LP2902,LP324

LP324/LP2902 Micropower Quad Operational Amplifier

Literature Number: SNOSBX6B

July 2001

National Semiconductor

LP324/LP2902
Micropower Quad Operational Amplifier

General Description

The LP324 series consists of four independent, high gain internally compensated micropower operational amplifiers. These amplifiers are specially suited for operation in battery systems while maintaining good input specifications, and extremely low supply current drain. In addition, the LP324 has an input common mode range, and output source range which includes ground, making it ideal in single supply applications.

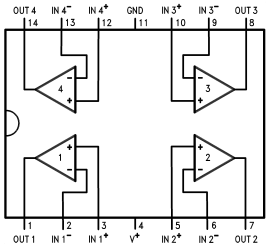
These amplifiers are ideal in applications which include portable instrumentation, battery backup equipment, and other circuits which require good DC performance and low supply current.

Features

- Low supply current: 85µA (typ)
- Low offset voltage: 2mV (typ)
- Low input bias current: 2nA (typ)
- Input common mode to GND
- Interfaces to CMOS logic
- Wide supply range: $3V < V^+ < 32V$
- Small Outline Package available
- Pin-for-pin compatible with LM324

Connection Diagrams

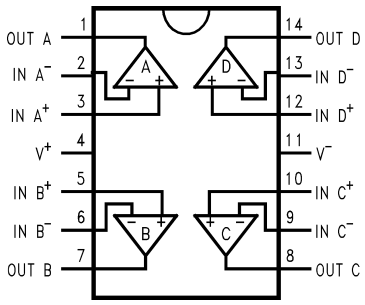
Dual-In-Line (N) and SO (M)



00856201

Order Number LP324M or LP2902M
See NS Package Number M14A
Order Number LP324N or LP2902N
See NS Package Number N14A

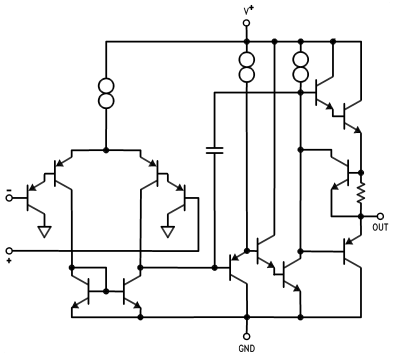
14-Pin TSSOP



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Order Number LP324MT and LP324MTX
See NS Package Number MTC14

Simplified Schematic



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Absolute Maximum Ratings (Note 1)

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

Supply Voltage	
LP324	32V or ± 16V
LP2902	26V or ± 13V
Differential Input Voltage	
LP324	32V
LP2902	26V
Input Voltage (Note 2)	
LP324	−0.3V to 32V
LP2902	−0.3V to 26V
Output Short-Circuit to GND (One Amplifier) (Note 3)	Continuous
$V^+ \leq 15V$ and $T_A = 25^\circ C$ ESD Susceptibility (Note 10)	±500V

Operating Conditions

T_{JMAX}	150˚C
θ_{JA} (Note 4)	
MT Package	154˚C/W
N Package	90˚C/W
M Package	140˚C/W
Operating Temp. Range	(Note 5)
Storage Temp. Range	$-65^\circ C \leq T_J \leq 150^\circ C$
Soldering Information	
Wave Soldering(10sec)	260˚C(lead temp.)
Convection or Infrared(20sec)	235˚C

Electrical Characteristics (Note 6)

Symbol	Parameter	Conditions	LP2902 (Note 9)			LP324			Units Limits
			Typ	Tested Limit (Note 7)	Design Limit (Note 8)	Typ	Tested Limit (Note 7)	Design Limit (Note 8)	
V_{OS}	Input Offset Voltage		2	4	**10**	2	4	**9**	mV (Max)
I_B	Input Bias Current		2	20	**40**	2	10	**20**	nA (Max)
I_{OS}	Input Offset Current		0.5	4	**8**	0.2	2	**4**	nA (Max)
A_{VOL}	Voltage Gain	R_L = 10k to GND V^+ = 30V	70	40	**30**	100	50	**40**	V/mV (Min)
CMRR	Common Mode Rej. Ratio	V^+ = 30V, 0V ≤ V_{CM} $V_{CM} < V^+ - 1.5$	90	80	**75**	90	80	**75**	dB (Min)
PSRR	Power Supply Rej. Ratio	V^+ = 5V to 30V	90	80	**75**	90	80	**75**	dB (Min)
I_S	Supply Current	$R_L = \infty$	85	150	**250**	85	150	**250**	µA (Max)
V_O	Output Voltage Swing	I_L = 350µA to GND V_{CM} = 0V	3.6	3.4	**V^+−1.9V**	3.6	3.4	**V^+−1.9V**	V (Min)
		I_L = 350µA to V^+ V_{CM} = 0V	0.7	0.8	**1.0**	0.7	0.8	**1.0**	V (Max)
I_{OUT} Source	Output Source Current	V_O = 3V V_{IN} (diff) = 1V	10	7	**4**	10	7	**4**	mA (Min)
I_{OUT} Sink	Output Sink Current	V_O = 1.5V V_{IN} (diff) = 1V	5	4	**3**	5	4	**3**	mA (Min)
I_{OUT} Sink	Output Sink Current	V_O = 1.5V V_{CM} = 0V	4	2	**1**	4	2	**1**	mA (Min)
I_{SOURCE}	Output Short to GND	V_{IN} (diff) = 1V	20	25 **35**	**35**	20	25 **35**	**35**	mA (Max)
I_{SINK}	Output Short to V^+	V_{IN} (diff) = 1V	15	30	**45**	15	30	**45**	mA (Max)
V_{OS} Drift			10			10			µV/C˚
I_{OS} Drift			10			10			pA/C˚

