

# LM2900,LM3301,LM3900

*LM2900/LM3900/LM3301 Quad Amplifiers*



Literature Number: SNOSBV6

## LM2900/LM3900/LM3301 Quad Amplifiers

### General Description

The LM2900 series consists of four independent, dual input, internally compensated amplifiers which were designed specifically to operate off of a single power supply voltage and to provide a large output voltage swing. These amplifiers make use of a current mirror to achieve the non-inverting input function. Application areas include: ac amplifiers, RC active filters, low frequency triangle, squarewave and pulse waveform generation circuits, tachometers and low speed, high voltage digital logic gates.

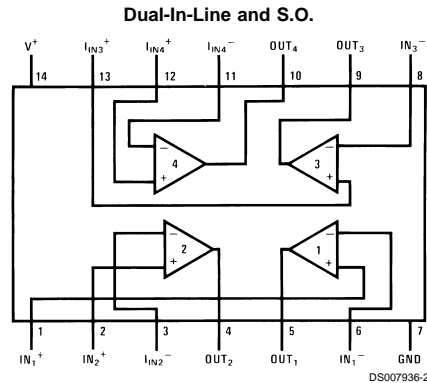
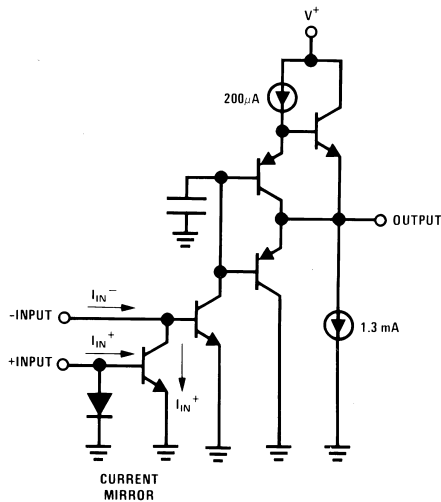
### Features

- Wide single supply voltage:  $4 V_{DC}$  to  $32 V_{DC}$

Range or dual supplies:  $\pm 2 V_{DC}$  to  $\pm 16 V_{DC}$

- Supply current drain independent of supply voltage
- Low input biasing current: 30 nA
- High open-loop gain: 70 dB
- Wide bandwidth: 2.5 MHz (unity gain)
- Large output voltage swing:  $(V^+ - 1) V_{p-p}$
- Internally frequency compensated for unity gain
- Output short-circuit protection

### Schematic and Connection Diagrams



Top View  
Order Number LM2900N, LM3900M, LM3900N or LM3301N  
See NS Package Number M14A or N14A

## Absolute Maximum Ratings (Note 1)

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

	LM2900/LM3900	LM3301
Supply Voltage	32 V <sub>DC</sub> ±16 V <sub>DC</sub>	28 V <sub>DC</sub> ±14 V <sub>DC</sub>
Power Dissipation (T <sub>A</sub> = 25°C) (Note 2)		
Molded DIP	1080 mW	1080 mW
S.O. Package	765 mW	
Input Currents, I <sub>IN</sub> <sup>+</sup> or I <sub>IN</sub> <sup>-</sup>	20 mA <sub>DC</sub>	20 mA <sub>DC</sub>
Output Short-Circuit Duration — One Amplifier	Continuous	Continuous
T <sub>A</sub> = 25°C (See Application Hints)		
Operating Temperature Range		-40°C to +85°C
LM2900	-40°C to +85°C	
LM3900	0°C to +70°C	
Storage Temperature Range	-65°C to +150°C	-65°C to +150°C
Lead Temperature (Soldering, 10 sec.)	260°C	260°C
Soldering Information		
Dual-In-Line Package		
Soldering (10 sec.)	260°C	260°C
Small Outline Package		
Vapor Phase (60 sec.)	215°C	215°C
Infrared (15 sec.)	220°C	220°C
See AN-450 "Surface Mounting Methods and Their Effect on Product Reliability" for other methods of soldering surface mount devices.		
ESD tolerance (Note 8)	2000V	2000V

## Electrical Characteristics

(Note 7) T<sub>A</sub> = 25°C, V<sup>+</sup> = 15 V<sub>DC</sub>, unless otherwise stated

Parameter		Conditions	LM2900			LM3900			LM3301			Units
			Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Open Loop	Voltage Gain	Over Temp.										V/mV
	Voltage Gain	ΔV <sub>O</sub> = 10 V <sub>DC</sub>	1.2	2.8		1.2	2.8		1.2	2.8		
	Input Resistance	Inverting Input		1			1			1		MΩ
	Output Resistance			8			8			9		kΩ
Unity Gain Bandwidth		Inverting Input		2.5			2.5			2.5		MHz
Input Bias Current		Inverting Input, V <sup>+</sup> = 5 V <sub>DC</sub>		30	200		30	200		30	300	nA
Slew Rate		Positive Output Swing		0.5			0.5			0.5		V/μs
		Negative Output Swing		20			20			20		
Supply Current		R <sub>L</sub> = ∞ On All Amplifiers		6.2	10		6.2	10		6.2	10	mA <sub>DC</sub>
Output Voltage Swing	V <sub>OUT</sub> High	R <sub>L</sub> = 2k, V <sup>+</sup> = 15.0 V <sub>DC</sub>	I <sub>IN</sub> <sup>-</sup> = 0, I <sub>IN</sub> <sup>+</sup> = 0	13.5			13.5			13.5		V <sub>DC</sub>
	V <sub>OUT</sub> Low				0.09	0.2		0.09	0.2		0.09	
	V <sub>OUT</sub> High	V <sup>+</sup> = Absolute Maximum Ratings	I <sub>IN</sub> <sup>-</sup> = 0, I <sub>IN</sub> <sup>+</sup> = 0 R <sub>L</sub> = ∞,	29.5			29.5			26.0		
Output Current	Source		6	18		6	10		5	18		mA <sub>DC</sub>
	Sink	(Note 3)	0.5	1.3		0.5	1.3		0.5	1.3		
Capability	I <sub>SINK</sub>	V <sub>OL</sub> = 1V, I <sub>IN</sub> <sup>-</sup> = 5 μA		5			5			5		
Power Supply Rejection		T <sub>A</sub> = 25°C, f = 100 Hz		70			70			70		dB

## Electrical Characteristics (Continued)

(Note 7)  $T_A = 25^\circ\text{C}$ ,  $V^+ = 15 V_{DC}$ , unless otherwise stated

Parameter	Conditions	LM2900			LM3900			LM3301			Units
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Mirror Gain	@ 20 $\mu\text{A}$ (Note 4)	0.90	1.0	1.1	0.90	1.0	1.1	0.90	1	1.10	$\mu\text{A}/\mu\text{A}$
	@ 200 $\mu\text{A}$ (Note 4)	0.90	1.0	1.1	0.90	1.0	1.1	0.90	1	1.10	
$\Delta$ Mirror Gain	@ 20 $\mu\text{A}$ to 200 $\mu\text{A}$ (Note 4)		2	5		2	5		2	5	%
Mirror Current	(Note 5)		10	500		10	500		10	500	$\mu\text{A}_{DC}$
Negative Input Current	$T_A = 25^\circ\text{C}$ (Note 6)		1.0			1.0			1.0		$\text{mA}_{DC}$
Input Bias Current	Inverting Input		300			300					nA

**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.

**Note 2:** For operating at high temperatures, the device must be derated based on a  $125^\circ\text{C}$  maximum junction temperature and a thermal resistance of  $92^\circ\text{C}/\text{W}$  which applies for the device soldered in a printed circuit board, operating in a still air ambient. Thermal resistance for the S.O. package is  $131^\circ\text{C}/\text{W}$ .

**Note 3:** The output current sink capability can be increased for large signal conditions by overdriving the inverting input. This is shown in the section on Typical Characteristics.

**Note 4:** This spec indicates the current gain of the current mirror which is used as the non-inverting input.

**Note 5:** Input  $V_{BE}$  match between the non-inverting and the inverting inputs occurs for a mirror current (non-inverting input current) of approximately 10  $\mu\text{A}$ . This is therefore a typical design center for many of the application circuits.

