

LM10QML

LM10QML Operational Amplifier and Voltage Reference



Literature Number: SNOSAP1

LM10QML

Operational Amplifier and Voltage Reference

General Description

The LM10 is a monolithic linear IC consisting of a precision reference, an adjustable reference buffer and an independent, high quality op amp.

The unit can operate from a total supply voltage as low as 1.1V or as high as 40V, drawing only 270 μ A. A complementary output stage swings within 15 mV of the supply terminals or will deliver ± 20 mA output current with ± 0.4 V saturation. Reference output can be as low as 200 mV.

The circuit is recommended for portable equipment and is completely specified for operation from a single power cell. In contrast, high output-drive capability, both voltage and current, along with thermal overload protection, suggest it in demanding general-purpose applications.

The device is capable of operating in a floating mode, independent of fixed supplies. It can function as a remote com-

parator, signal conditioner, SCR controller or transmitter for analog signals, delivering the processed signal on the same line used to supply power. It is also suited for operation in a wide range of voltage- and current-regulator applications, from low voltages to several hundred volts, providing greater precision than existing ICs.

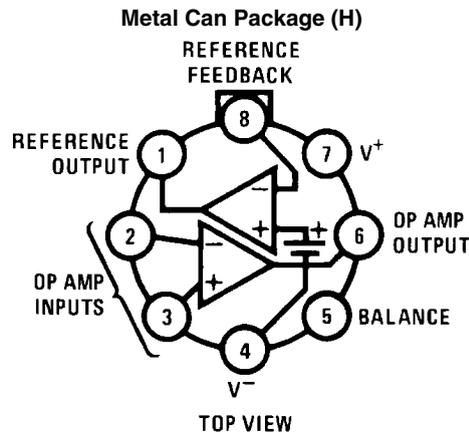
Features

- Input offset voltage: 2.0 mV (max)
- Input offset current: 0.7 nA (max)
- Input bias current: 20 nA (max)
- Reference regulation: 0.1% (max)
- Offset voltage drift: 2 μ V/ $^{\circ}$ C
- Reference drift: 0.002%/ $^{\circ}$ C

Ordering Information

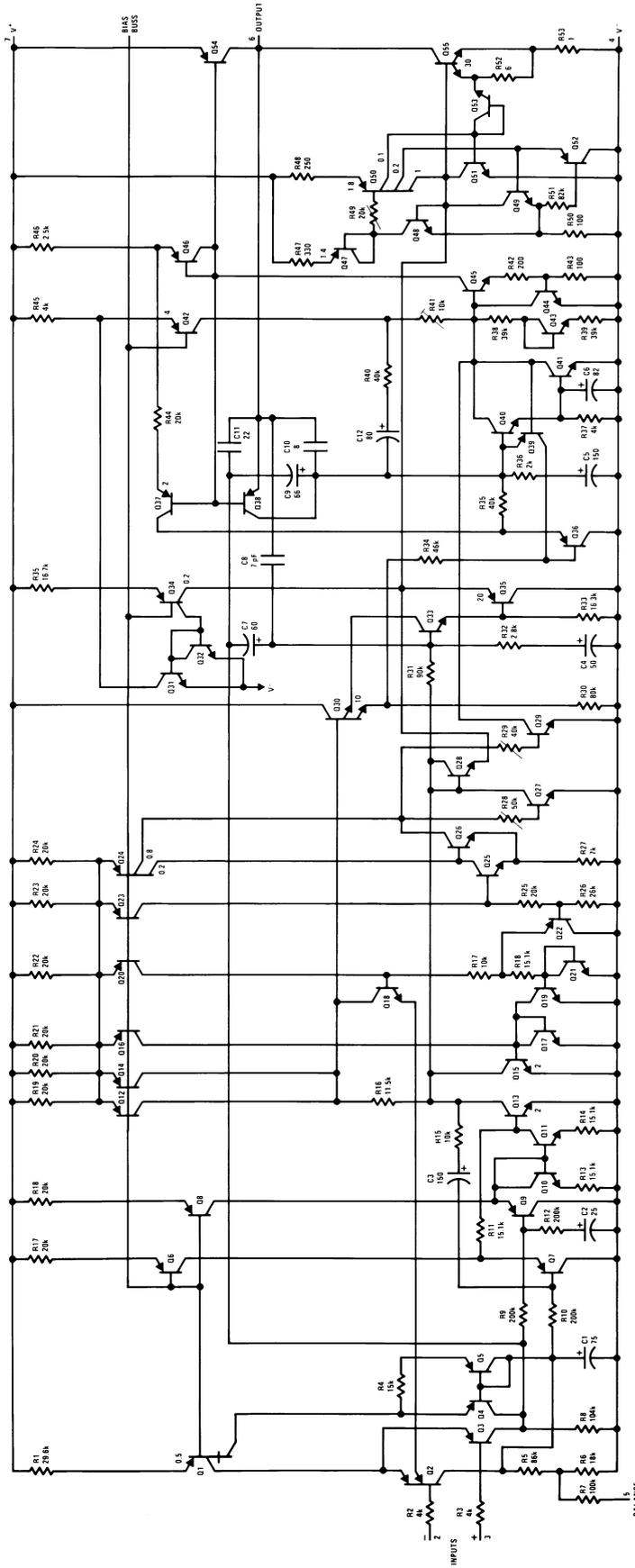
NS Part Number	SMD Part Number	NS Package Number	Package Description
LM10H/883	5962-8760401GA	H08A	8LD Metal Can

Connection and Functional Diagram



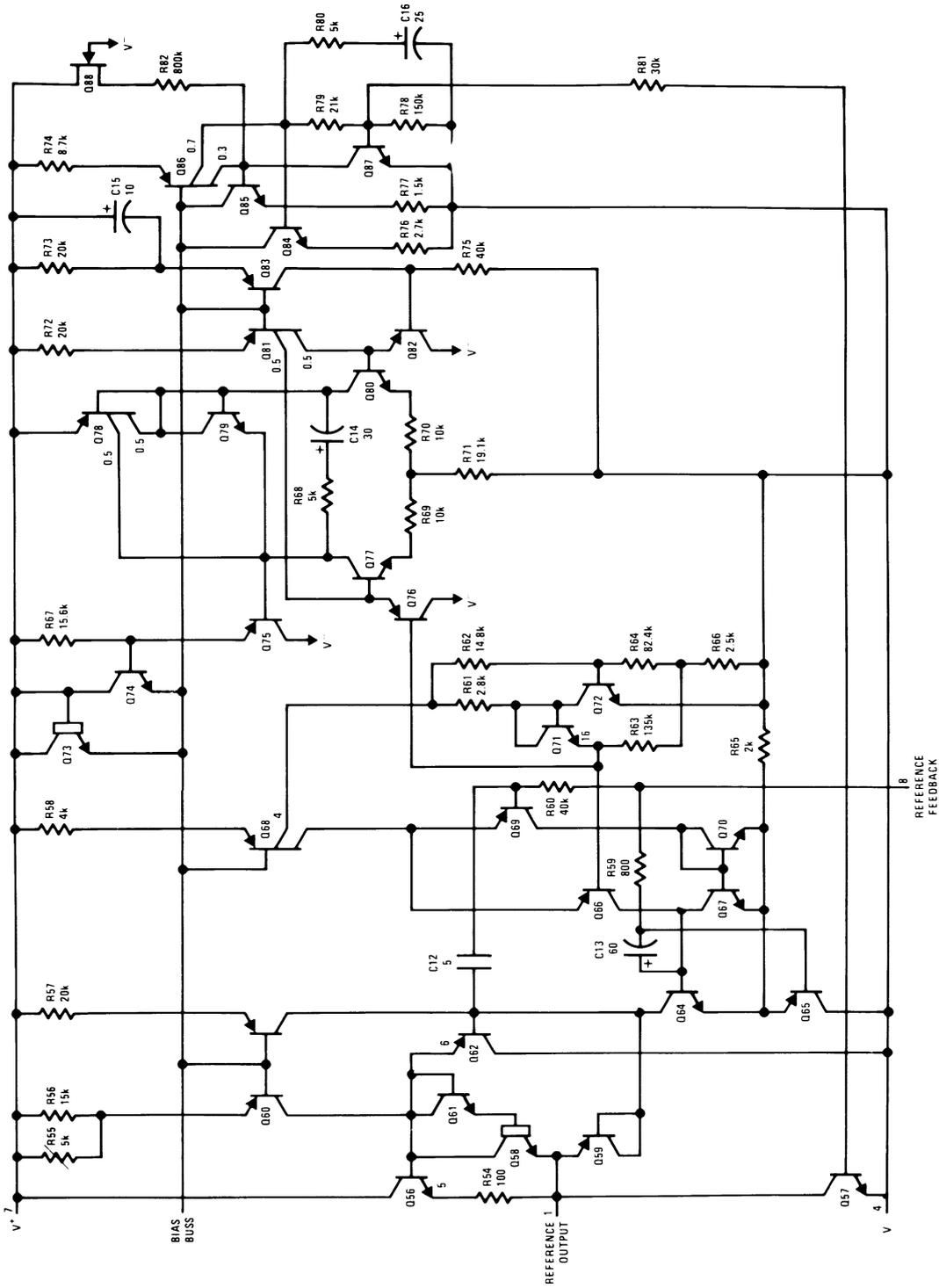
See NS Package Number H08A 20149701

Operational Amplifier Schematic — (Pin numbers are for 8-pin packages)



20149713

Reference and Internal Regulator Schematic — (Pin numbers are for 8-pin packages)



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Absolute Maximum Ratings *(Note 1)*

Total Supply Voltage	45V
Differential Input Voltage <i>(Note 3)</i>	±40V
Power Dissipation (P_{Dmax}) <i>(Note 2)</i>	Internally Limited
Output Short-circuit Duration <i>(Note 4)</i>	Continuous
Storage Temperature Range	$-55^{\circ}\text{C} \leq T_A \leq +150^{\circ}\text{C}$
Maximum Junction Temperature (T_{Jmax})	150°C
Lead Temperature (Soldering 10 seconds)	300°C
Thermal Resistance	
θ_{JA}	
Still Air	150°C
500LF/Min Air flow	45°C
θ_{JC}	
	45°C
ESD	Rating to be determined

Quality Conformance Inspection

Mil-Std-883, Method 5005 - Group A

Subgroup	Description	Temp °C
1	Static tests at	+25
2	Static tests at	+125
3	Static tests at	-55
4	Dynamic tests at	+25
5	Dynamic tests at	+125
6	Dynamic tests at	-55
7	Functional tests at	+25
8A	Functional tests at	+125
8B	Functional tests at	-55
9	Switching tests at	+25
10	Switching tests at	+125
11	Switching tests at	-55
12	Settling time at	+25
13	Settling time at	+125
14	Settling time at	-55

LM10H Electrical Characteristics

DC Parameters

The following conditions apply to all the following parameters, unless otherwise specified.