Electrical Characteristics (Note 6) (Continued)

Symbol	Parameter	Conditions	LP2902 (Note 9)			LP324			Units Limits
			Typ	Tested Limit (Note 7)	Design Limit (Note 8)	Typ	Tested Limit (Note 7)	Design Limit (Note 8)	
GBW	Gain Bandwidth Product		100			100			KHz
SR	Slew Rate		50			50			V/mS

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: The input voltage is not allowed to go more than −0.3V below V^- (GND) as this will turn on a parasitic transistor causing large currents to flow through the device.

Note 3: Short circuits from the output to GND can cause excessive heating and eventual destruction. The maximum sourcing output current is approximately 30 mA independent of the magnitude of V^+. At values of supply voltage in excess of 15 V_{DC}, continuous short-circuit to GND can exceed the power dissipation ratings (particularly at elevated temperatures) and cause eventual destruction. Destructive dissipation can result from simultaneous shorts on all amplifiers.

Note 4: For operation at elevated temperatures, these devices must be derated based on a thermal resistance of θ_{JA} and T_J max. $T_J = T_A + \theta_{JA}P_D$.

Note 5: The LP2902 may be operated from $-40^\circ C \le T_A \le +85^\circ C$, and the LP324 may be operated from $0^\circ C \le T_A \le +70^\circ C$.

Note 6: **Boldface** numbers apply at temperature extremes. All other numbers apply only at $T_A = T_J = 25^\circ C$, $V^+ = 5V$, $V_{cm} = V/2$, and R_L =100k connected to GND unless otherwise specified.

Note 7: Guaranteed and 100% production tested.

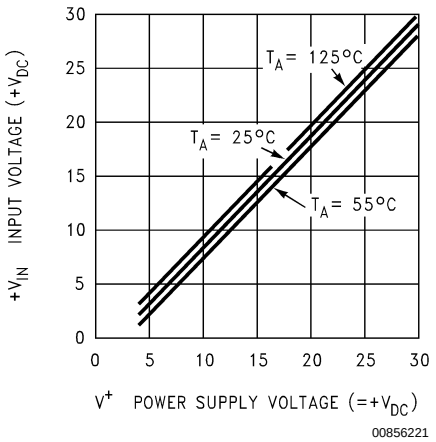
Note 8: Guaranteed (but not 100% production tested) over the operating supply voltage range (3.0V to 32V for the LP324, LP324, and 3.0V to 26V for the LP2902), and the common mode range (0V to V^+ −1.5V), unless otherwise specified. These limits are not used to calculate outgoing quality levels.

Note 9: The LP2902 operating supply range is 3V to 26V, and is not tested above 26V.

Note 10: The test circuit used consists of the human body model of 100 pF in series with 1500Ω.

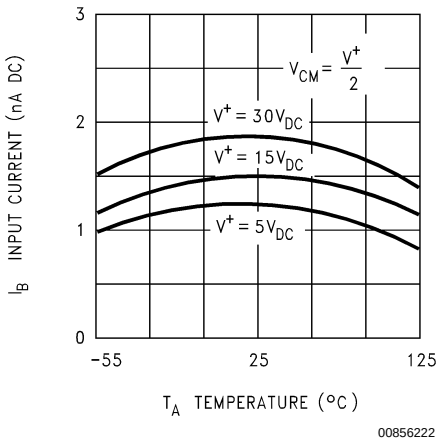
Typical Performance Curves

Input Voltage Range



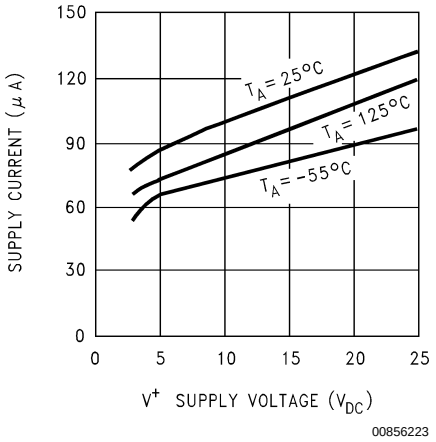
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Input Current