**Note 6:** Clamp transistors are included on the IC to prevent the input voltages from swinging below ground more than approximately  $-0.3 V_{DC}$ . The negative input currents which may result from large signal overdrive with capacitance input coupling need to be externally limited to values of approximately 1 mA. Negative input currents in excess of 4 mA will cause the output voltage to drop to a low voltage. This maximum current applies to any one of the input terminals. If more than one of the input terminals are simultaneously driven negative smaller maximum currents are allowed. Common-mode current biasing can be used to prevent negative input voltages; see for example, the "Differentiator Circuit" in the applications section.

**Note 7:** These specs apply for  $-40^\circ\text{C} \leq T_A \leq +85^\circ\text{C}$ , unless otherwise stated.

**Note 8:** Human body model, 1.5 k $\Omega$  in series with 100 pF.

## Application Hints

When driving either input from a low-impedance source, a limiting resistor should be placed in series with the input lead to limit the peak input current. Currents as large as 20 mA will not damage the device, but the current mirror on the non-inverting input will saturate and cause a loss of mirror gain at mA current levels — especially at high operating temperatures.

Precautions should be taken to insure that the power supply for the integrated circuit never becomes reversed in polarity or that the unit is not inadvertently installed backwards in a test socket as an unlimited current surge through the resulting forward diode within the IC could cause fusing of the internal conductors and result in a destroyed unit.

Output short circuits either to ground or to the positive power supply should be of short time duration. Units can be destroyed, not as a result of the short circuit current causing metal fusing, but rather due to the large increase in IC chip dissipation which will cause eventual failure due to excessive junction temperatures. For example, when operating from a well-regulated  $+5 V_{DC}$  power supply at  $T_A = 25^\circ\text{C}$  with a 100 k $\Omega$  shunt-feedback resistor (from the output to the inverting input) a short directly to the power supply will not cause catastrophic failure but the current magnitude will be approximately 50 mA and the junction temperature will be above  $T_J$  max. Larger feedback resistors will reduce the current, 11 M $\Omega$  provides approximately 30 mA, an open circuit provides 1.3 mA, and a direct connection from the output to the non-inverting input will result in catastrophic failure when the output is shorted to  $V^+$  as this then places the base-emitter junction of the input transistor directly across the power supply. Short-circuits to ground will have magnitudes of approximately 30 mA and will not cause catastrophic failure at  $T_A = 25^\circ\text{C}$ .

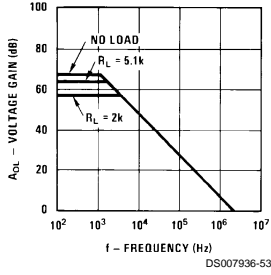
Unintentional signal coupling from the output to the non-inverting input can cause oscillations. This is likely only in breadboard hook-ups with long component leads and can be prevented by a more careful lead dress or by locating the non-inverting input biasing resistor close to the IC. A quick check of this condition is to bypass the non-inverting input to ground with a capacitor. High impedance biasing resistors used in the non-inverting input circuit make this input lead highly susceptible to unintentional AC signal pickup.

Operation of this amplifier can be best understood by noticing that input currents are differenced at the inverting-input terminal and this difference current then flows through the external feedback resistor to produce the output voltage. Common-mode current biasing is generally useful to allow operating with signal levels near ground or even negative as this maintains the inputs biased at  $+V_{BE}$ . Internal clamp transistors (Note 6) catch-negative input voltages at approximately  $-0.3 V_{DC}$  but the magnitude of current flow has to be limited by the external input network. For operation at high temperature, this limit should be approximately 100  $\mu\text{A}$ .

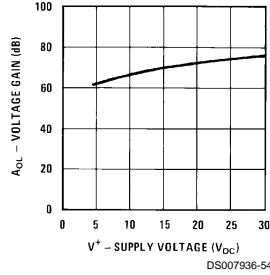
This new "Norton" current-differencing amplifier can be used in most of the applications of a standard IC op amp. Performance as a DC amplifier using only a single supply is not as precise as a standard IC op amp operating with split supplies but is adequate in many less critical applications. New functions are made possible with this amplifier which are useful in single power supply systems. For example, biasing can be designed separately from the AC gain as was shown in the "inverting amplifier," the "difference integrator" allows controlling the charging and the discharging of the integrating capacitor with positive voltages, and the "frequency doubling tachometer" provides a simple circuit which reduces the ripple voltage on a tachometer output DC voltage.

