National Semiconductor Corporation

**PRELIMINARY**

# LH0032/LH0032A/LH0032C/LH0032AC Ultra Fast FET-Input Operational Amplifier

## General Description

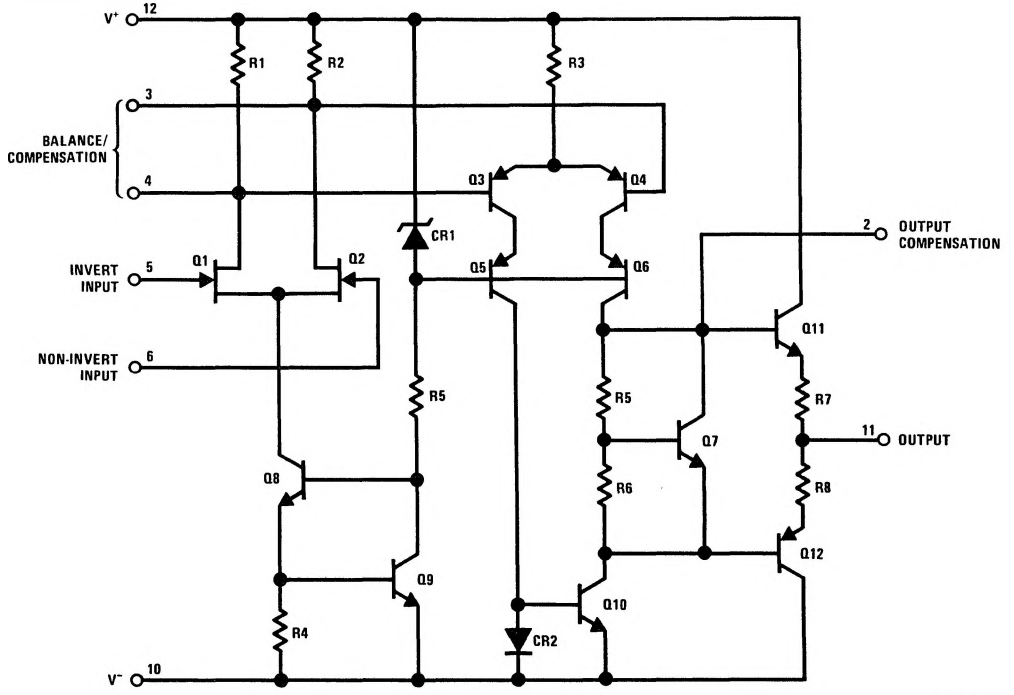
The LH0032/LH0032A is a high slew rate, high input impedance differential operational amplifier suitable for diverse application in fast signal handling. The high allowable differential input voltage, ease of output clamping, and high output drive capability particularly suit it for comparator applications. It may be used in applications normally reserved for video amplifiers allowing the use of operational gain setting and frequency response shaping into the megahertz region.

The LH0032's wide bandwidth, high input impedance and high output capacity make it an ideal choice for applications such as summing amplifiers in high speed D to A converters, buffers in data acquisition systems and sample and hold circuits. Additional applications include high speed integrators and video amplifiers. The LH0032 and LH0032A are guaranteed for operation over the temperature range −55°C to +125°C, the LH0032C and LH0032AC are guaranteed for −25°C to +85°C.

## Features

- 500 V/μs slew rate
- 70 MHz bandwidth
- $10^{12}\Omega$ input impedance
- As low as 2 mV max input offset voltage
- FET input
- Offset null with single pot
- No compensation for gains above 50
- Peak output current to 100 mA

## Block Diagram

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## Absolute Maximum Ratings

| | | | |
|---|---|---|---|
| Supply Voltage, $V_S$ | ±18V | Operating Temperature Range, $T_A$ | |
| Input Voltage, $V_{IN}$ | $\pm V_S$ | LH0032G/AG/E | −55°C to +125°C |
| Differential Input Voltage | ±30V or $\pm 2V_S$ | LH0032CG/ACG | −25°C to +85°C |
| Power Dissipation, $P_D$ | | Operating Junction Temperature, $T_J$ | 175°C |
| $T_A$ = 25°C | 1.5W, derate 100°C/W to 125°C (Note 1) | Storage Temperature Range | −65°C to +150°C |
| $T_C$ = 25°C | 2.2W, derate 70°C/W to 125°C (Note 1) | Lead Temp. (Soldering, 10 seconds) | 300°C |