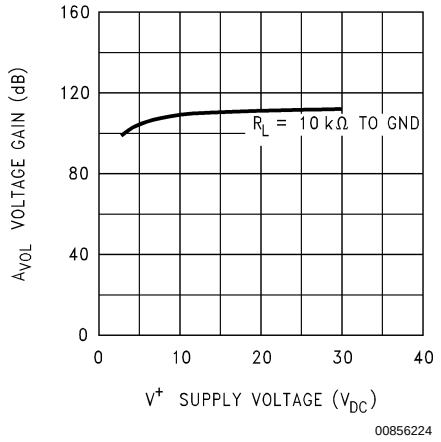
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Supply Current



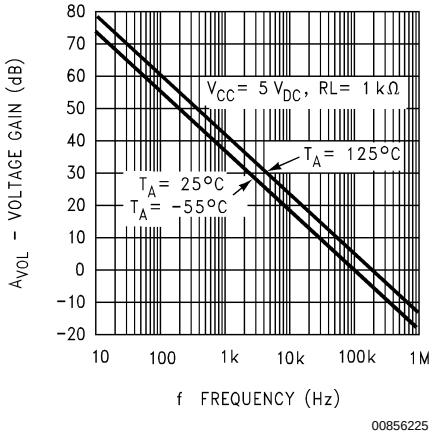
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Voltage Gain



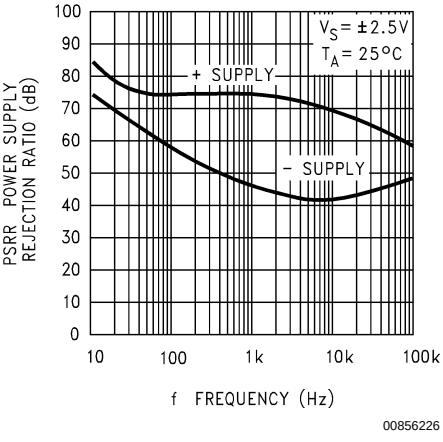
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Open Loop Frequency Response



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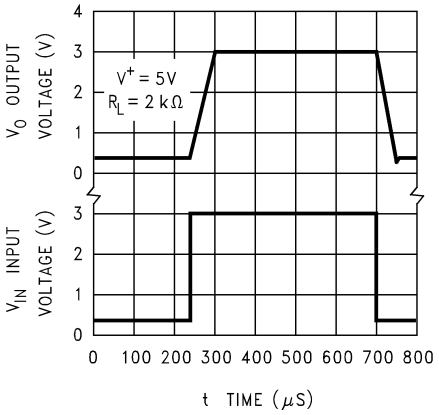
Power Supply Rejection Ratio



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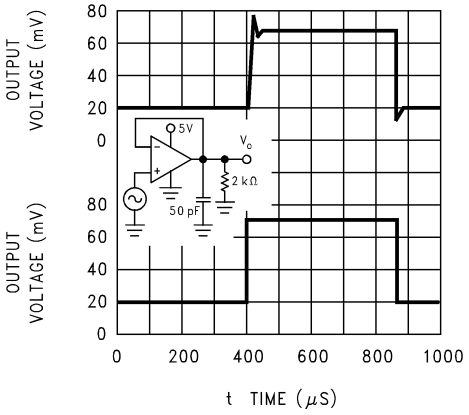
Typical Performance Curves (Continued)

Voltage Follower Pulse Response



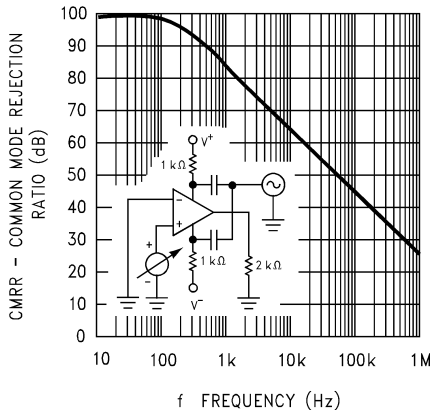
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Voltage Follower Pulse Response (Small Signal)