DC: At room temperature $1.2V \leq V_S \leq 45V$, $V_S^- \leq V_{CM} \leq V \pm 0.85V$.

DC: At temperature extremes $1.3V \leq V_S \leq 45V$, $V_S^- \leq V_{CM} \leq V \pm 1.0V$.

Symbol	Parameter	Conditions	Notes	Min	Max	Unit	Sub-groups
V_{IO}	Input Offset Voltage	$I_O = 0mA$		-2.0	2.0	mV	1
				-3.0	3.0	mV	2, 3
		$V_S = 1.2V, I_O = \pm 2mA$		-3.0	3.0	mV	1
		$V_S = 1.3V, I_O = \pm 2mA$		-4.0	4.0	mV	2, 3
		$V_S = 4V, I_O = \pm 20mA$		-3.0	3.0	mV	1
		$V_S = 4V, I_O = \pm 15mA$		-4.0	4.0	mV	2, 3
I_{IO}	Input Offset Current			-0.7	0.7	nA	1
				-1.5	1.5	nA	2, 3
I_{IB}	Input Bias Current				20	nA	1
					30	nA	2, 3
CMRR	Common Mode Rejection	$V_S = 45V, -20V \leq V_{CM} \leq 24.2V$		93		dB	1
				87		dB	2, 3
PSRR	Supply Voltage Rejection	$V_S^+ = 0.85V,$ $-0.35V \geq V_S^- \geq -44.2V$		90		dB	1
				84		dB	2, 3
		$0.85V \leq V_S^+ \leq 44.6V,$ $V_S^- = -0.35V$		96		dB	1
				90		dB	2, 3
V_{RLine}	Line Regulation	$I_{Ref} = 1mA$		91		dB	1
				85		dB	2, 3
V_{RLoad}	Load Regulation	$V_S = 1.2V, 0 \leq I_O \leq 1mA$		60		dB	1
		$V_S = 1.3V, 0 \leq I_O \leq 1mA$		57		dB	2, 3
I_S	Supply Current				400	μA	1
					500	μA	2, 3
A_V	Large Signal Voltage Gain	$V_S = \pm 20V, I_O = 0A,$ $V_O = \pm 19.95V$		120		K	4
				80		K	5, 6
		$V_S = \pm 2V, I_O = \pm 20mA,$ $V_O = \pm 1.4V$		5.0		K	4
				1.5		K	5, 6
		$V_S^+ = 0.85V, V_{CM} = -0.25V$ $V_S^- = -0.35V, I_O = \pm 2mA,$ $-0.15V \leq V_O \leq 0.65V,$		1.5		K	4
$V_S^+ = 1V, V_{CM} = -0.35V$ $V_S^- = -0.3V, I_O = \pm 2mA,$ $+0.05V \leq V_O \leq 0.65V,$		0.5		K	5, 6		

Symbol	Parameter	Conditions	Notes	Min	Max	Unit	Sub-groups
A _{VSH}	Shunt Gain	1.1V ≤ V _{OUT} ≤ 6.1V, -5mA ≤ I _{OUT} ≤ -0.1mA	(Note 6)	14		K	4
		1.2V ≤ V _{OUT} ≤ 6.2V, -5mA ≤ I _{OUT} ≤ -0.1mA	(Note 6)	6.0		K	5, 6
		1.4V ≤ V _{OUT} ≤ 6.4V, -5mA ≤ I _{OUT} ≤ -0.1mA	(Note 6)	8.0		K	4
		1.4V ≤ V _{OUT} ≤ 6.4V, -20mA ≤ I _{OUT} ≤ -0.1mA	(Note 6)	4.0		K	5, 6
A _V	Amplifier Gain	0.2V ≤ V _{Ref} ≤ 35V, I _{Ref} = 1mA		50		K	
				23		K	
V _{Sense}	Feedback Sense Voltage	0.2V ≤ V _{Ref} ≤ 35V, 0 ≤ I _{Ref} ≤ 1 mA		195	205	mV	
				194	206	mV	
I _{Sense}	Feedback Current				50	nA	
					65	nA	
ΔI _S	Supply Current Change	0.5V ≤ V _O ≤ 25V		-75	75	μA	
		V _S = 5V, 4.5V ≤ V _O ≤ 5V		-60	60	μA	
R _I	Input Resistance		(Note 5)		250	KΩ	
			(Note 5)		150	KΩ	

Note 1: Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is functional, but do not guarantee specific performance limits. For guaranteed specifications and test conditions, see the 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: The maximum power dissipation must be derated at elevated temperatures and is dictated by T_{Jmax} (maximum junction temperature), θ_{JA} (package junction to ambient thermal resistance), and T_A (ambient temperature). The maximum allowable power dissipation at any temperature is P_{Dmax} = (T_{Jmax} - T_A) / θ_{JA} or the number given in the Absolute Maximum Ratings, whichever is lower.

Note 3: The Input voltage can exceed the supply voltages provided that the voltage from the input to any other terminal does not exceed the maximum differential input voltage and excess dissipation is accounted for when V_I < V_S⁻.

Note 4: Internal thermal limiting prevents excessive heating that could result in sudden failure, but the IC can be subjected to accelerated stress with a shorted output and worst-case conditions.

Note 5: Guaranteed parameter, not tested,

Note 6: This defines operation in floating applications such as the bootstrapped regulator or two-wire transmitter. Output is connected to the V_S⁺ terminal of the IC and input common mode is referred to V_S⁻ (see typical applications). Effect of larger output-voltage swings with higher load resistance can be accounted for by adding the positive-supply rejection error.

Definition of Terms

Input offset voltage: That voltage which must be applied between the input terminals to bias the unloaded output in the linear region.

Input offset current: The difference in the currents at the input terminals when the unloaded output is in the linear region.

Input bias current: The absolute value of the average of the two input currents.

Input resistance: The ratio of the change in input voltage to the change in input current on either input with the other grounded.

Large signal voltage gain: The ratio of the specified output voltage swing to the change in differential input voltage required to produce it.

Shunt gain: The ratio of the specified output voltage swing to the change in differential input voltage required to produce it with the output tied to the V_{S+} terminal of the IC. The load and power source are connected between the V_{S+} and V_{S-} terminals, and input common-mode is referred to the V_{S-} terminal.

Common-mode rejection: The ratio of the input voltage range to the change in offset voltage between the extremes.

Supply-voltage rejection: The ratio of the specified supply-voltage change to the change in offset voltage between the extremes.

Line regulation: The average change in reference output voltage over the specified supply voltage range.

Load regulation: The change in reference output voltage from no load to that load specified.

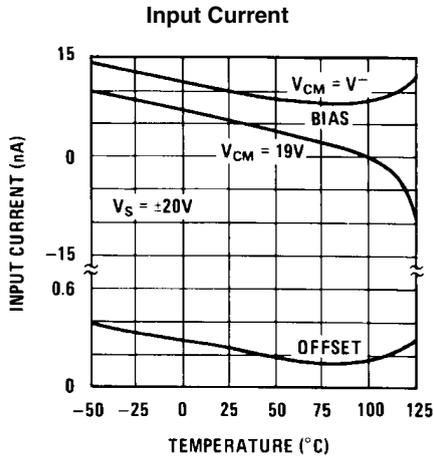
Feedback sense voltage: The voltage, referred to V_{S-} , on the reference feedback terminal while operating in regulation.

Reference amplifier gain: The ratio of the specified reference output change to the change in feedback sense voltage required to produce it.

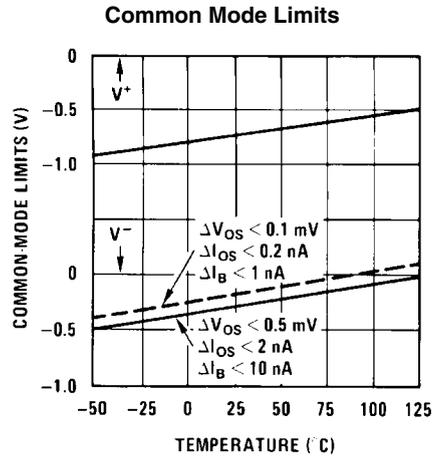
Feedback current: The absolute value of the current at the feedback terminal when operating in regulation.

Supply current: The current required from the power source to operate the amplifier and reference with their outputs unloaded and operating in the linear range.