## Typical Performance Characteristics

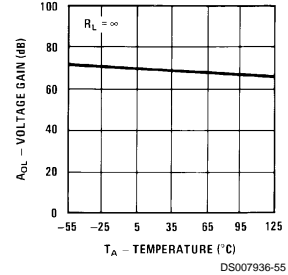
Open Loop Gain



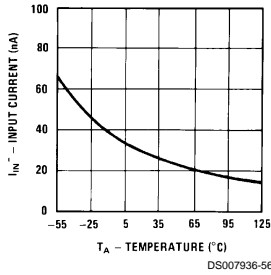
Voltage Gain



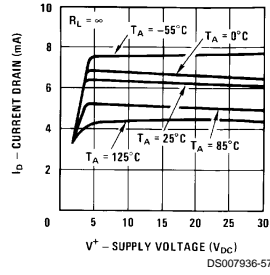
Voltage Gain



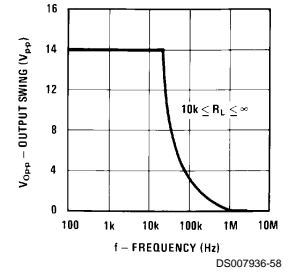
Input Current



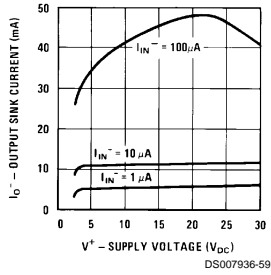
Supply Current



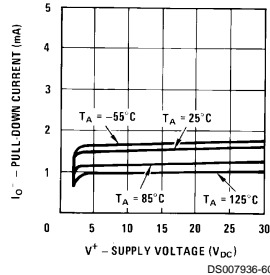
Large Signal Frequency Response



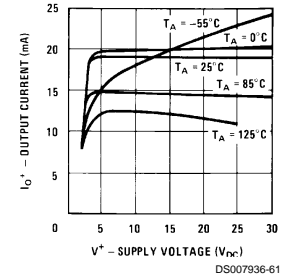
Output Sink Current



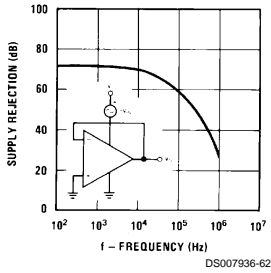
Output Class-A Bias Current



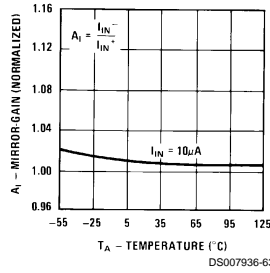
Output Source Current



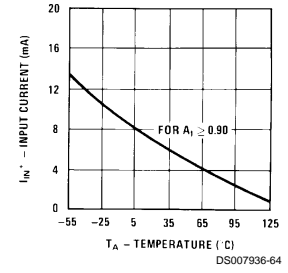
Supply Rejection



Mirror Gain

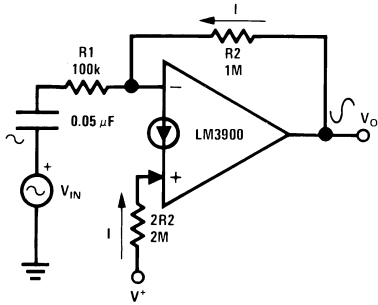


Maximum Mirror Current



## Typical Applications ( $V^+ = 15 V_{DC}$ )

### Inverting Amplifier

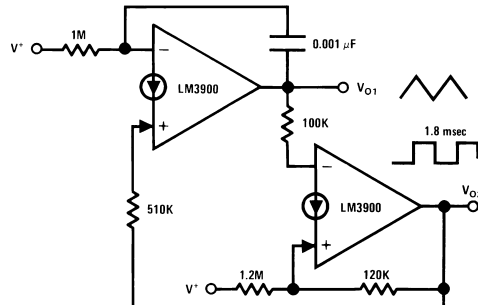


DS007936-3

$$V_{ODC} = \frac{V^+}{2}$$

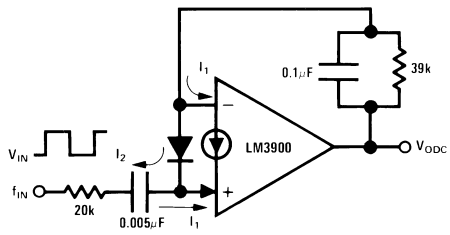
$$A_v \cong -\frac{R2}{R1}$$

### Triangle/Square Generator



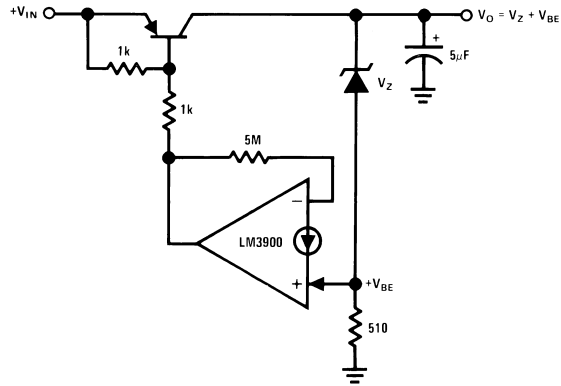
DS007936-4

### Frequency-Doubling Tachometer



DS007936-5

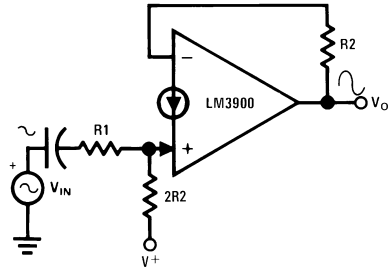
### Low $V_{IN} - V_{OUT}$ Voltage Regulator



DS007936-6

**Typical Applications** ( $V^+ = 15\text{ V}_{DC}$ ) (Continued)

**Non-Inverting Amplifier**

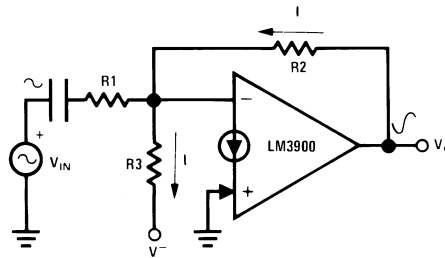


DS007936-7

$$V_{ODC} = \frac{V^+}{2}$$

$$A_V \cong \frac{R_2}{R_1}$$

**Negative Supply Biasing**

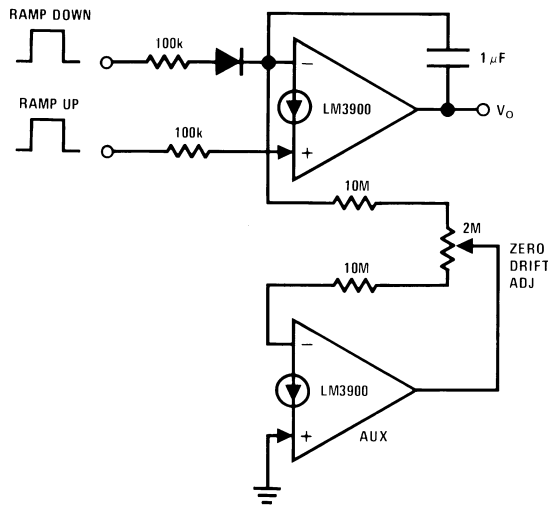


DS007936-8

$$V_{ODC} = \frac{R_2}{R_3} V^-$$

$$A_V \cong \frac{R_2}{R_1}$$

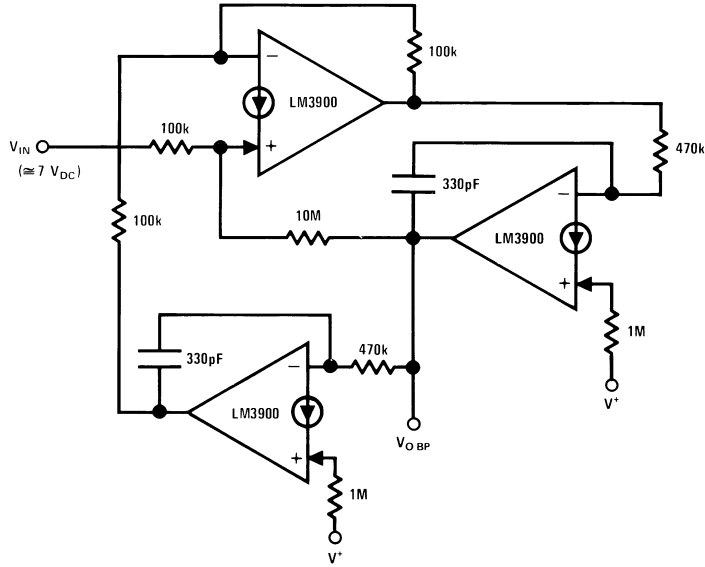
**Low-Drift Ramp and Hold Circuit**



DS007936-10

**Typical Applications** ( $V^+ = 15 V_{DC}$ ) (Continued)

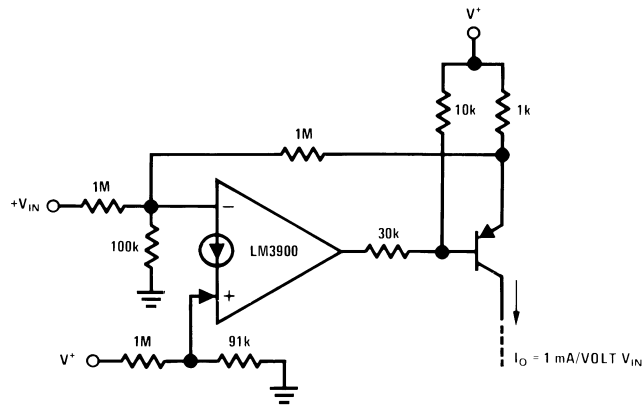
**Bi-Quad Active Filter  
(2nd Degree State-Variable Network)**



DS007936-11

$Q = 50$   
 $f_0 = 1 \text{ kHz}$

**Voltage-Controlled Current Source  
(Transconductance Amplifier)**

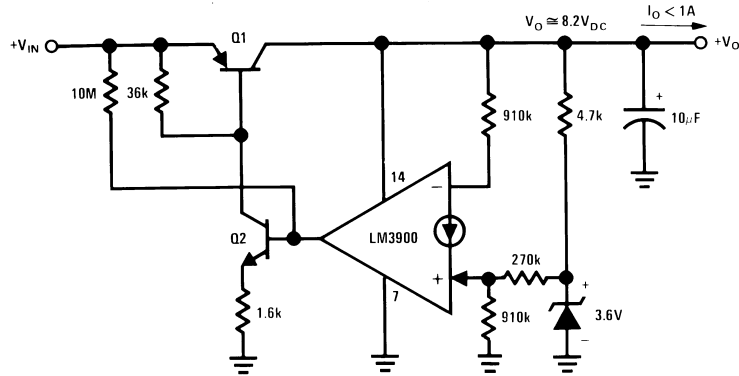


DS007936-12



**Typical Applications** ( $V^+ = 15 V_{DC}$ ) (Continued)

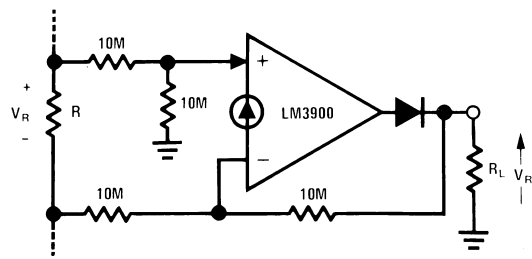
**Hi  $V_{IN}$ , Lo ( $V_{IN} - V_O$ ) Self-Regulator**