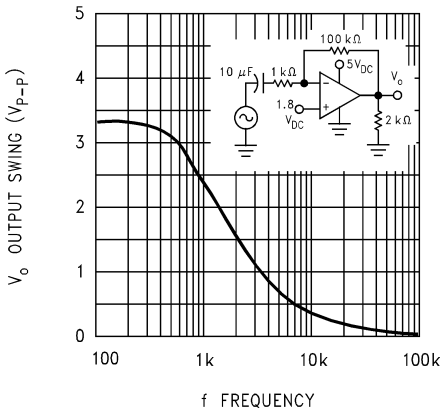
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Common Mode Rejection Ratio



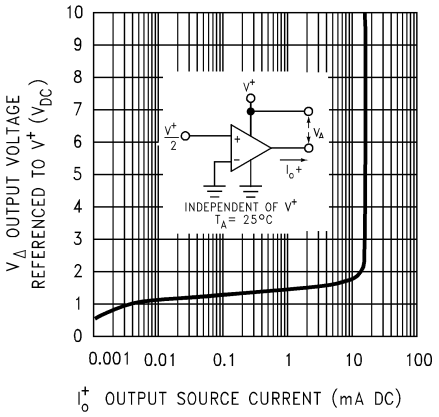
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Large Signal Frequency Response



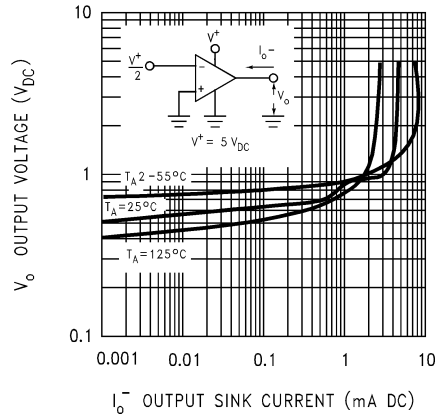
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Output Characteristics Current Sourcing



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Output Characteristics Current Sinking

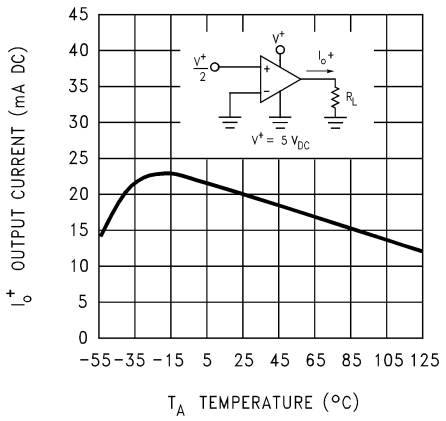


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Typical Performance Curves

(Continued)

Current Limiting



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Application Hints

The LP324 series is a micro-power pin-for-pin equivalent to the LM324 op amps. Power supply current, input bias current, and input offset current have all been reduced by a factor of 10 over the LM324. Like its predecessor, the LP324 series op amps can operate on single supply, have true-differential inputs, and remain in the linear mode with an input common-mode voltage of 0 V_{DC}.

The pinouts of the package have been designed to simplify PC board layouts. Inverting inputs are adjacent to outputs for all of the amplifiers and the outputs have also been placed at the corners of the package (pins 1, 7, 8, and 14).

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

Large differential input voltages can be easily accommodated and, as input differential voltage protection diodes are not needed, no large input currents result from large differential input voltages. The differential input voltage may be larger than V^+ without damaging the device. Protection should be provided to prevent the input voltages from going negative more than −0.3 V_{DC} (at 25˚C). An input clamp diode with a resistor to the IC input terminal can be used.

The amplifiers have a class B output stage which allows the amplifiers to both source and sink output currents. In applications where crossover distortion is undesirable, a resistor should be used from the output of the amplifier to ground. The resistor biases the output into class A operation.

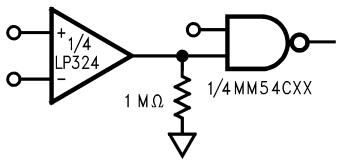
The LP324 has improved stability margin for driving capacitive loads. No special precautions are needed to drive loads in the 50 pF to 1000 pF range. It should be noted however that since the power supply current has been reduced by a factor of 10, so also has the slew rate and gain bandwidth product. This reduction can cause reduced performance in AC applications where the LM324 is being replaced by an LP324. Such situations usually occur when the LM324 has been operated near its power bandwidth.

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: If all four amplifiers were simultaneously shorted to ground on a 10V supply the junction temperature would rise by 110˚C.