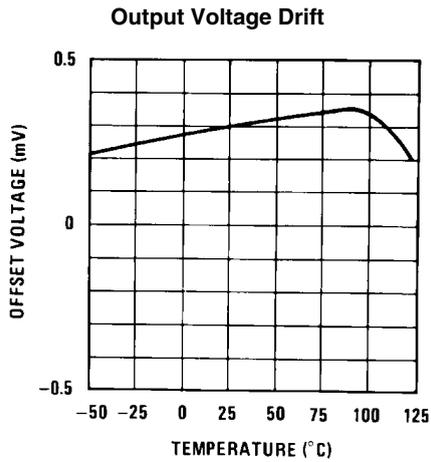
Typical Performance Characteristics (Op Amp)



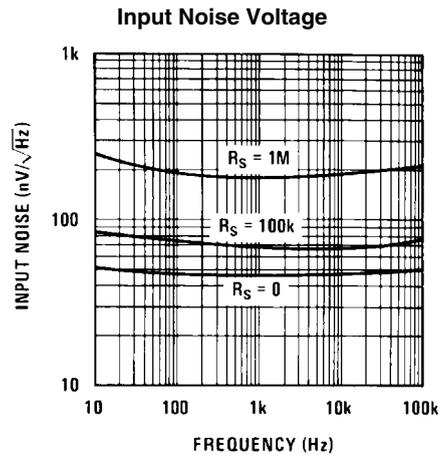
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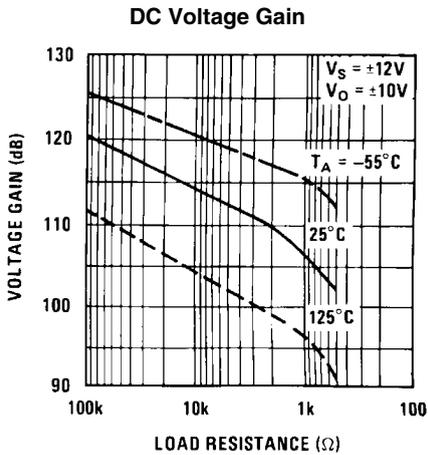
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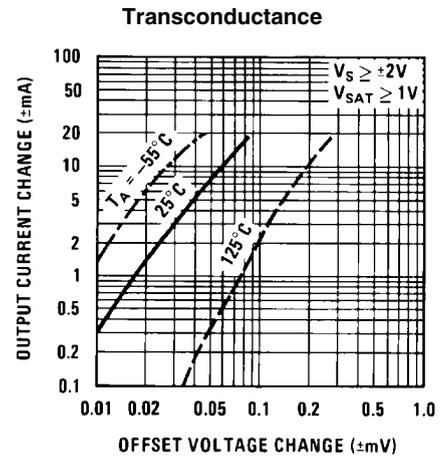
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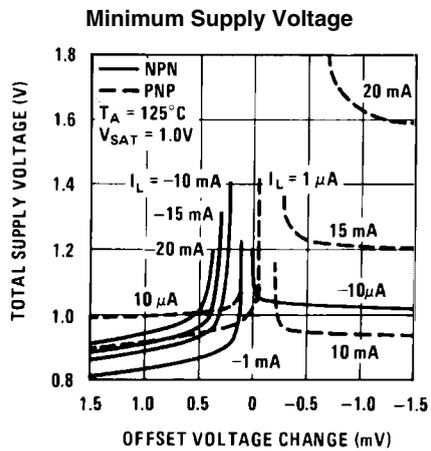
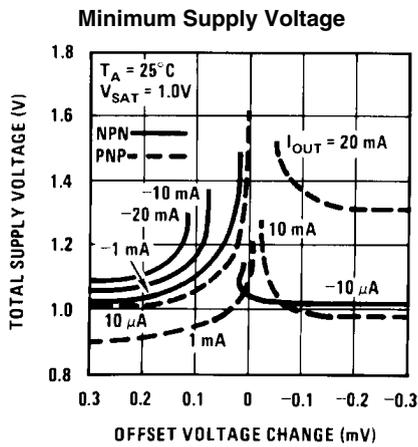
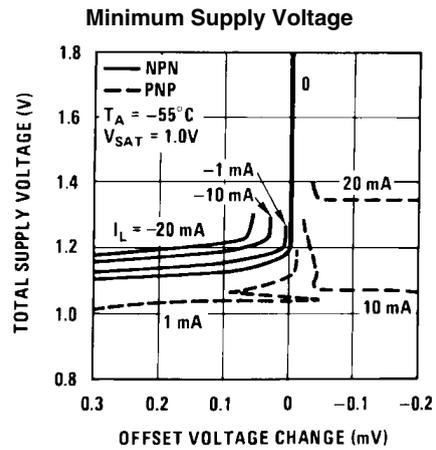
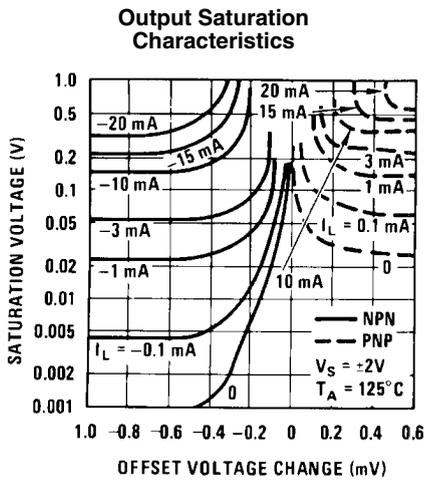
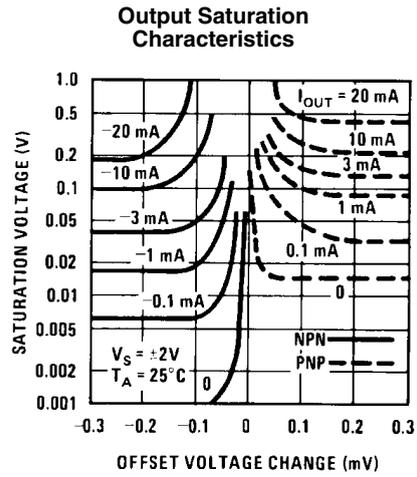
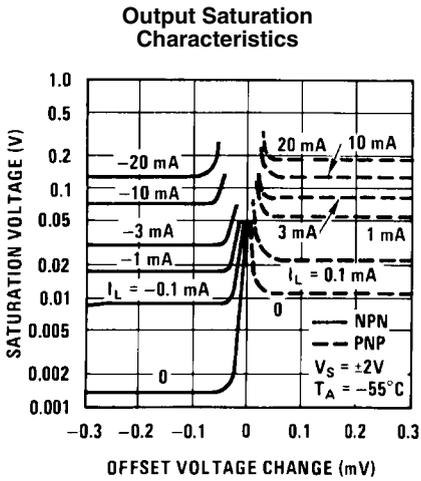
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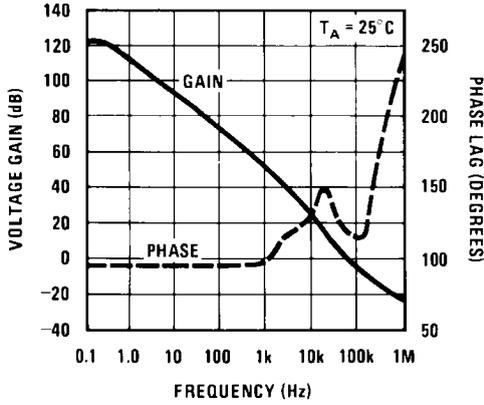
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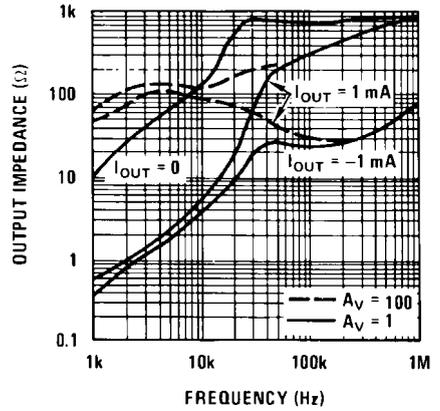


Frequency Response



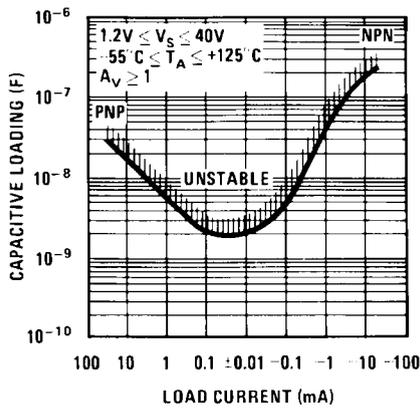
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Output Impedance



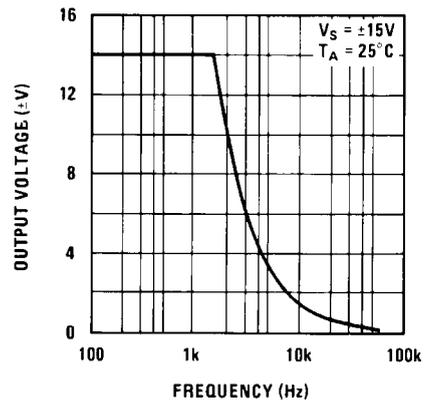
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Typical Stability Range



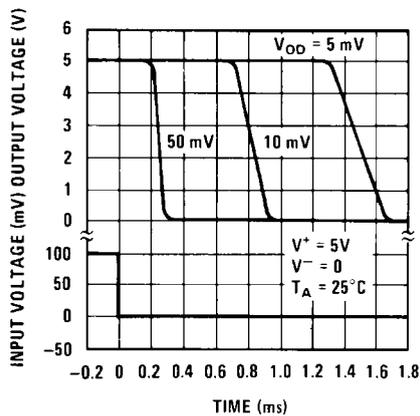
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Large Signal Response



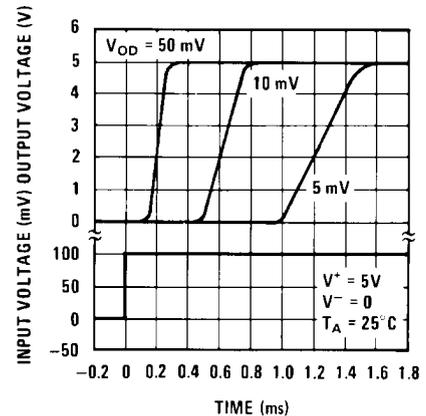
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Comparator Response Time For Various Input Overdrives