DS007936-13

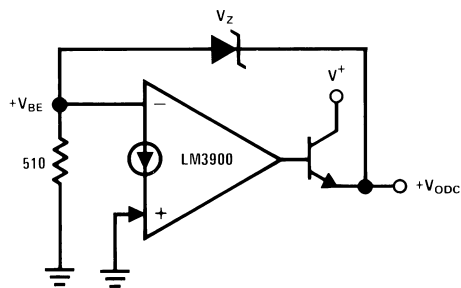
Q1 & Q2 absorb Hi  $V_{IN}$

**Ground-Referencing a Differential Input Signal**



DS007936-14

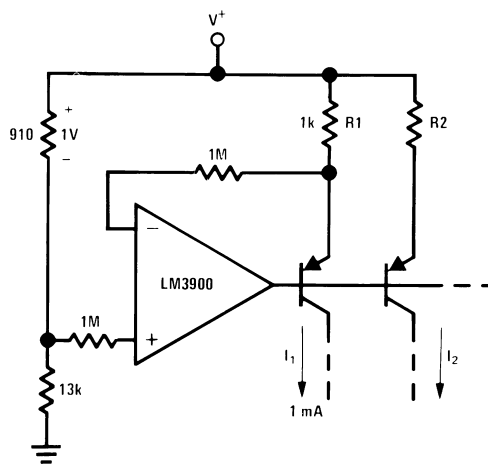
**Voltage Regulator**



DS007936-15

$(V_O = V_Z + V_{BE})$

**Fixed Current Sources**

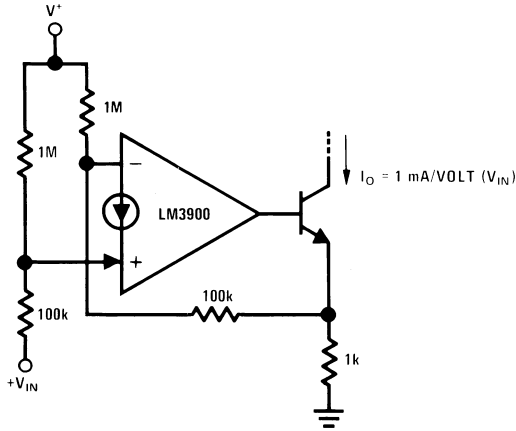


DS007936-16

$$I_2 = \frac{R_1}{R_2} I_1$$

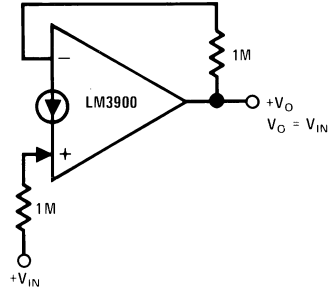
**Typical Applications** ( $V^+ = 15 V_{DC}$ ) (Continued)

**Voltage-Controlled Current Sink (Transconductance Amplifier)**



DS007936-17

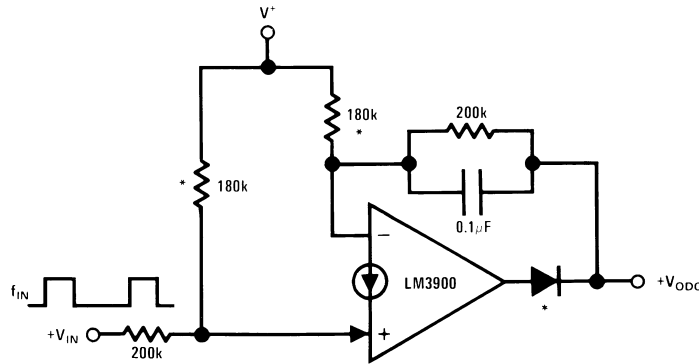
**Buffer Amplifier**



DS007936-18

$V_{IN} \geq V_{BE}$

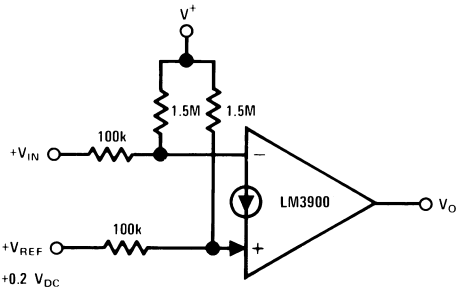
**Tachometer**



DS007936-19

$V_{ODC} = A f_{IN}$   
\* Allows  $V_O$  to go to zero.

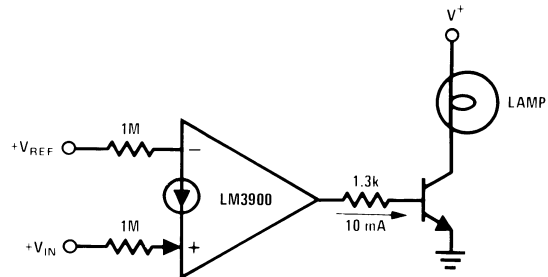
**Low-Voltage Comparator**



DS007936-20

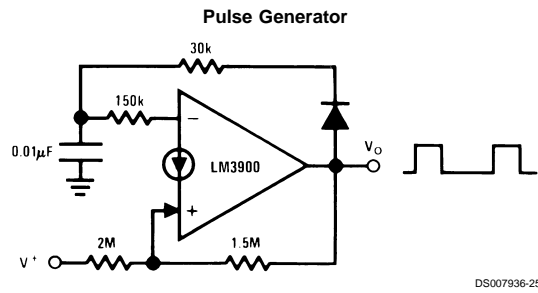
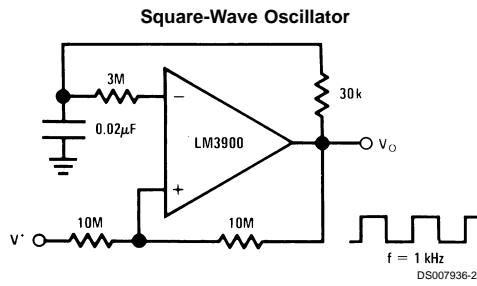
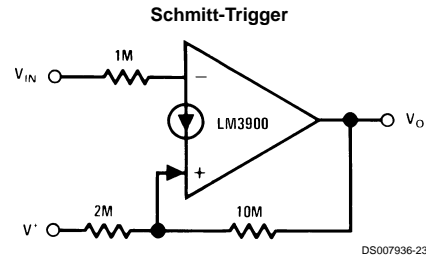
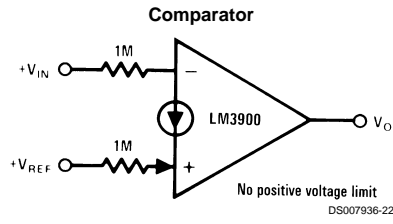
No negative voltage limit if properly biased.

**Power Comparator**

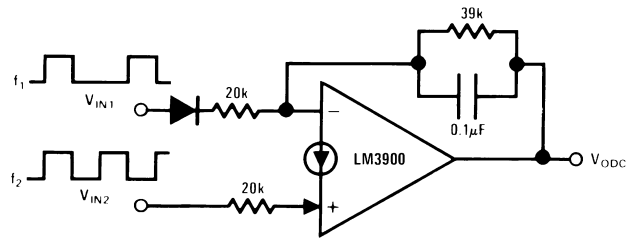


DS007936-21

**Typical Applications** ( $V^+ = 15 V_{DC}$ ) (Continued)

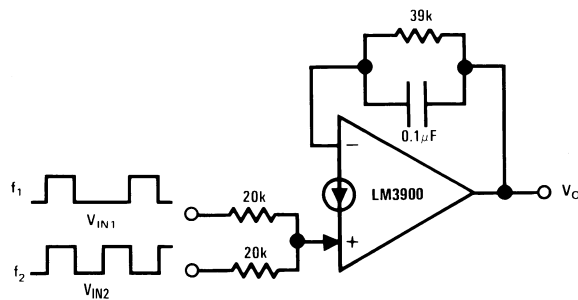


**Frequency Differencing Tachometer**



$V_{ODC} = A (f_1 - f_2)$

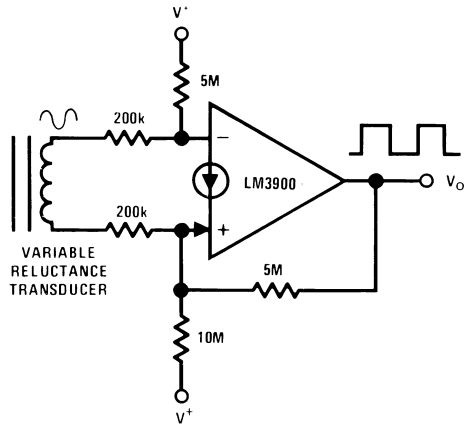
**Frequency Averaging Tachometer**



$V_{ODC} = A (f_1 + f_2)$

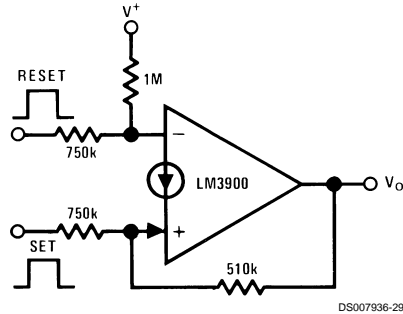
## Typical Applications ( $V^+ = 15 V_{DC}$ ) (Continued)