Exceeding the negative common-mode limit on either input will cause a reversal of phase to the output and force the amplifier to the corresponding high or low state. Exceeding the negative common-mode limit on both inputs will force the amplifier output to a high state. Exceeding the positive common-mode limit on a single input will not change the phase of the output. However, if both inputs exceed the limit, the output of the amplifier will be forced to a low state. In neither case does a latch occur since returning the input within the common mode range puts the input stage and thus the amplifier in a normal operating mode.

The circuits presented in the section on typical applications emphasize operation on only a single power supply voltage. If complementary power supplies are available, all of the standard op amp circuits can be used. In general, introducing a pseudo-ground (a bias voltage reference to $V^+/2$) will allow operation above and below this value in single power supply systems. Many application circuits are shown which take advantage of the wide input common-mode voltage range which includes ground. In most cases, input biasing is not required and input voltages which range to ground can easily be accommodated.

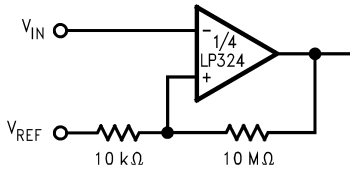
Driving CMOS



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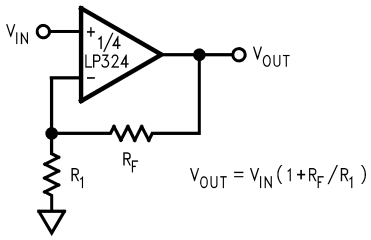
Application Hints (Continued)

Comparator with Hysteresis



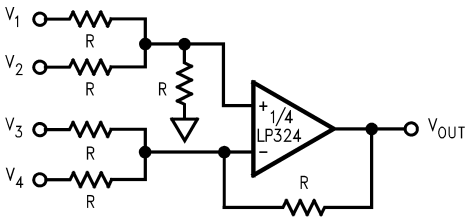
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Non-Inverting Amplifier



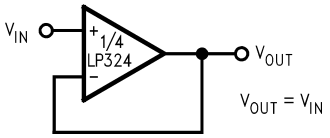
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Adder/Subtractor



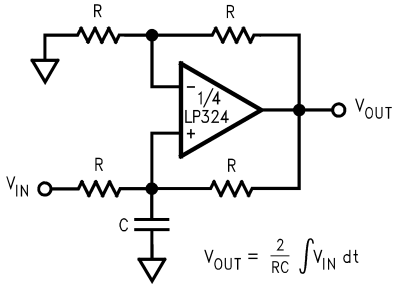
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Unity Gain Buffer



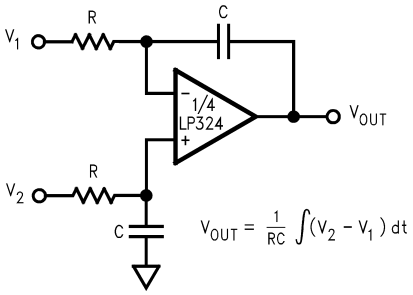
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Positive Integrator



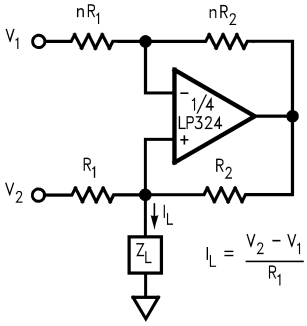
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Differential Integrator



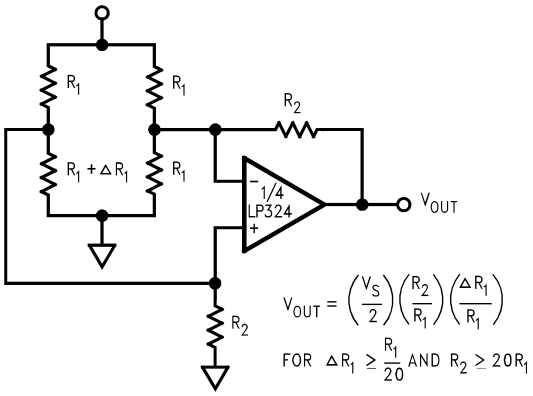
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Howland Current Pump



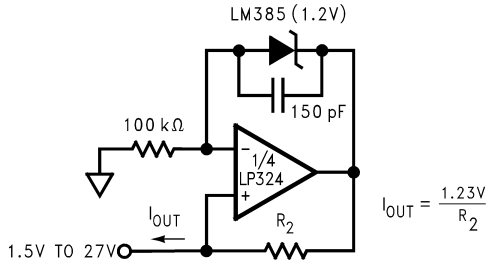
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Bridge Current Amplifier