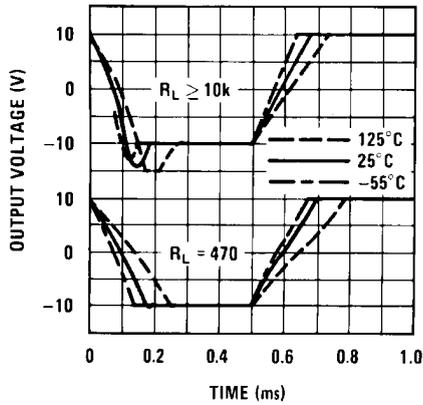
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Comparator Response Time For Various Input Overdrives



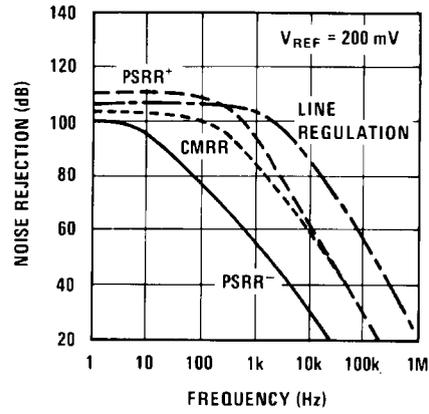
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Follower Pulse Response



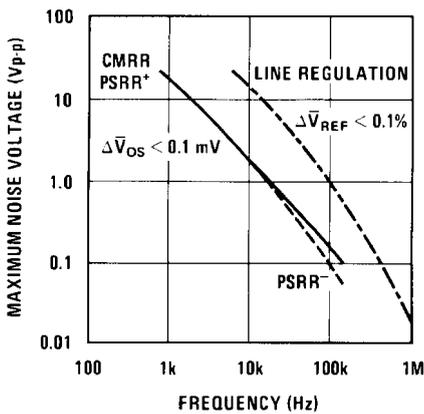
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Noise Rejection



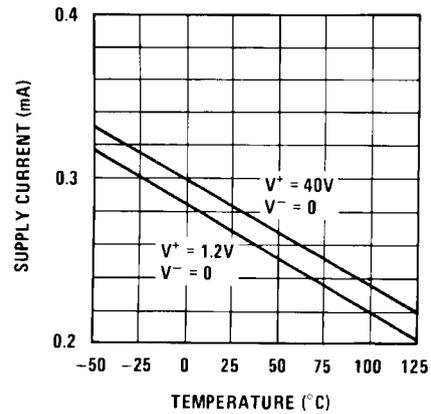
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Rejection Slew Limiting



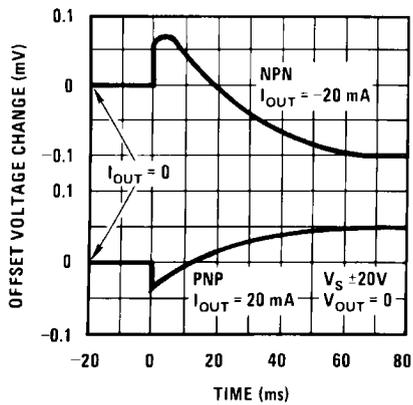
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Supply Current



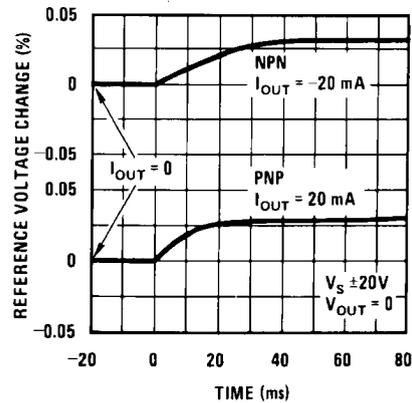
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Thermal Gradient Feedback



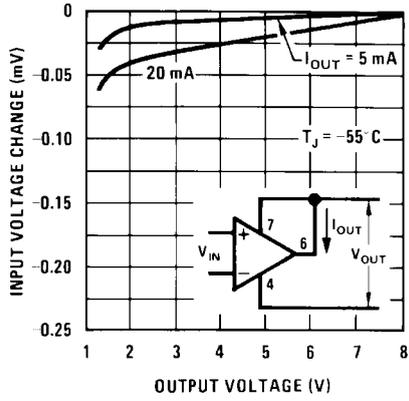
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Thermal Gradient Cross-coupling



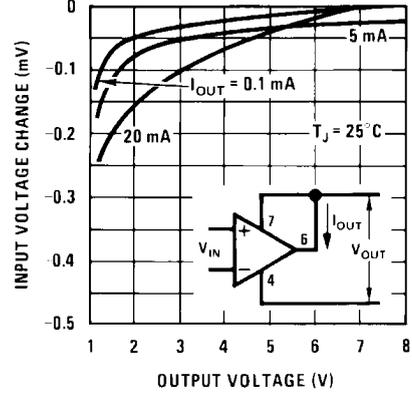
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Shunt Gain



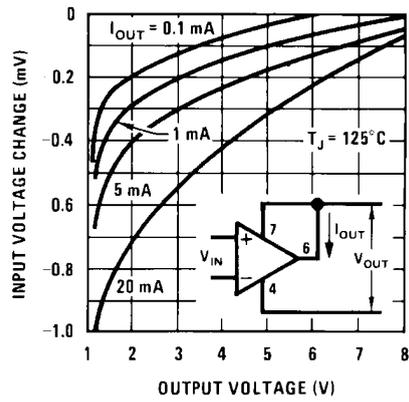
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Shunt Gain



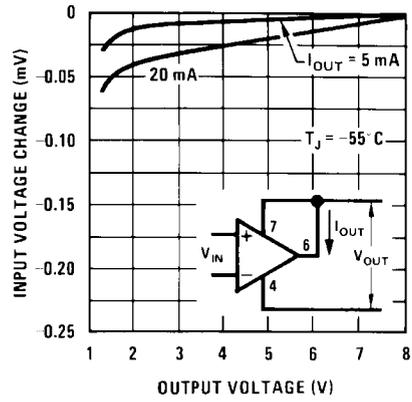
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Shunt Gain



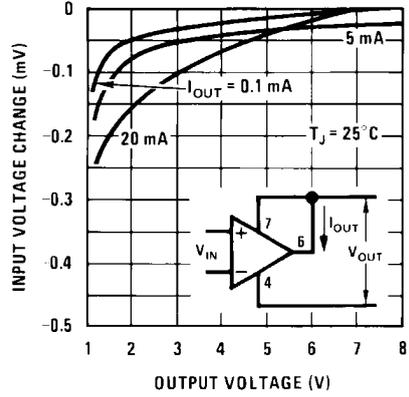
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Shunt Gain



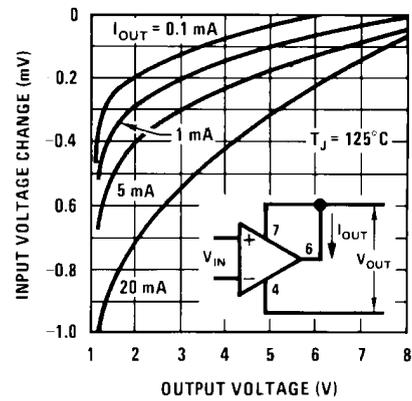
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Shunt Gain



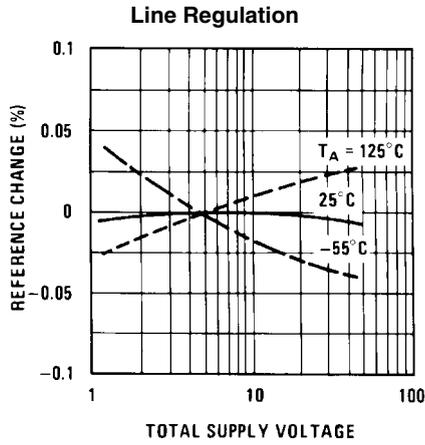
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Shunt Gain

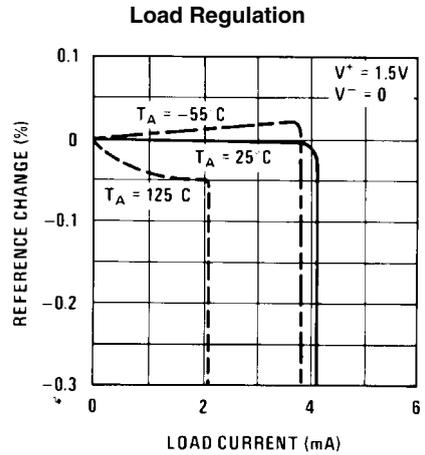


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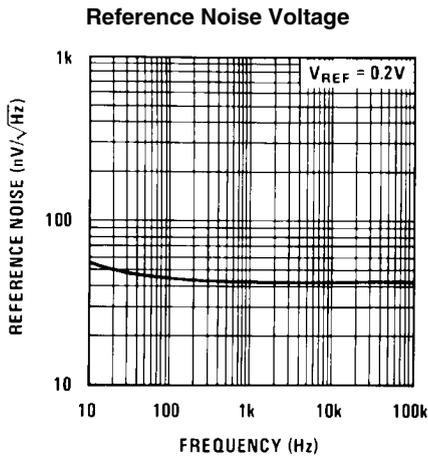
Typical Performance Characteristics (Reference)