### Squaring Amplifier (W/Hysteresis)



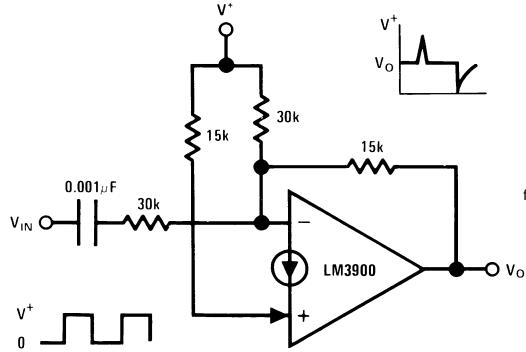
DS007936-28

### Bi-Stable Multivibrator



DS007936-29

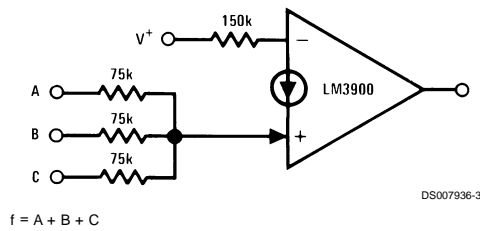
### Differentiator (Common-Mode Biasing Keeps Input at $+V_{BE}$ )



DS007936-30

$$A_V = \frac{1}{2}$$

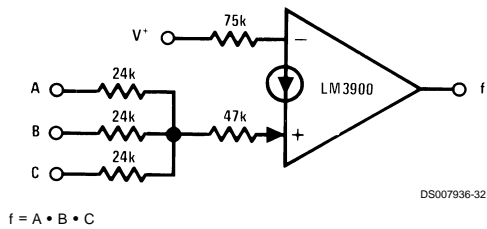
### "OR" Gate



DS007936-31

$$f = A + B + C$$

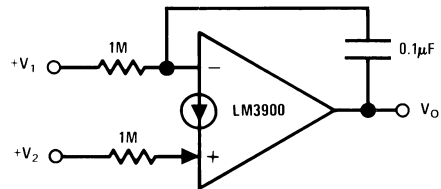
### "AND" Gate



DS007936-32

$$f = A \cdot B \cdot C$$

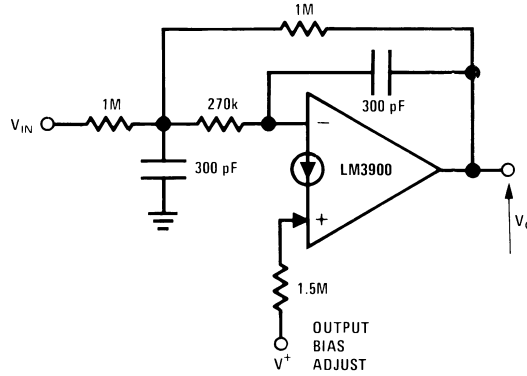
### Difference Integrator



DS007936-33

**Typical Applications** ( $V^+ = 15 V_{DC}$ ) (Continued)

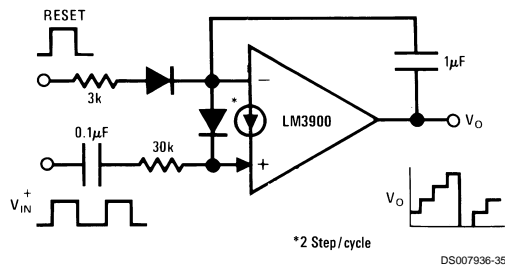
**Low Pass Active Filter**



DS007936-34

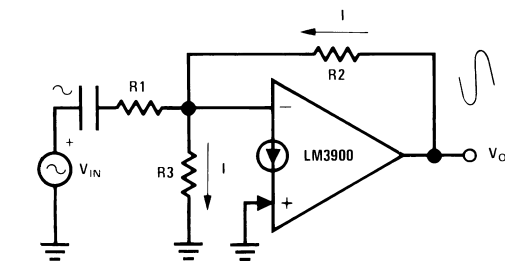
$f_0 = 1 \text{ kHz}$

**Staircase Generator**



DS007936-35

**$V_{BE}$  Biasing**



$$V_{BE} = 0.5 V_{DC}$$

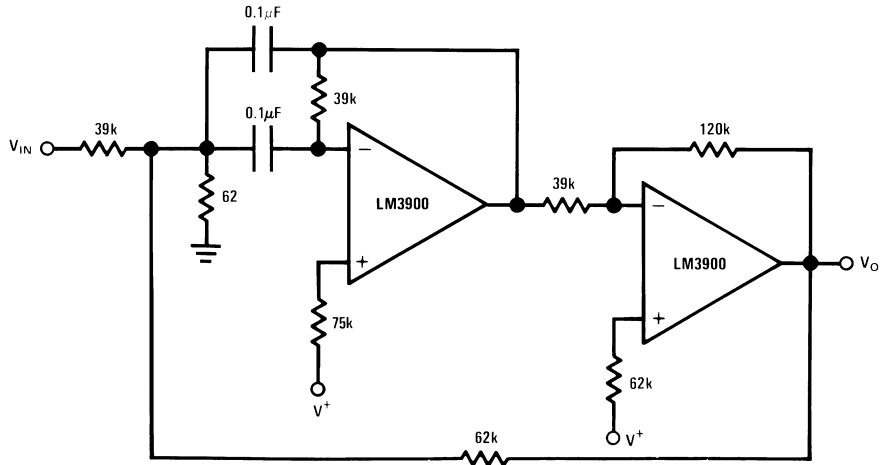
$$V_{ODC} = V_{BE} \left( 1 + \frac{R2}{R3} \right)$$