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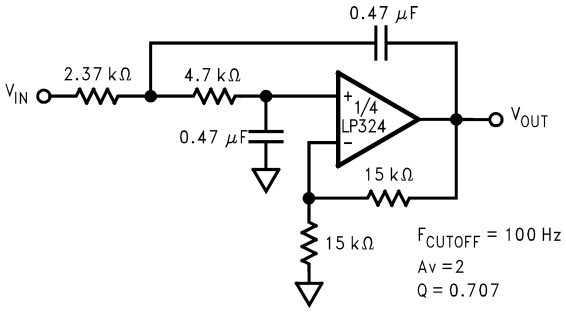
µ Power Current Source



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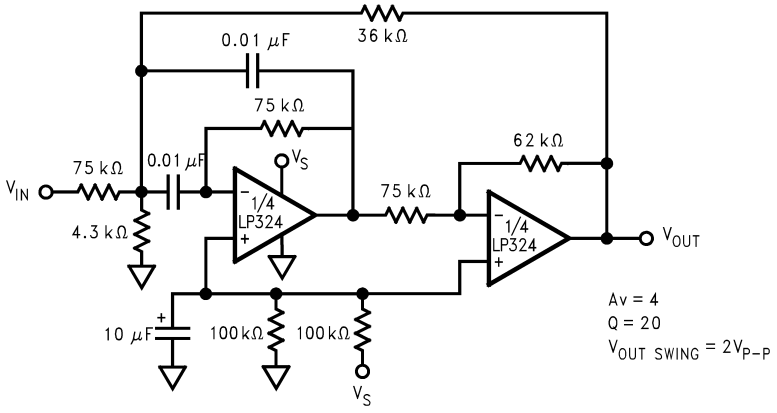
Application Hints (Continued)

Lowpass Filter



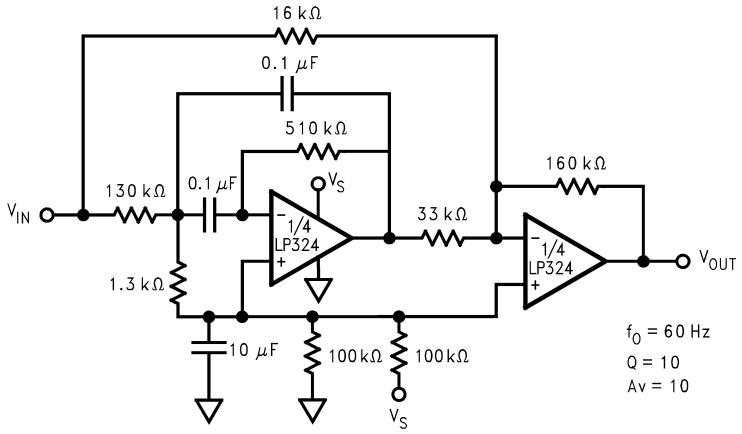
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1 kHz Bandpass Active Filter



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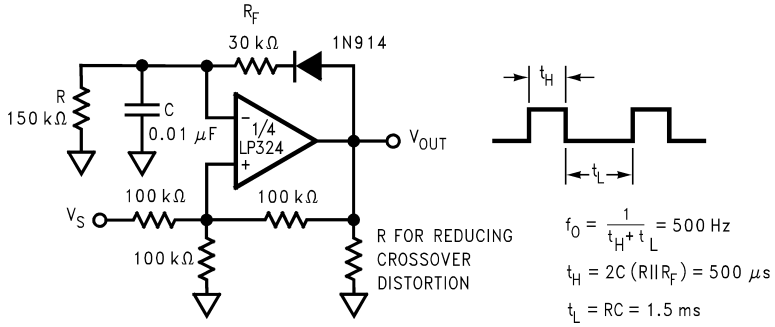
Band-Reject Filter



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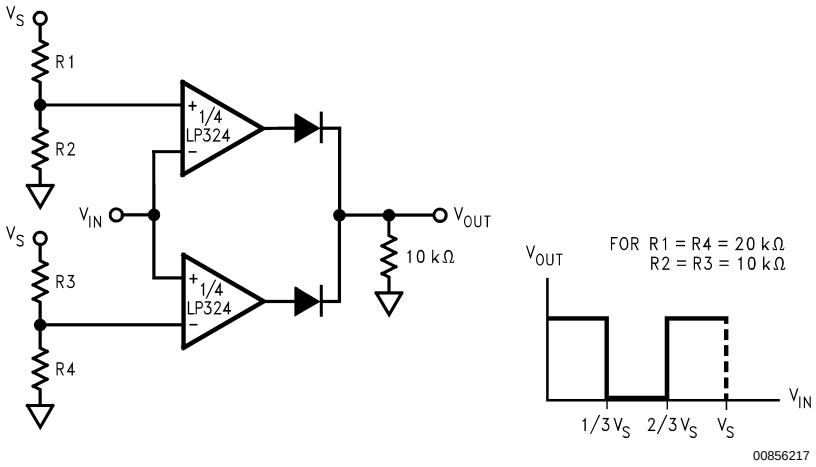
Application Hints (Continued)