## DC Electrical Characteristics $V_S = \pm 15V$, $T_{MIN} \le T_A \le T_{MAX}$ unless otherwise noted (Note 2) ($T_A = T_j$)

| Symbol | Parameter | Test Conditions | | LH0032A | | | LH0032AC | | | LH0032 | | | LH0032C | | | Units |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Min | Typ | Max | Min | Typ | Max | Min | Typ | Max | Min | Typ | Max | |
| $V_{OS}$ | Input Offset Voltage | $V_{IN}=0$ | $T_A=T_J=25°C$ (Note 3) | | 1 | 2<br>5 | | 2 | 5<br>7 | | 2 | 5<br>10 | | 2 | 15<br>20 | mV |
| $\Delta V_{OS}/\Delta T$ | Average Offset Voltage Drift | | (Note 4) | | 15 | 30 | | 15 | 30 | | 15 | 50 | | 15 | 50 | µV/°C |
| $I_{OS}$ | Input Offset Current | | $T_J=25°C$ (Note 3)<br>$T_A=25°C$ (Note 5) | | | 10<br>250<br>10 | | | 30<br>500<br>3 | | | 25<br>250<br>25 | | | 50<br>500<br>5 | pA<br>pA<br>nA |
| $I_B$ | Input Bias Current | | $T_J=25°C$ (Note 3)<br>$T_A=25°C$ (Note 5) | | | 50<br>1<br>25 | | | 150<br>5<br>10 | | | 100<br>1<br>50 | | | 500<br>5<br>15 | pA<br>nA<br>nA |
| *$V_{INCM}$ | Input Voltage Range | | | ±10 | ±12 | | ±10 | ±12 | | ±10 | ±12 | | ±10 | ±12 | | V |
| CMRR | Common Mode Rejection Ratio | $\Delta V_{IN} = \pm 10V$ | | 50 | 60 | | 50 | 60 | | 50 | 60 | | 50 | 60 | | dB |
| $A_{VOL}$ | Open-Loop Voltage Gain | $V_O = \pm 10V$, f = 1 kHz, $R_L$ = 1 kΩ (Note 6) | $T_J=25°C$ | 60 | 70 | | 60 | 70 | | 60 | 70 | | 60 | 70 | | dB |
| | | | | 57 | | | 57 | | | 57 | | | 57 | | | |
| $V_O$ | Output Voltage Swing | $R_L$ = 1 kΩ | | ±10 | ±13.5 | | ±10 | ±13 | | ±10 | ±13.5 | | ±10 | ±13 | | V |
| $I_S$ | Power Supply Current | $T_A=25°C$, $I_O=0$ (Note 5) | | | 18 | 20 | | 20 | 22 | | 18 | 20 | | 20 | 22 | mA |
| PSRR | Power Supply Rejection Ratio | $\Delta V_S = 10V$ (±5 to ±15V) | | 50 | 60 | | 50 | 60 | | 50 | 60 | | 50 | 60 | | dB |

## AC Electrical Characteristics $V_S = \pm 15V$, $R_L$ = 1kΩ, $T_J$ = 25°C (Note 7)

| Symbol | Parameter | Conditions | | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|---|
| $S_R$ | Slew Rate | $A_V = +1$ | $\Delta V_{IN} = 20V$ | 350 | 500 | | V/µs |
| $t_s$ | Settling Time to 1% of Final Value | $A_V = -1$, | | | 100 | | |
| $t_s$ | Settling Time to 0.1% of Final Value | | | | 300 | | ns |
| $t_R$ | Small Signal Rise Time | $A_V = +1$, $\Delta V_{IN} = 1V$ | | | 8 | 20 | |
| $t_D$ | Small Signal Delay Time | | | | 10 | 25 | |

**Note 1.** In order to limit maximum junction temperature to +175°C, it may be necessary to operate with VS < ±15V when $T_A$ or $T_C$ exceeds specific values depending on the $P_D$ within the device package. Total $P_D$ is the sum of quiescent and load-related dissipation. See applications notes AN-277, "Applications of Wide-Band Buffer Amplifiers" and AN-253, "High-Speed Operational-Amplifier Applications" for a discussion of load-related power dissipation.

**Note 2.** LH0032AG/G are 100% production tested as specified at 25°C, 125°C, and −55°C. LH0032ACG/CG are 100% production tested at 25°C only. Specifications at temperature extremes are verified by sample testing, but these limits are not used to calculate outgoing quality level.

**Note 3.** Specification is at 25°C junction temperature due to requirements of high-speed automatic testing. Actual values at operating temperature will exceed the value at $T_J$ = 25 C. When supply voltages are ± 15V, no-load operating junction temperature may rise 40–60°C above ambient, and more under load conditions. Accordingly, $V_{OS}$ may change one to several mV, and $I_B$ and $I_{OS}$ will change significantly during warm-up. Refer to $I_B$ and $I_{OS}$ vs. temperature graph for expected values.