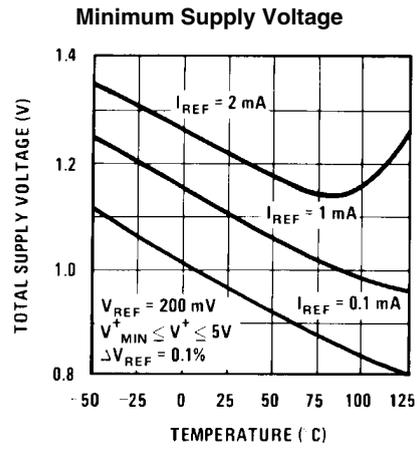
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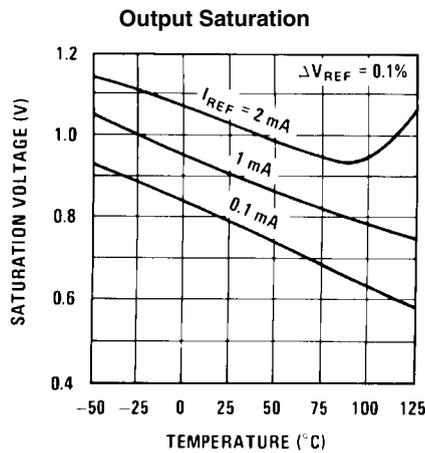
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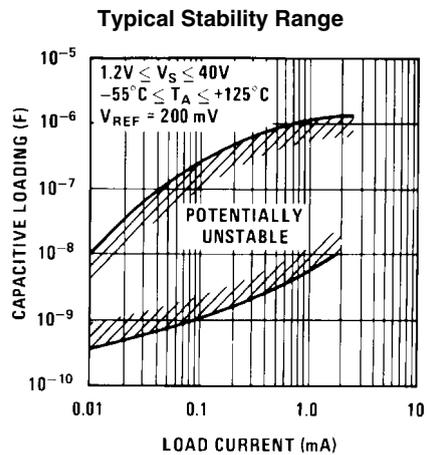
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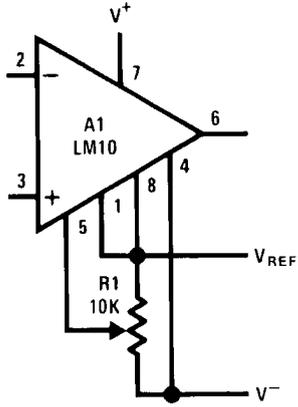
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Typical Applications (Note 8)

(Pin numbers are for devices in 8-pin packages)

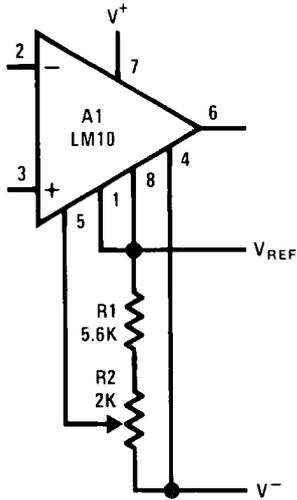
Op Amp Offset Adjustment

Standard



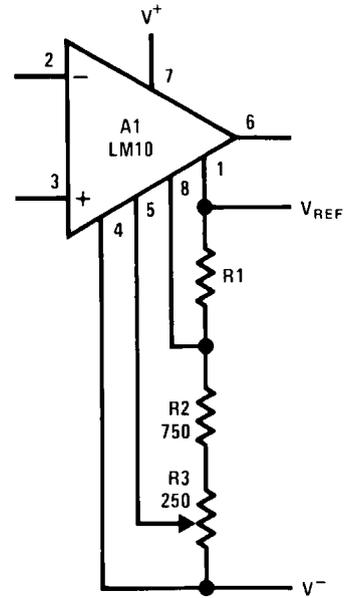
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Limited Range



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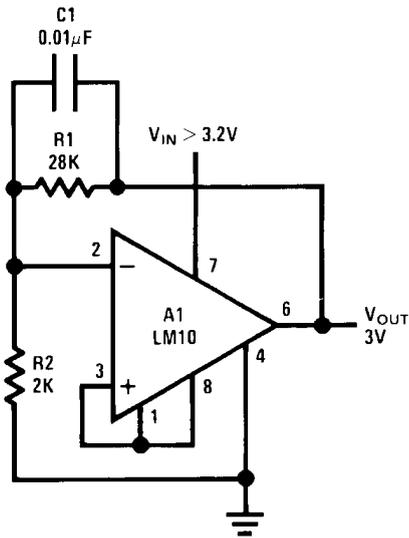
Limited Range With Boosted Reference



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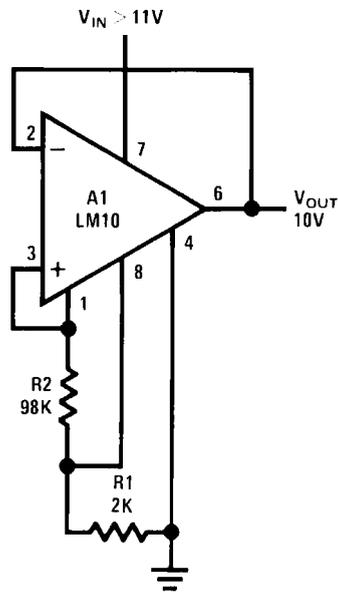
Positive Regulators (Note 7)

Low Voltage



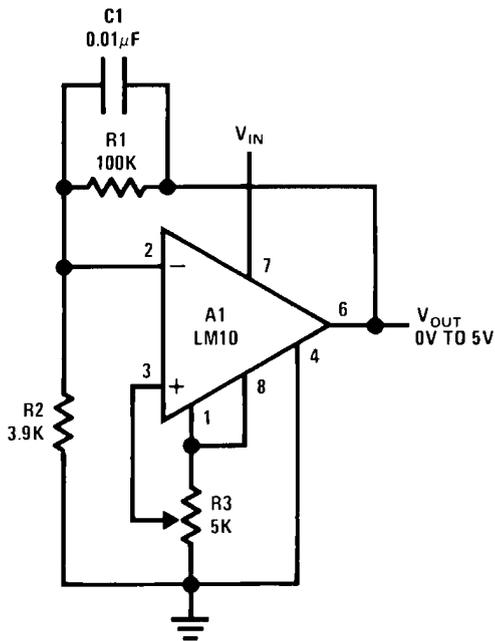
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Best Regulation



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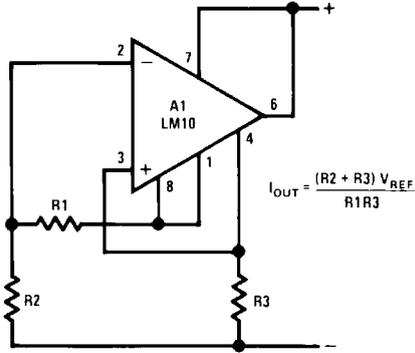
Zero Output



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Note 7: Use only electrolytic output capacitors.

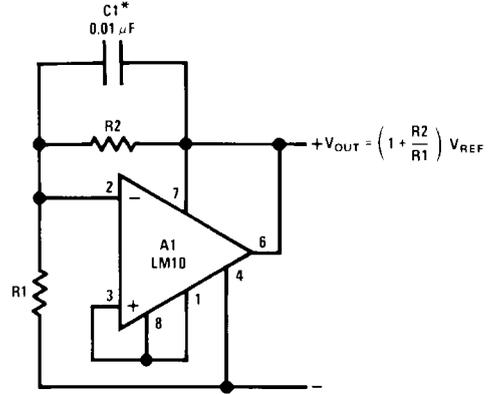
Current Regulator



$$I_{OUT} = \frac{(R2 + R3) V_{REF}}{R1 R3}$$

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Shunt Regulator

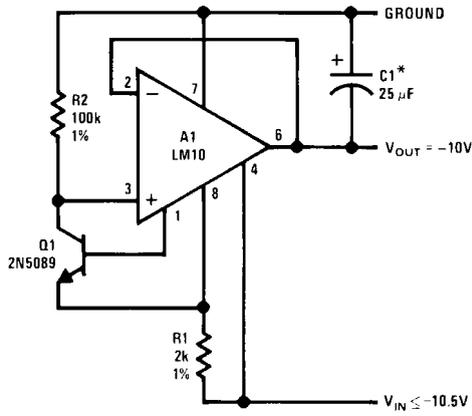


$$+V_{OUT} = \left(1 + \frac{R2}{R1}\right) V_{REF}$$

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Required For Capacitive Loading

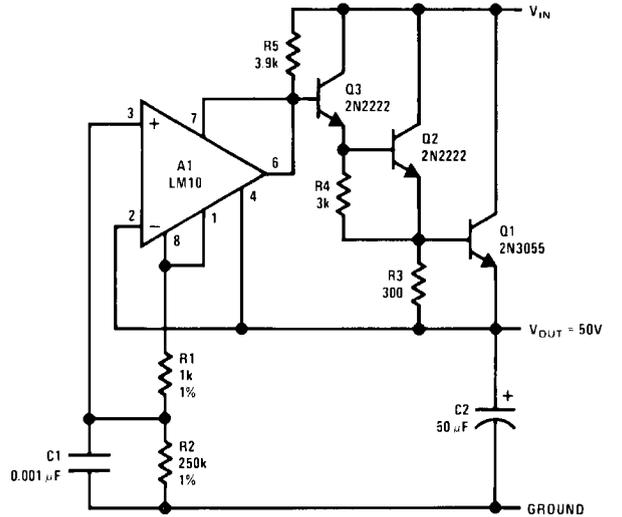
Negative Regulator



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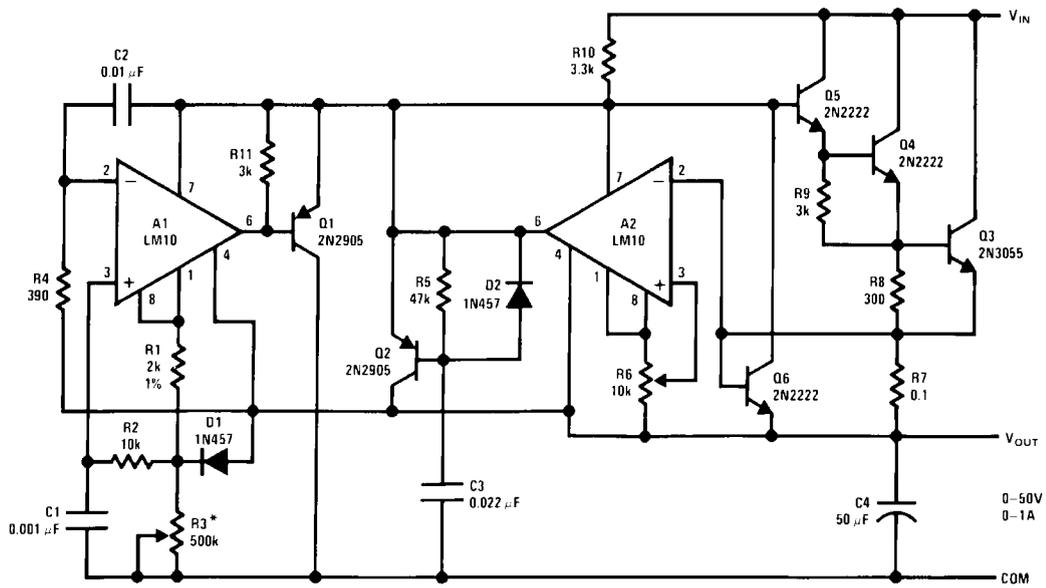
*Electrolytic