DS007936-36

$$A_V \approx - \frac{R2}{R1}$$

**Typical Applications** ( $V^+ = 15 V_{DC}$ ) (Continued)

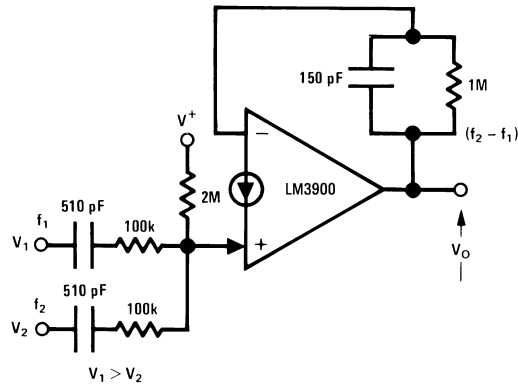
**Bandpass Active Filter**



DS007936-37

$f_o = 1 \text{ kHz}$   
 $Q = 25$

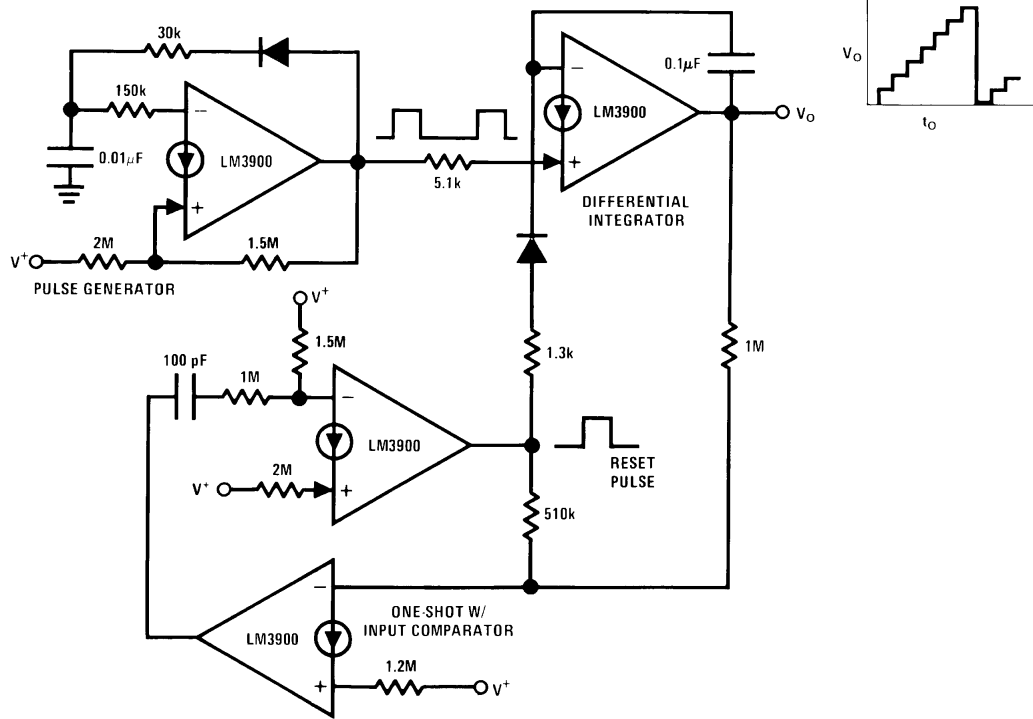
**Low-Frequency Mixer**



DS007936-38

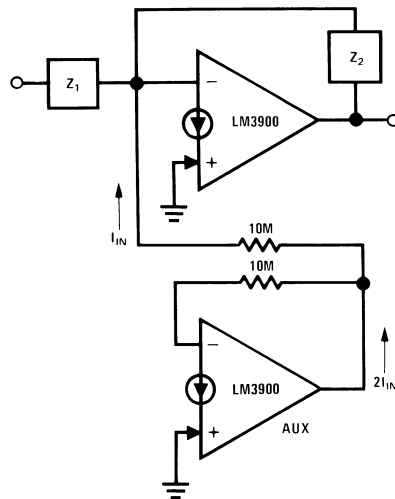
Typical Applications ( $V^+ = 15 V_{DC}$ ) (Continued)

Free-Running Staircase Generator/Pulse Counter



DS007936-39

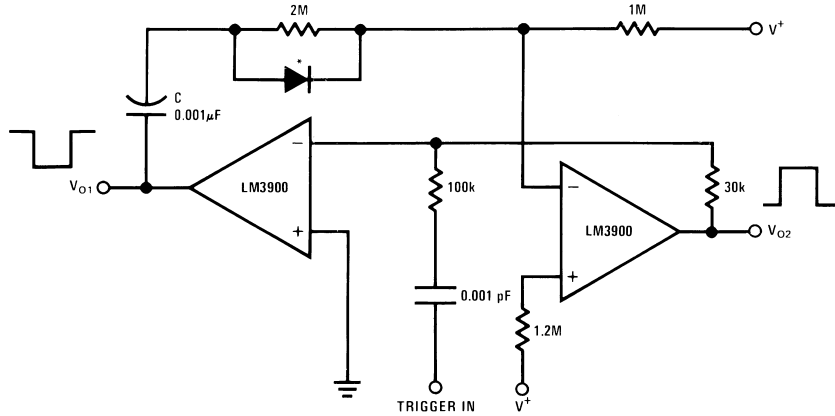
Supplying  $I_{IN}$  with Aux. Amp  
(to Allow Hi-Z Feedback Networks)



DS007936-40

**Typical Applications** ( $V^+ = 15 V_{DC}$ ) (Continued)

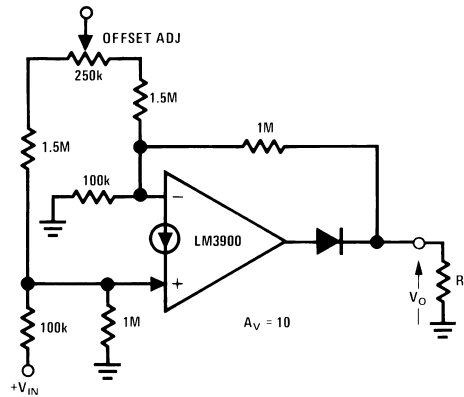
**One-Shot Multivibrator**



DS007936-41

$PW \cong 2 \times 10^6 C$   
 \* Speeds recovery.

**Non-Inverting DC Gain to (0,0)**

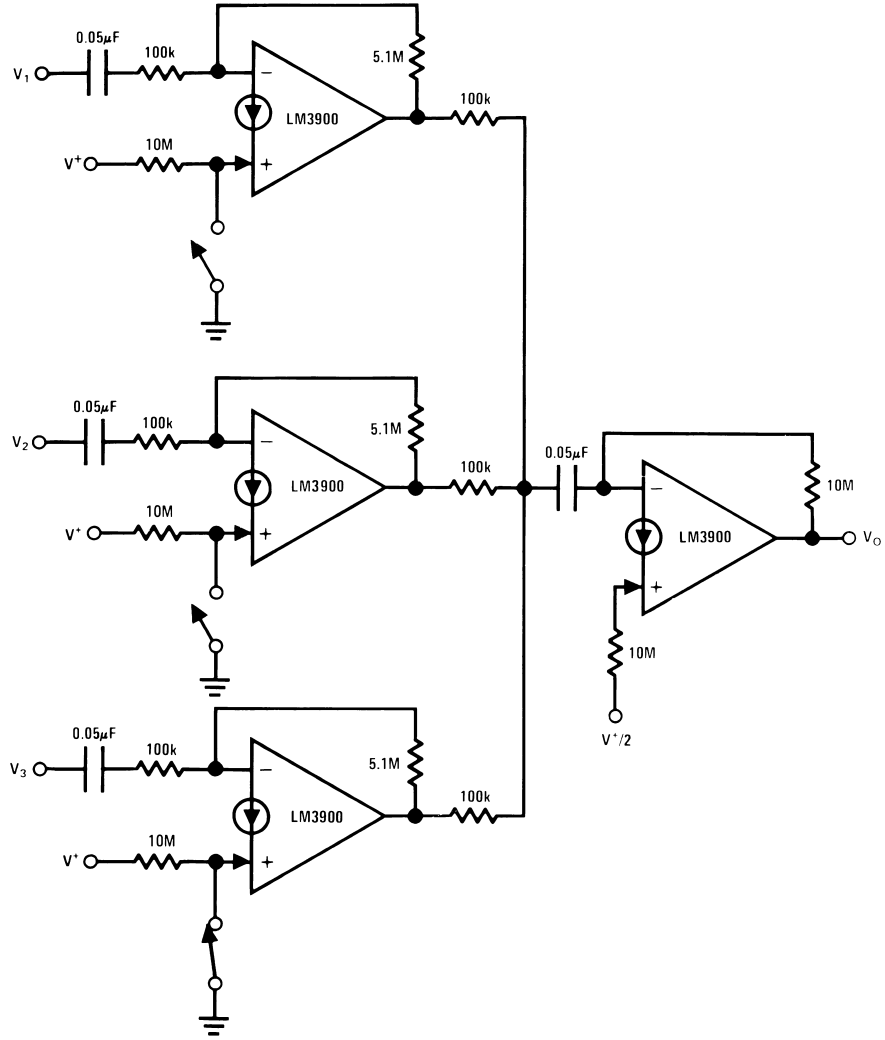


DS007936-42



Typical Applications ( $V^+ = 15 V_{DC}$ ) (Continued)

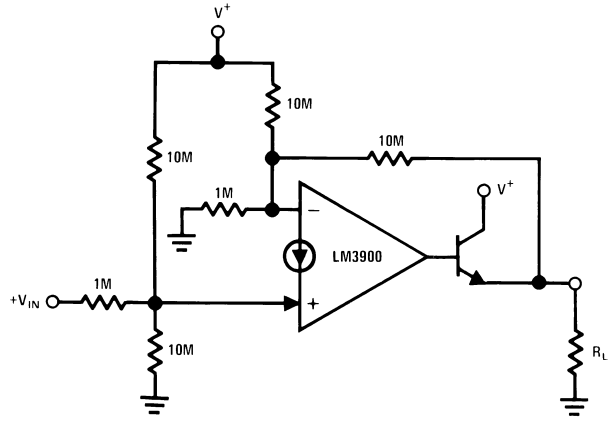
Channel Selection by DC Control (or Audio Mixer)