**Note 4.** LH0032AG/G are 100% production tested for this parameter. LH0032ACG/CG are sample tested only. Limits are not used to calculate outgoing quality levels. $\Delta V_{OS}/\Delta T$ is the average value calculated from measurements at 25°C and $T_{MAX}$.

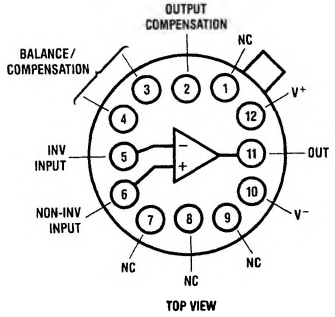
**Note 5.** Measured in still air 7 minutes after application of power. Guaranteed thru correlated automatic pulse testing.

**Note 6.** Guaranteed thru correlated automatic pulse testing at $T_J$ = 25°C.

**Note 7.** Not 100% production tested; verified by sample testing only. Limits are not used to calculate outgoing quality level.

*Guaranteed by CMRR test condition.

## Connection Diagrams

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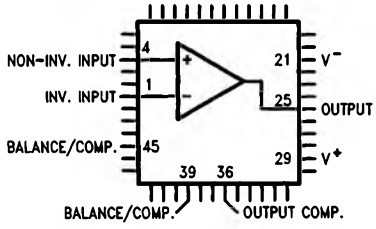
**Order Number LH0032G, LH0032AG, LH0032CG or LH0032ACG**
**See NS Package Number G12B**

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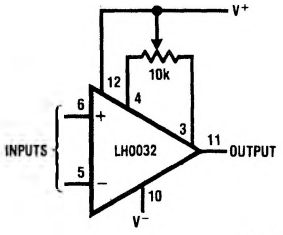
**Order Number LH0032E**
**See NS Package Number E48B**

## Auxiliary Circuits

**Offset Null**

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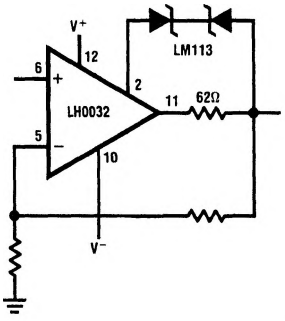
**Output Short Circuit Protection**

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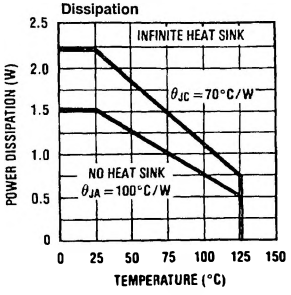
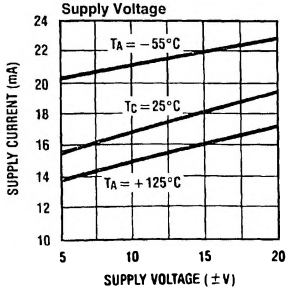
## Typical Performance Characteristics