Precision Regulator



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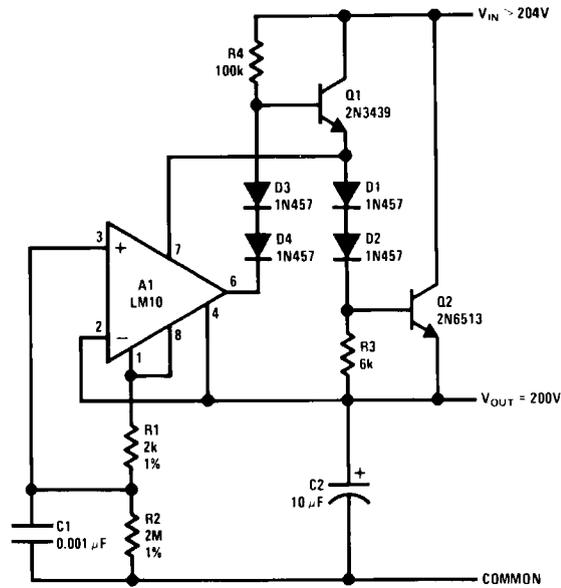
Laboratory Power Supply



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* $V_O = 10^{-4} R_3$

HV Regulator

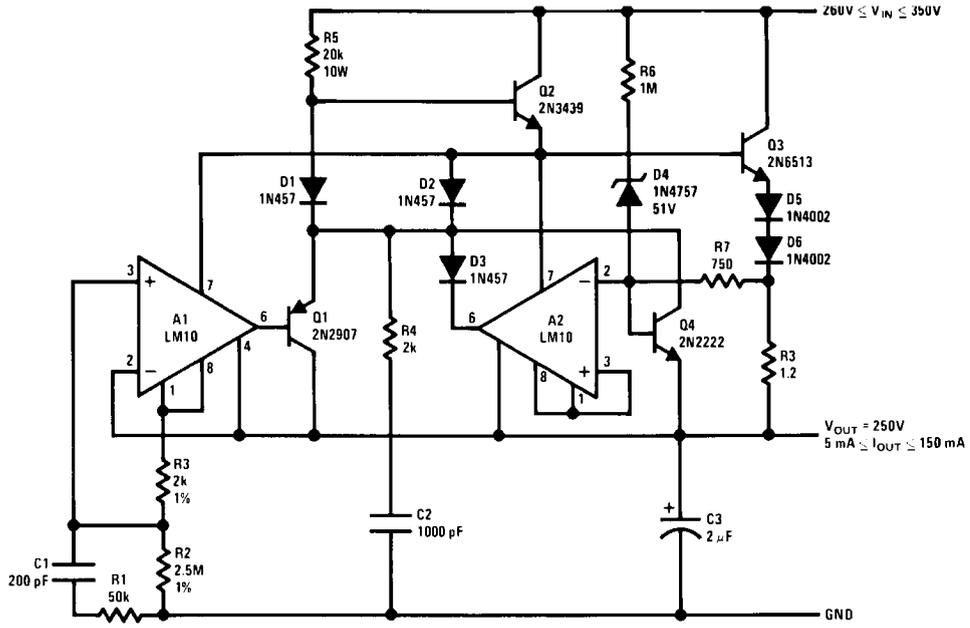


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$$V_{OUT} = \frac{R_2}{R_1} V_{REF}$$

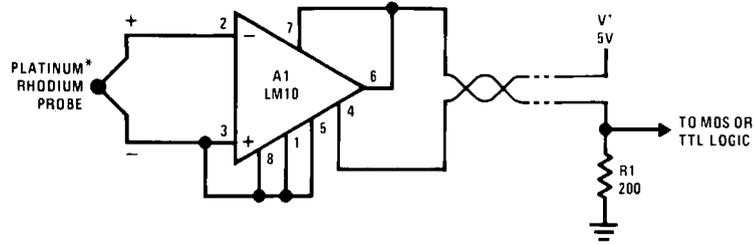
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Protected HV Regulator



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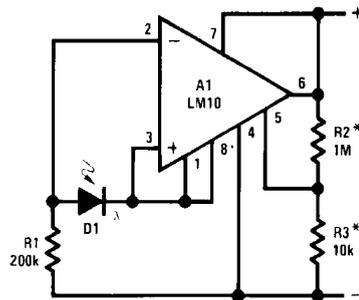
Flame Detector



20149764

*800°C Threshold Is Established By Connecting Balance To V_{Ref} .