DS007936-43

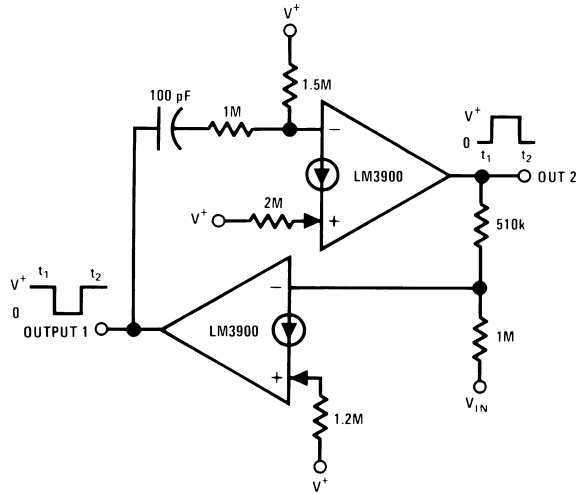
**Typical Applications** ( $V^+ = 15 V_{DC}$ ) (Continued)

**Power Amplifier**



DS007936-44

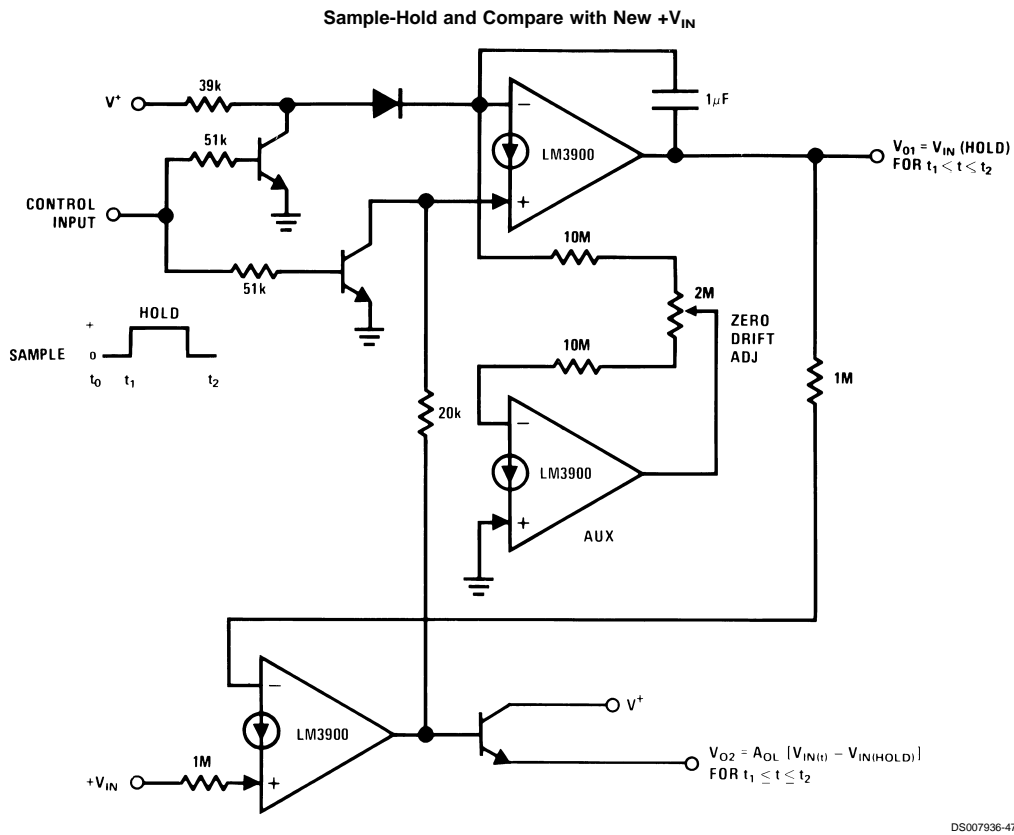
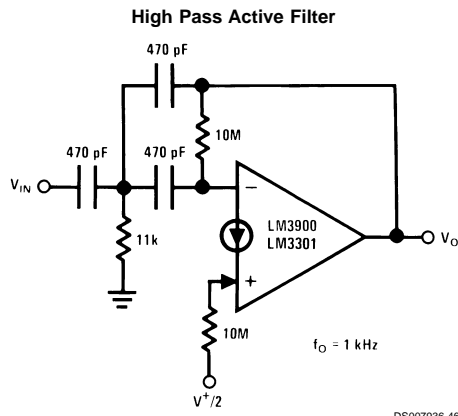
**One-Shot with DC Input Comparator**



DS007936-45

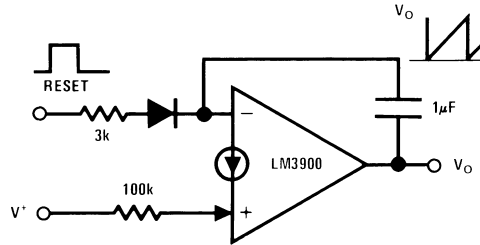
Trips at  $V_{IN} \cong 0.8 V^+$   
 $V_{IN}$  must fall  $0.8 V^+$  prior to  $t_2$

Typical Applications ( $V^+ = 15 V_{DC}$ ) (Continued)



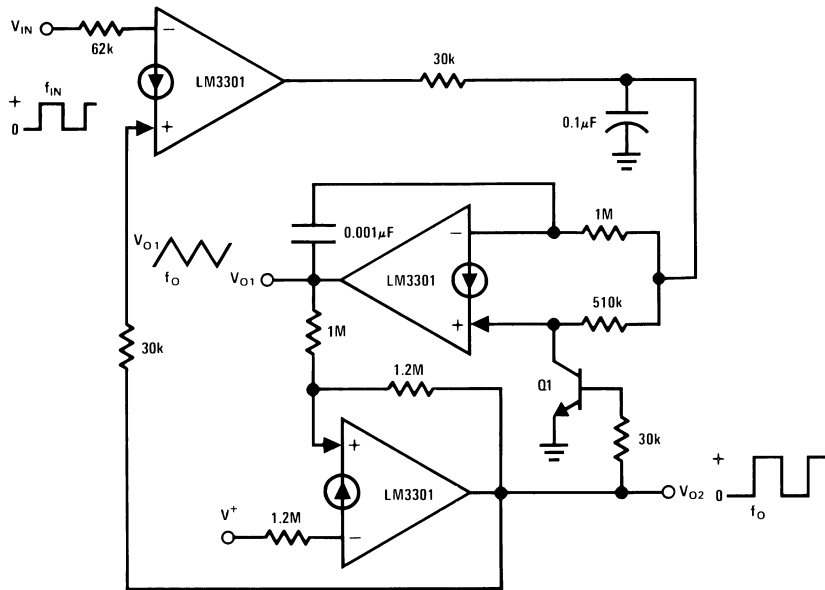
**Typical Applications** ( $V^+ = 15 V_{DC}$ ) (Continued)

