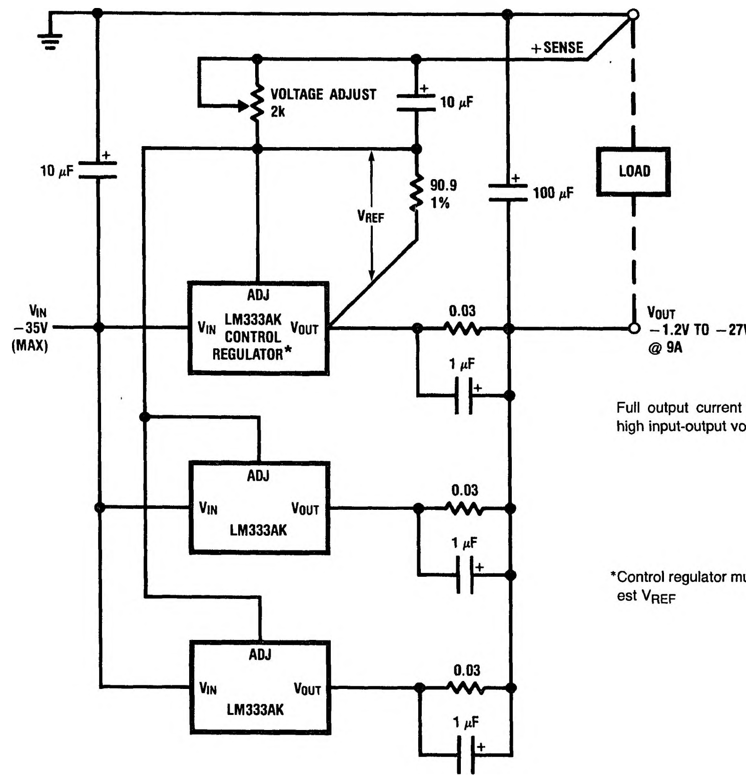
High Stability—10V Regulator



TL/H/9065–10

Typical Applications (Continued)

High-Current Adjustable Regulator

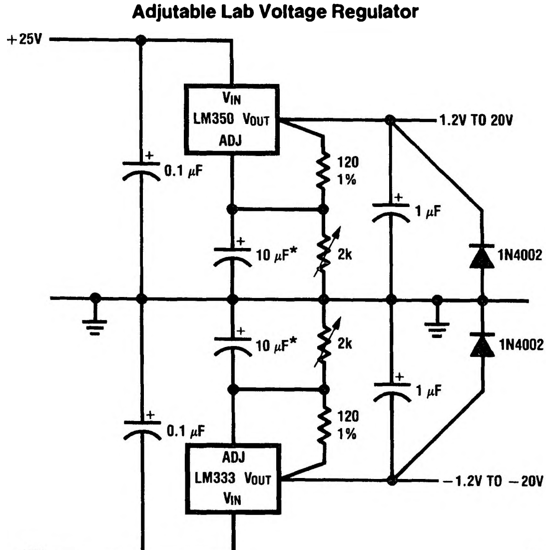


Full output current not available at high input-output voltages

*Control regulator must have the largest V_{REF}

TL/H/9065–11

Adjustable Lab Voltage Regulator

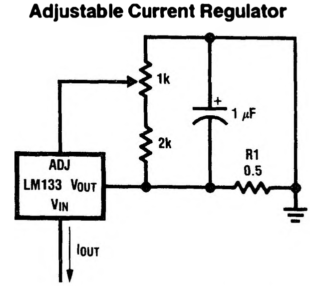


TL/H/9065–12

Full output current not available at high input-output voltages.

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

Adjustable Current Regulator



TL/H/9065–13

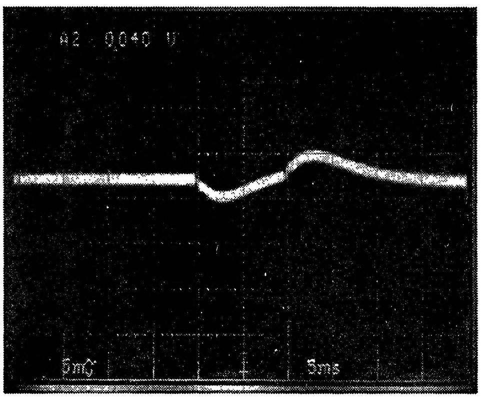
$$I_{OUT} = \left(\frac{1.5V}{R1}\right) \pm 15\% \text{ adjustable}$$

Typical Applications (Continued)

THERMAL REGULATION

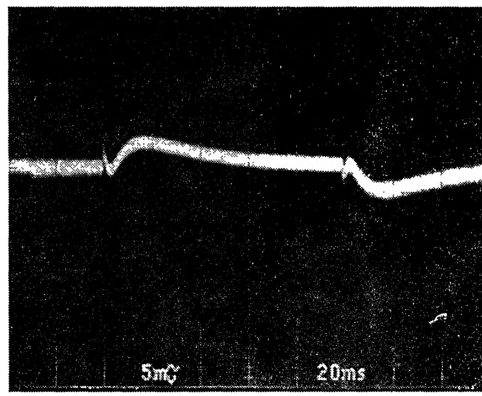
When power is dissipated in an IC, a temperature gradient occurs across the IC chip affecting the individual IC circuit components. With an IC regulator, this gradient can be especially severe since the power dissipation is large. Thermal regulation is the effect of these temperature gradients on output 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 50 ms 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 rms after a step of power is applied. The LM133's specification is 0.01%/W, max.

In *Figure 1*, a typical LM133's output drifts only 2 mV (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×20W = 0.2% max. When the 20W pulse is ended, the thermal regulation again shows a 2 mV step as the LM133 chip cools off. Note that the load regulation error of about 1 mV (0.01%) is additional to the thermal regulation error. In *Figure 2*, when the 20W pulse is applied for 100 ms, the output drifts only slightly beyond the drift in the first 10 ms, and the thermal error stays well within 0.1% (10 mV).



TL/H/9065-14

FIGURE 1



TL/H/9065-15

FIGURE 2