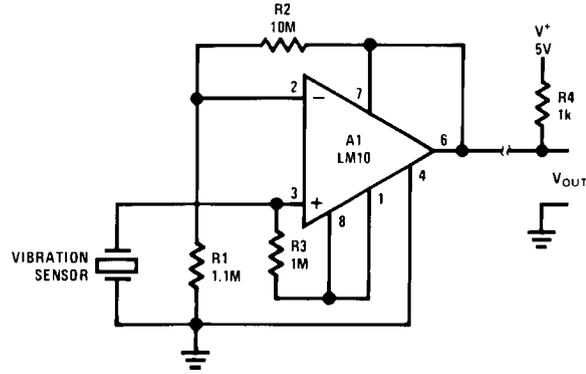
Light Level Sensor



20149765

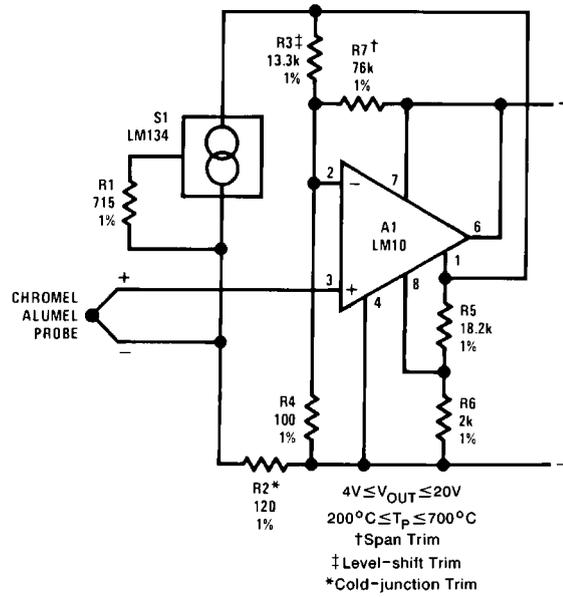
*Provides Hysteresis

Remote Amplifier



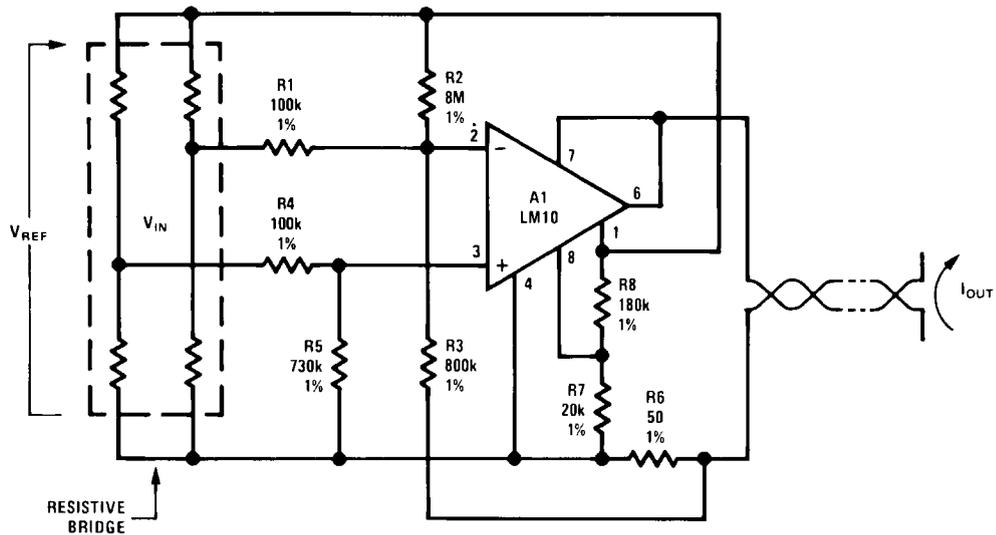
20149766

Remote Thermocouple Amplifier



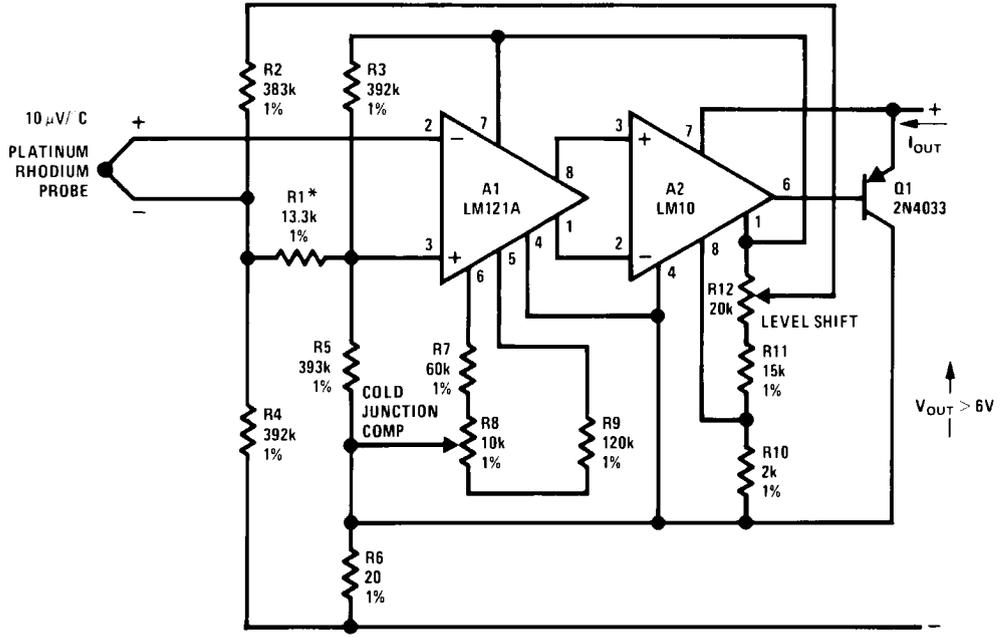
20149767

Transmitter for Bridge Sensor



20149768

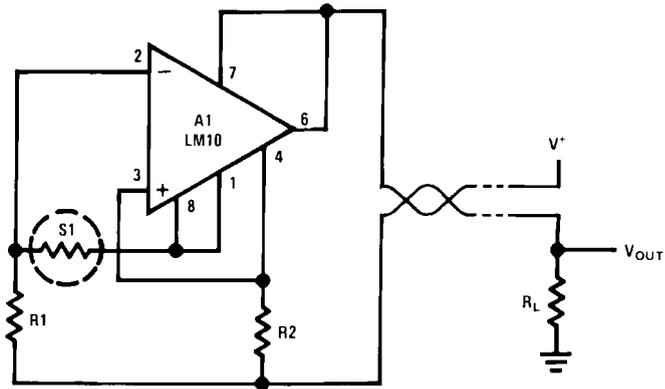
Precision Thermocouple Transmitter



10 mA ≤ I_{OUT} ≤ 50 mA 500°C ≤ T_P ≤ 1500°C *Gain Trim

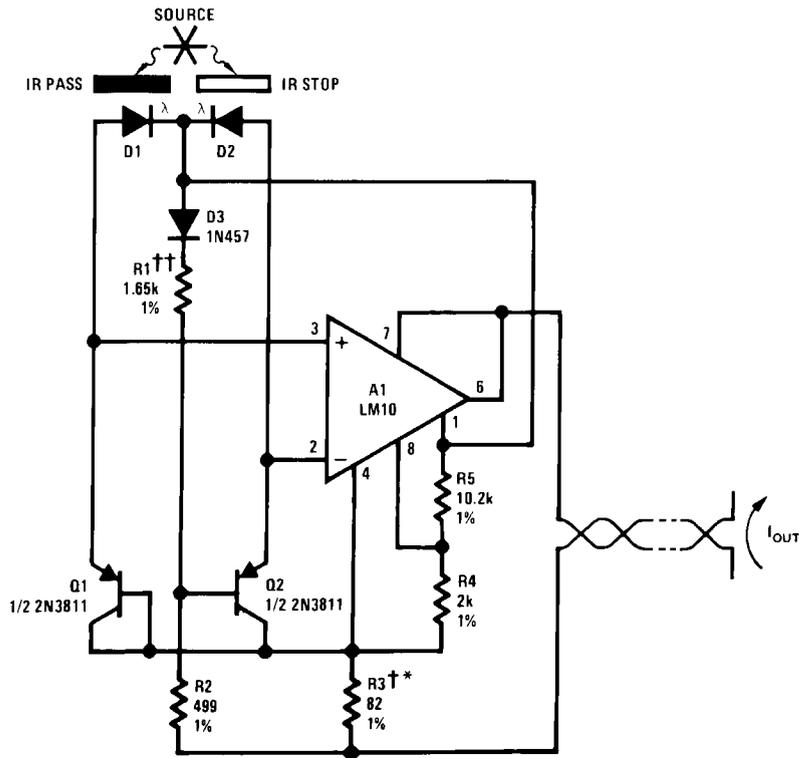
20149769

Resistance Thermometer Transmitter



20149770

Optical Pyrometer



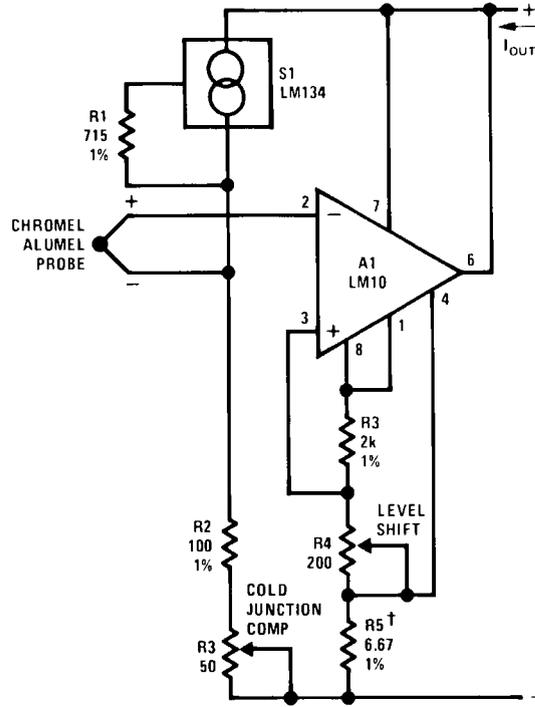
20149771

††Level-shift Trim
 *Scale Factor Trim
 †Copper Wire Wound

$$1 \text{ mA} \leq I_{OUT} \leq 5 \text{ mA}$$

$$0.01 \leq \frac{I_{D2}}{I_{D1}} \leq 100$$

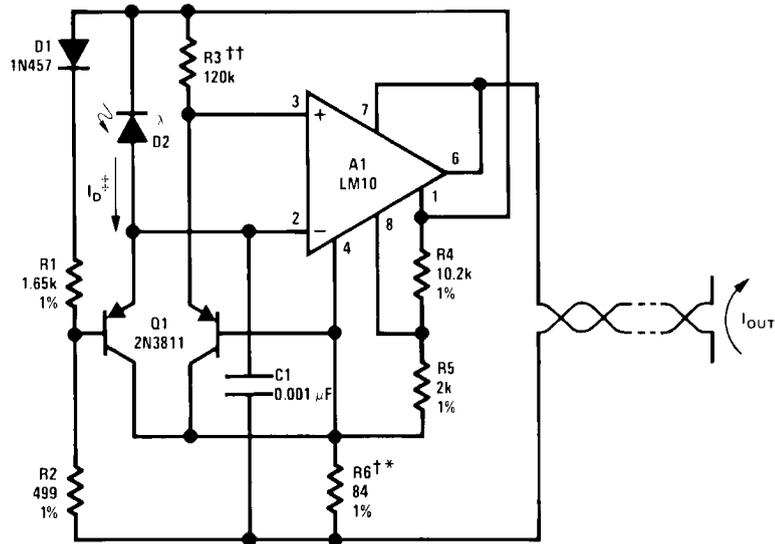
Thermocouple Transmitter



200°C ≤ T_p ≤ 700°C
 1 mA ≤ I_{OUT} ≤ 5 mA
 †Gain Trim

20149772

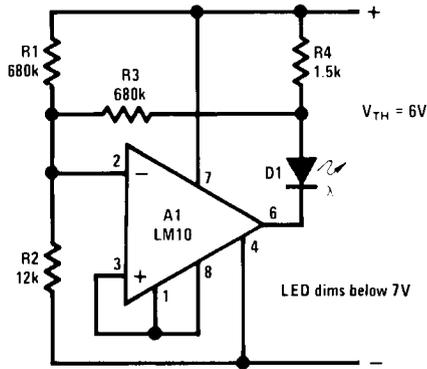
Logarithmic Light Sensor



1 mA ≤ I_{OUT} ≤ 5 mA
 ±50 μA ≤ I_D ≤ 500 μA
 ††Center Scale Trim
 †Scale Factor Trim
 *Copper Wire Wound