**Sawtooth Generator**



DS007936-48

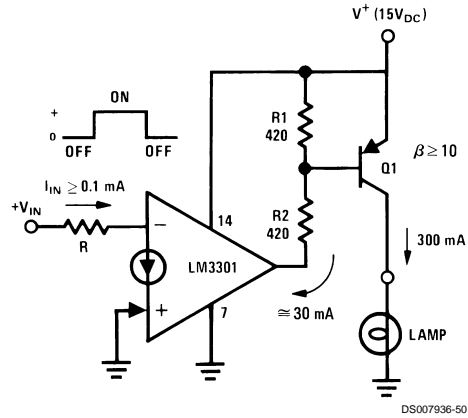
**Phase-Locked Loop**



DS007936-49

**Typical Applications** ( $V^+ = 15 V_{DC}$ ) (Continued)

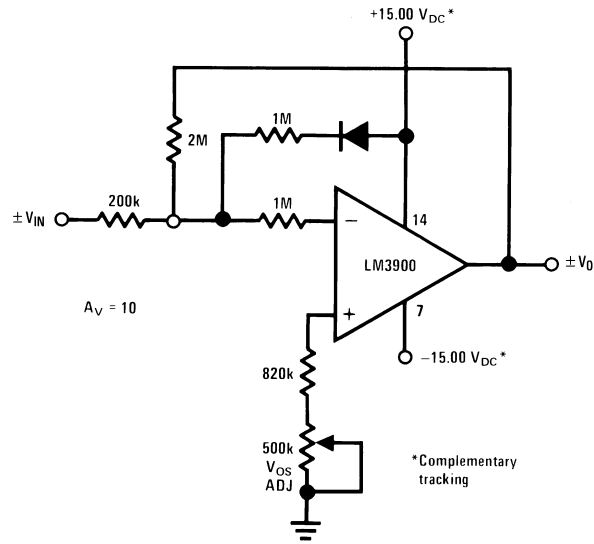
**Boosting to 300 mA Loads**



DS007936-50

**Split-Supply Applications** ( $V^+ = +15 V_{DC}$  &  $V^- = -15 V_{DC}$ )

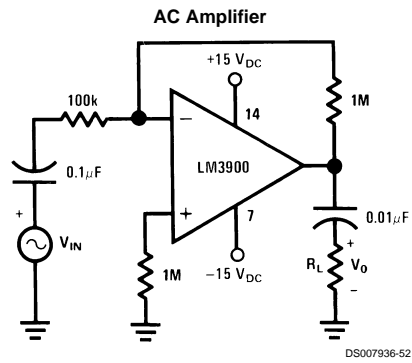
**Non-Inverting DC Gain**



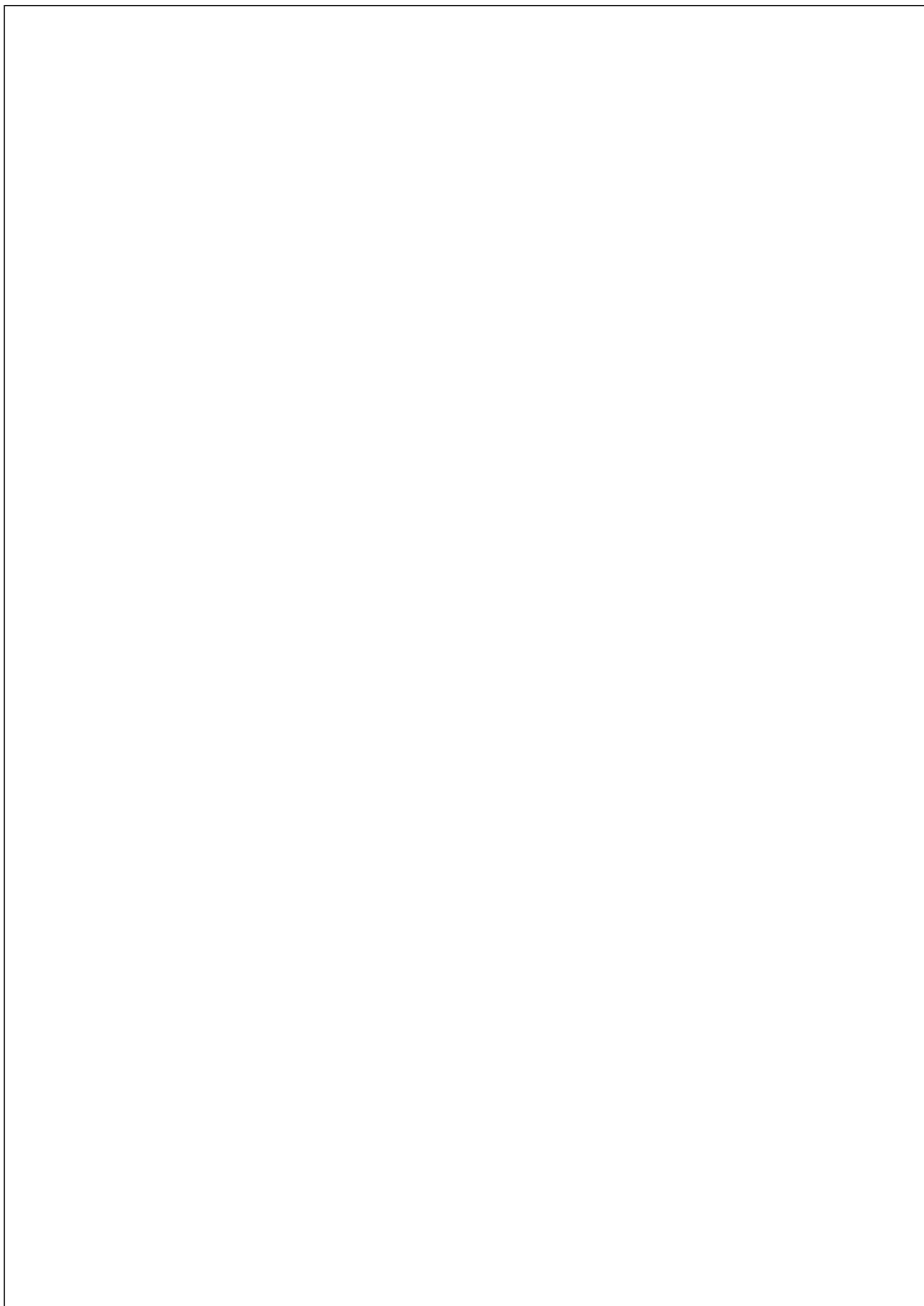
DS007936-51

Book  
Extract  
End

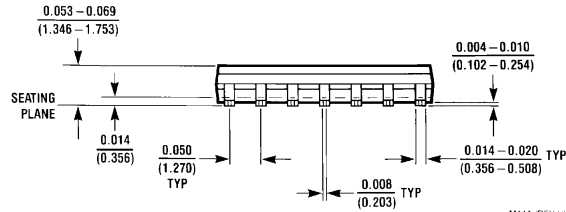
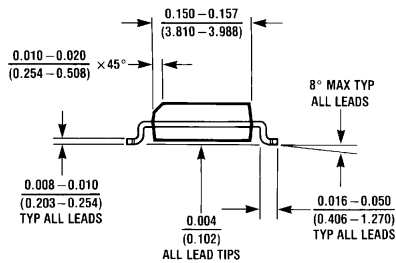
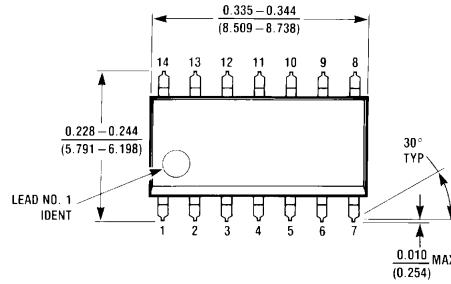
**Split-Supply Applications** ( $V^+ = +15 V_{DC}$  &  $V^- = -15 V_{DC}$ ) (Continued)



Book  
Extract  
End

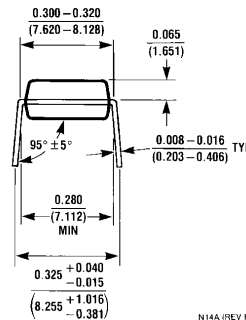
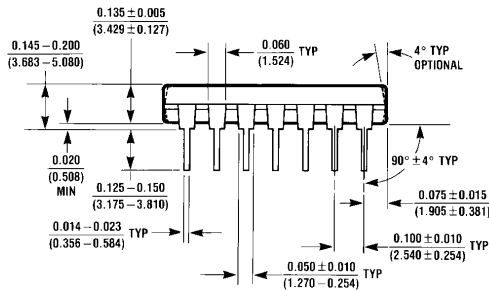
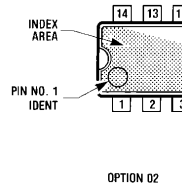
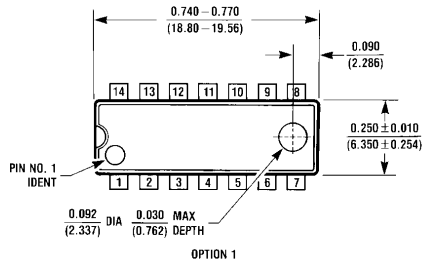


**Physical Dimensions** inches (millimeters) unless otherwise noted



M14A (REV H)

**Small Outline Package (M)**  
**Order Number LM3900M**  
**NS Package Number M14A**



N14A (REV F)

**Molded Dual-In-Line Package (N)**  
**Order Number LM2900N, LM3900N or LM3301N**  
**NS Package Number N14A**



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