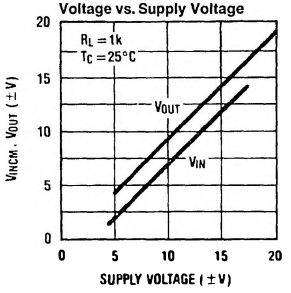
**Maximum Power Dissipation**



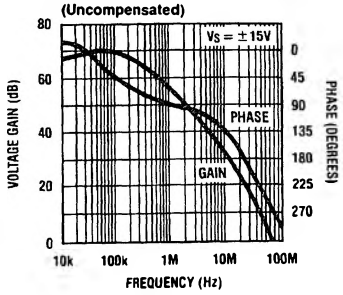

**Supply Current vs. Supply Voltage**



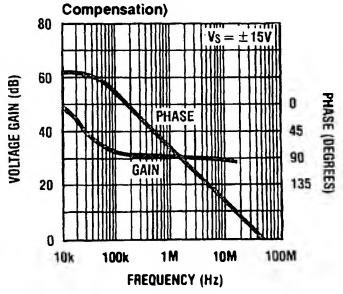

**Input Voltage Range and Output Voltage vs. Supply Voltage**



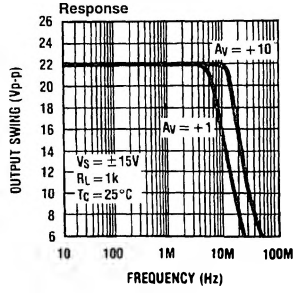

**Bode Plot (Uncompensated)**



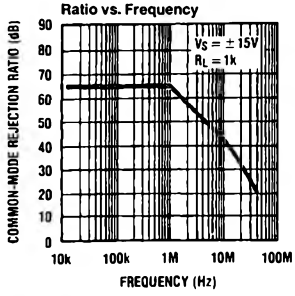

**Bode Plot (Unity Gain Compensation)**



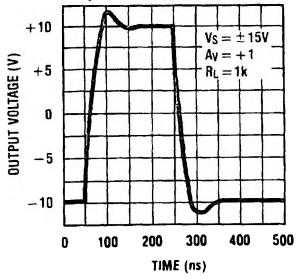

**Large Signal Frequency Response**



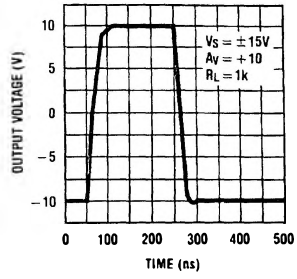

**Common Mode Rejection Ratio vs. Frequency**



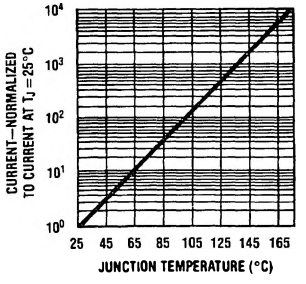

**Large Signal Pulse Response**



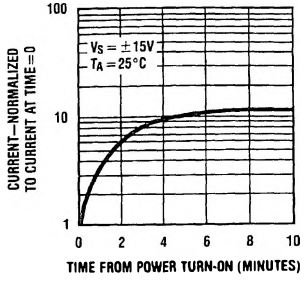

**Large Signal Pulse Response**



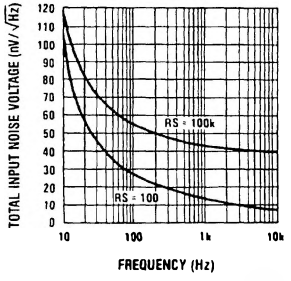

**Normalized Input Bias and Offset Current vs. Junction Temperature**




**Normalized Input Bias Current During Warm-Up**




**Total Input Noise Voltage vs. Frequency***

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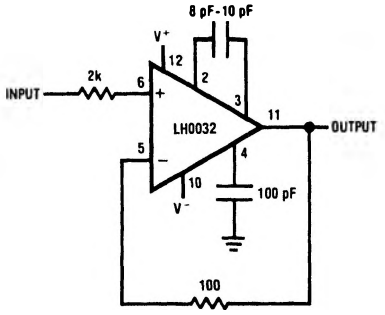
*Noise voltage includes contribution from source resistance.

## Typical Applications

### Unity Gain Amplifier

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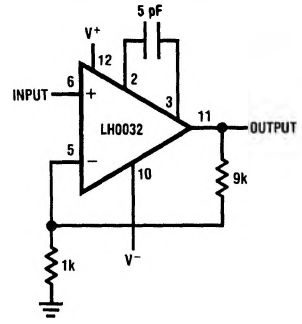
### 10X Buffer Amplifier

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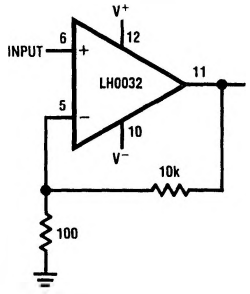
### 100X Buffer Amplifier

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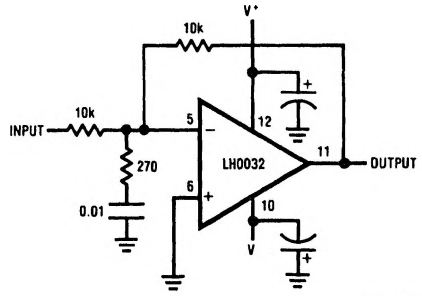
### Non-Compensated Unity Gain Inverter

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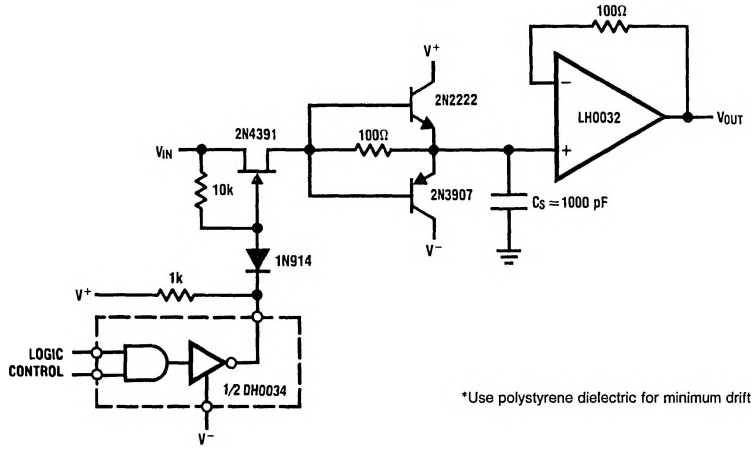
## Typical Applications (Continued)