Pulse Generator



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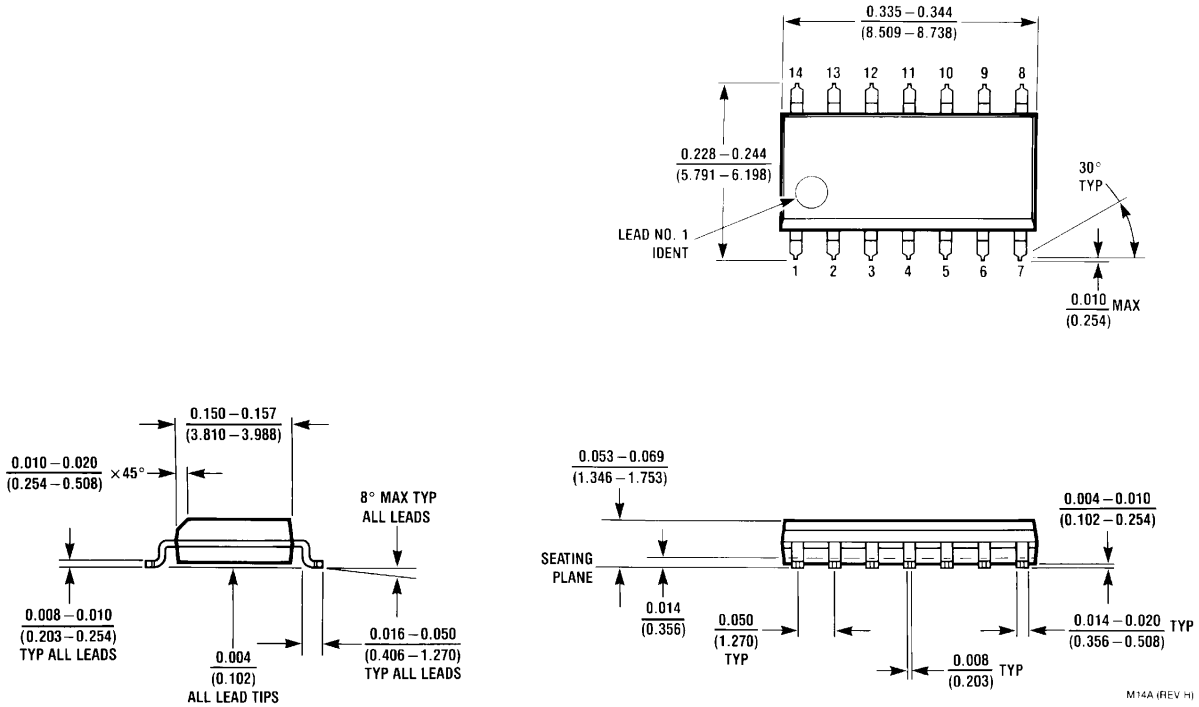
Window Comparator



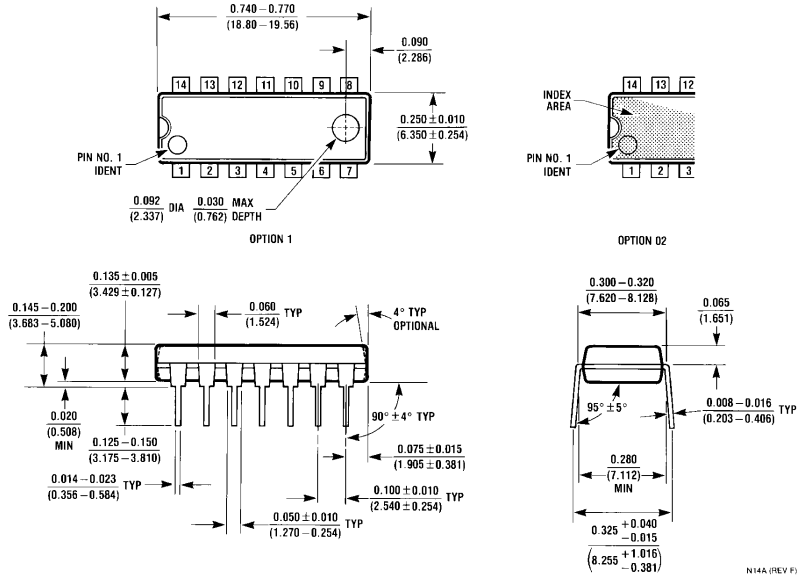
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Physical Dimensions inches (millimeters)