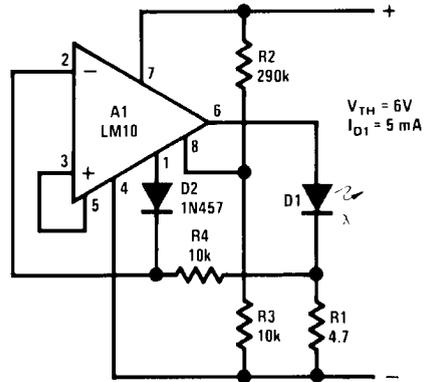
20149773

Battery-level Indicator



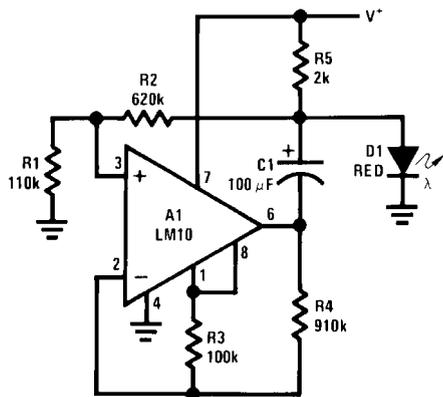
20149774

Battery-threshold Indicator



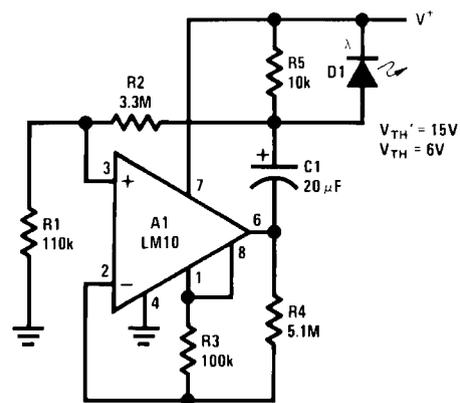
20149775

Single-cell Voltage Monitor



20149776

Double-ended Voltage Monitor

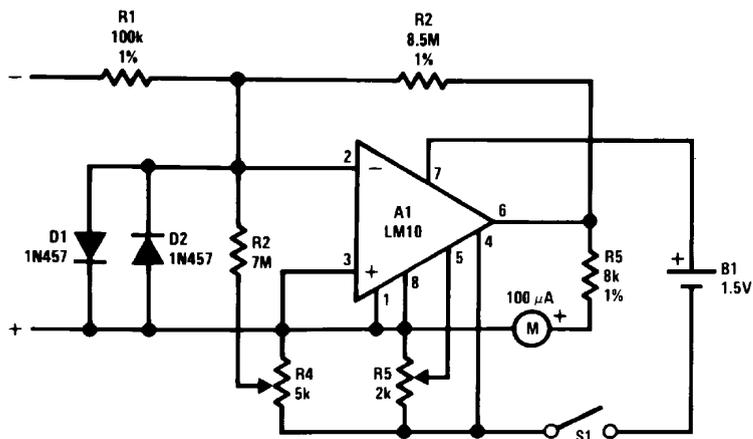


20149777

Flashes Above 1.2V
Rate Increases With
Voltage

Flash Rate Increases
Above 6V and Below 15V

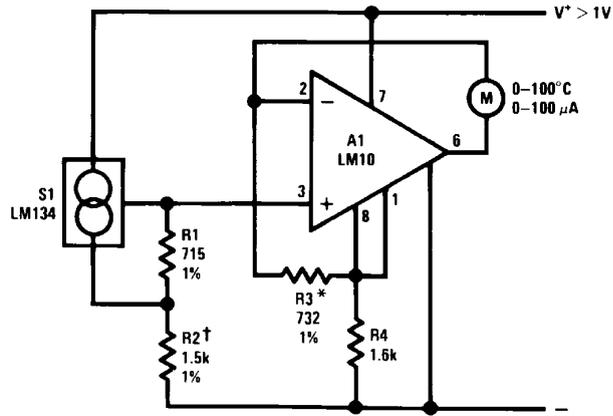
Meter Amplifier



20149778

Input
10 mV, 100nA
Full-Scale

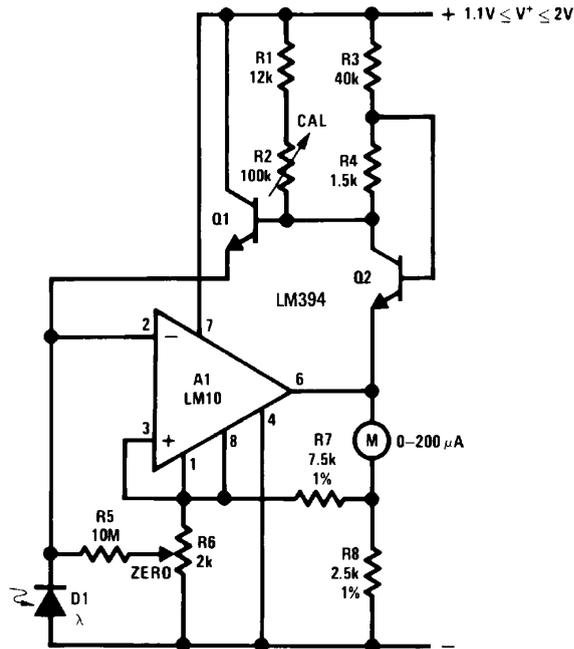
Thermometer



20149779

*Trim For Span
 †Trim For Zero

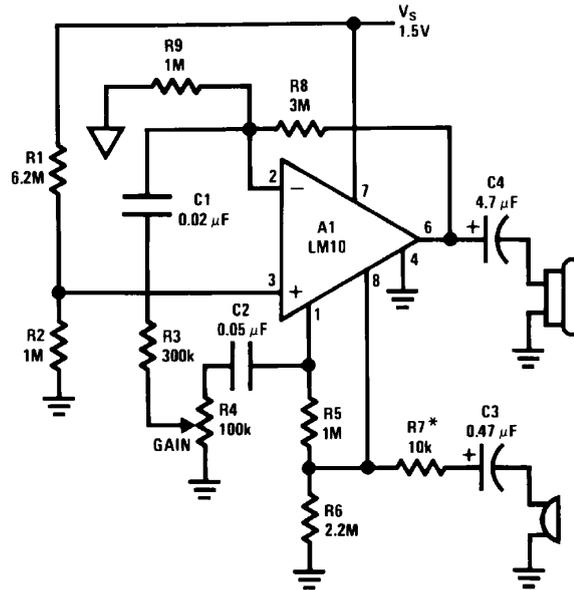
Light Meter



20149780

$1 \leq \lambda/\lambda_0 \leq 10^5$

Microphone Amplifier

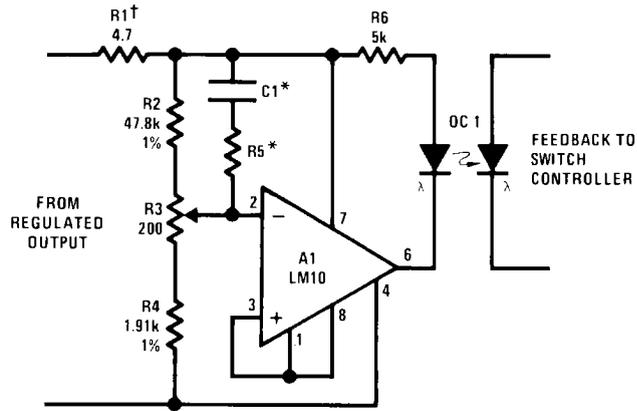


20149781

 $Z_{OUT} \sim 680\Omega @ 5 \text{ kHz}$
 $A_v \leq 1k$
 $f_1 \sim 100 \text{ Hz}$
 $f_2 \sim 5 \text{ kHz}$
 $R_L \sim 500$

*Max Gain Trim

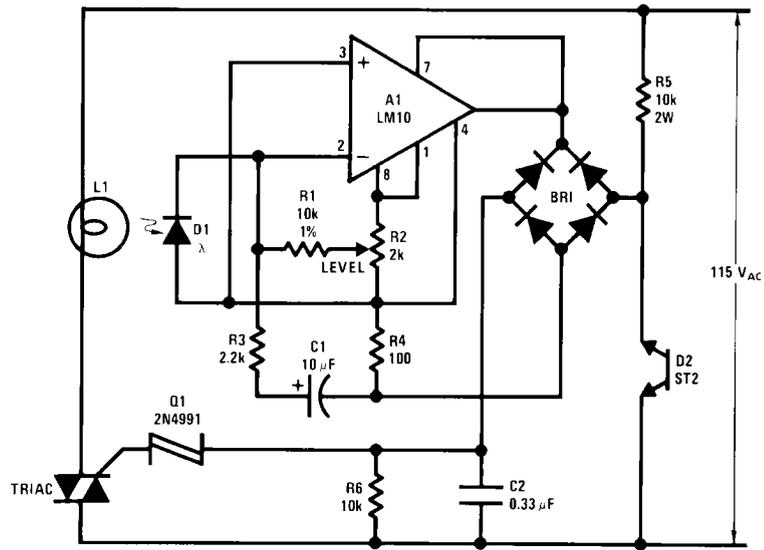
Isolated Voltage Sensor



20149782

†Controls "Loop Gain"
 *Optional Frequency Shaping

Light-level Controller



20149783

Note 8: Circuit descriptions available in application note AN-211.

Application Hints

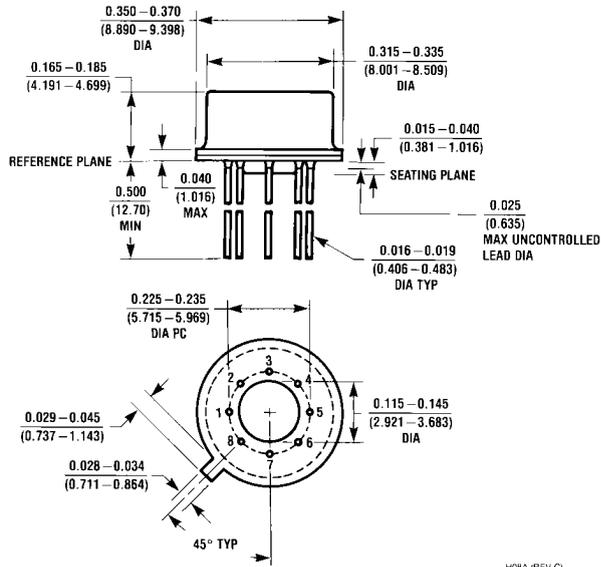
With heavy amplifier loading to V_S^- , resistance drops in the V_S^- lead can adversely affect reference regulation. Lead resistance can approach 1Ω . Therefore, the common to the

reference circuitry should be connected as close as possible to the package.

Revision History

Date Released	Revision	Section	Changes
10/26/2010	A	New release to corporate format	1 MDS converted to standard corporate format. MNLM10-X Rev 0AL will be archived

Physical Dimensions inches (millimeters) unless otherwise noted



Metal Can Package (H)
NS Package Number H08A

H08A (REV C)

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Power Management	www.national.com/power	Green Compliance	www.national.com/quality/green
Switching Regulators	www.national.com/switchers	Distributors	www.national.com/contacts
LDOs	www.national.com/ldo	Quality and Reliability	www.national.com/quality
LED Lighting	www.national.com/led	Feedback/Support	www.national.com/feedback
Voltage References	www.national.com/vref	Design Made Easy	www.national.com/easy
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