**High Speed Sample and Hold**

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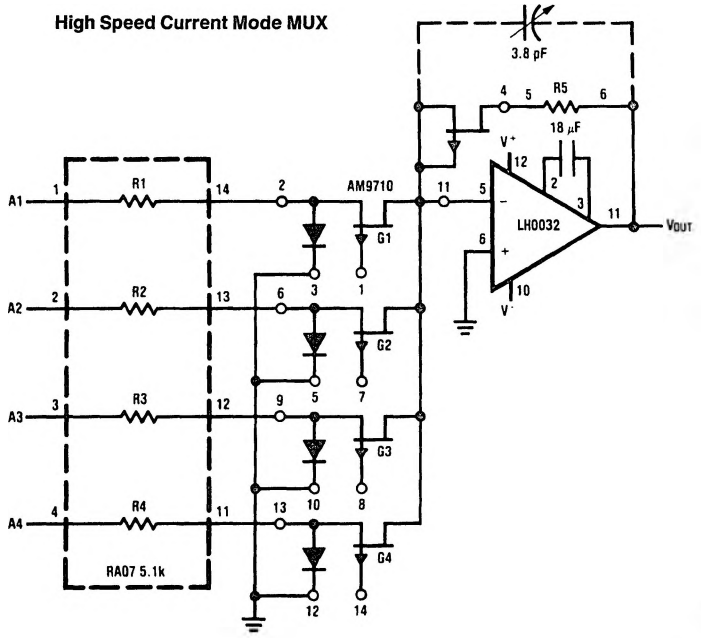
*Use polystyrene dielectric for minimum drift

**High Speed Current Mode MUX**

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## Applications Information

### POWER SUPPLY DECOUPLING

The LH0032/LH0032A, like most high speed circuits, is sensitive to layout and stray capacitance. Power supplies should be by passed as near to pins 10 and 12 as practicable with low inductance capacitors such as 0.01 μF disc ceramics. Compensation components should also be located close to the appropriate pins to minimize stray reactances.

### INPUT CURRENT

Because the input devices are FETs, the input bias current may be expected to double for each 11°C junction temperature rise. This characteristic is plotted in the typical performance characteristics graphs. The device will self-heat due to internal power dissipation after application of power thus raising the FET junction temperature 40–60°C above free-air ambient temperature when supplies are ±15V. The de-

## Applications Information (Continued)

vice temperature will stabilize within 5–10 minutes after application of power, and the input bias currents measured at that time will be indicative of normal operating currents. An additional rise would occur as power is delivered to a load due to additional internal power dissipation.

There is an additional effect on input bias current as the input voltage is changed. The effect, common to all FETs, is an avalanche-like increase in gate current as the FET gate-to-drain voltage is increased above a critical value depending on FET geometry and doping levels. This effect will be noted as the input voltage of the LH0032 is taken below ground potential when the supplies are ±15V. All of the effects described here may be minimized by operating the device with $V_S \leq \pm 15V$.

These effects are indicated in the typical performance curves.

### INPUT CAPACITANCE

The input capacitance to the LH0032/LH0032C is typically 5pF and thus may form a significant time constant with high value resistors. For optimum performance, the input capacitance to the inverting input should be compensated by a small capacitor across the feedback resistor. The value is strongly dependent on layout and closed loop gain, but will typically be in the neighborhood of several picofarads.

In the non-inverting configuration, it may be advantageous to bootstrap the case and/or a guard conductor to the inverting input. This serves both to divert leakage currents away from the non-inverting input and to reduce the effective input capacitance. A unity gain follower so treated will have an input capacitance under a picofarad.

### HEAT SINKING

While the LH0032/LH0032A is specified for operation without any explicit heat sink, internal power dissipation does cause a significant temperature rise. Improved bias current performance can thus be obtained by limiting this temperature rise with a small heat sink such as the Thermalloy No. 2241 or equivalent. The case of the device has no internal connection, so it may be electrically connected to the sink if this is advantageous. Be aware, however, that this will affect the stray capacitances to all pins and may thus require adjustment of circuit compensation values.

***For additional applications information request Application Note AN-253.***