unless otherwise noted

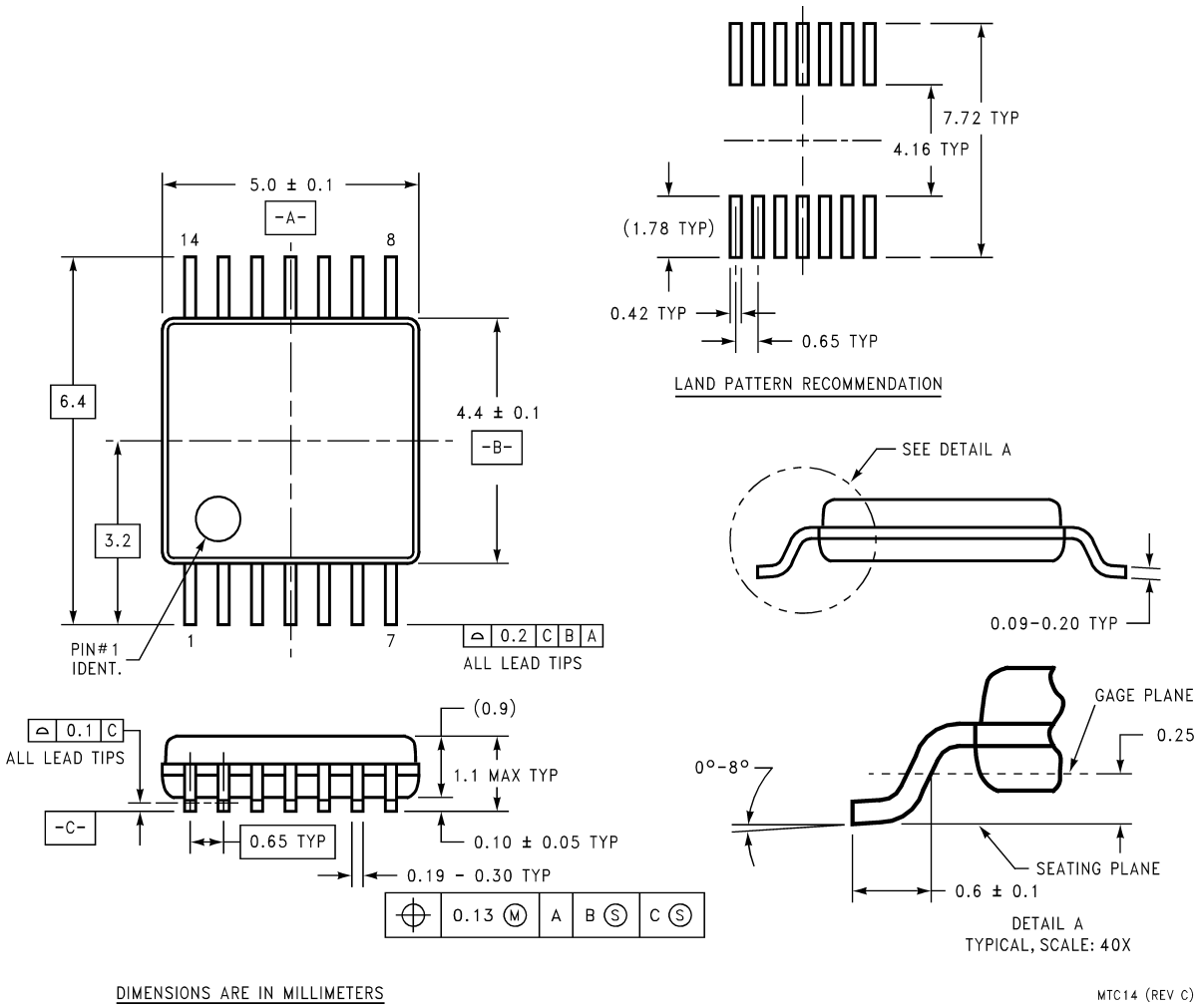


S.O. Package (M)
Order Number LP324M, LP324MX, LP2902M or LP2902MX
NS Package Number M14A



Dual-in-Line Package (N)
Order Number LP324N or LP2902N
NS Package Number N14A

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



14-Pin TSSOP
Order Number LP324MT and LP324MTX
NS Package Number MTC14

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2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

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