

# LM392

## Low Power Operational Amplifier/Voltage Comparator

### General Description

The LM392 series consists of 2 independent building block circuits. One is a high gain, internally frequency compensated operational amplifier, and the other is a precision voltage comparator. Both the operational amplifier and the voltage comparator have been specifically designed to operate from a single power supply over a wide range of voltages. Both circuits have input stages which will common-mode input down to ground when operating from a single power supply. Operation from split power supplies is also possible and the low power supply current is independent of the magnitude of the supply voltage.

Application areas include transducer amplifier with pulse shaper, DC gain block with level detector, VCO, as well as all conventional operational amplifier or voltage comparator circuits. Both circuits can be operated directly from the standard 5 V<sub>DC</sub> power supply voltage used in digital systems, and the output of the comparator will interface directly with either TTL or CMOS logic. In addition, the low power drain makes the LM392 extremely useful in the design of portable equipment.

### Advantages

- Eliminates need for dual power supplies
- An internally compensated op amp and a precision comparator in the same package
- Allows sensing at or near ground

- Power drain suitable for battery operation
- Pin-out is the same as both the LM358 dual op amp and the LM393 dual comparator

### Features

- Wide power supply voltage range  
Single supply: 3V to 32V  
Dual supply: ±1.5V to ±16V
- Low supply current drain—essentially independent of supply voltage: 600 µA
- Low input biasing current: 50 nA
- Low input offset voltage: 2 mV
- Low input offset current: 5 nA
- Input common-mode voltage range includes ground
- Differential input voltage range equal to the power supply voltage

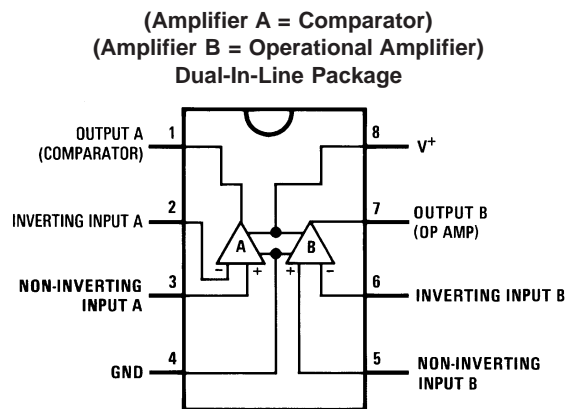
#### ADDITIONAL OP AMP FEATURES

- Internally frequency compensated for unity gain
- Large DC voltage gain: 100 dB
- Wide bandwidth (unity gain): 1 MHz
- Large output voltage swing: 0V to V<sup>+</sup> - 1.5V

#### ADDITIONAL COMPARATOR FEATURES

- Low output saturation voltage: 250 mV at 4 mA
- Output voltage compatible with all types of logic systems

### Connection Diagram



(Top View)

Order Number LM392M or LM392MX

See NS Package Number M08A

Order Number LM392N

See NS Package Number N08E

## Absolute Maximum Ratings (Note 1)

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

|   | <b>LM392</b>     |
|---|------------------|
| Supply Voltage, $V^+$                             | 32V or $\pm 16V$ |
| Differential Input Voltage                        | 32V              |
| Input Voltage                                     | -0.3V to +32V    |
| Power Dissipation (Note 2)                        |                  |
| Molded DIP (LM392N)                               | 820 mW           |
| Small Outline Package (LM392M)                    | 530 mW           |
| Output Short-Circuit to Ground (Note 3)           | Continuous       |
| Input Current ( $V_{IN} < -0.3 V_{DC}$ ) (Note 4) | 50 mA            |
| Operating Temperature Range                       | 0°C to +70°C     |
| Storage Temperature Range                         | -65°C to +150°C  |
| Lead Temperature (Soldering, 10 seconds)          | 260°C            |
| ESD rating to be determined.                      |                  |
| Soldering Information                             |                  |
| Dual-in-Line Package                              |                  |
| Soldering (10 seconds)                            | 260°C            |
| Small Outline Package                             |                  |
| Vapor Phase (60 seconds)                          | 215°C            |
| Infrared (15 seconds)                             | 220°C            |

See AN-450 "Surface Mounting Methods and Their Effect on Product Reliability" for other methods of soldering surface mount devices.

## Electrical Characteristics

( $V^+ = 5 V_{DC}$ ; specifications apply to both amplifiers unless otherwise stated) (Note 5)

| Parameter                       | Conditions   | LM392 |         |             | Units |
|---------------------------------|--|-------|---------|-------------|-------|
|                                 |  | Min   | Typ     | Max         |       |
| Input Offset Voltage            | $T_A = 25^\circ\text{C}$ , (Note 6)  |       | $\pm 2$ | $\pm 5$     | mV    |
| Input Bias Current              | IN(+) or IN(-), $T_A = 25^\circ\text{C}$ , (Note 7), $V_{CM} = 0V$                           |       | 50      | 250         | nA    |
| Input Offset Current            | IN(+) - IN(-), $T_A = 25^\circ\text{C}$  |       | $\pm 5$ | $\pm 50$    | nA    |
| Input Common-Mode Voltage Range | $V^+ = 30 V_{DC}$ , $T_A = 25^\circ\text{C}$ , (Note 8)                                      | 0     |         | $V^+ - 1.5$ | V     |
| Supply Current                  | $R_L = \infty$ , $V^+ = 30 V$  |       | 1       | 2           | mA    |
| Supply Current                  | $R_L = \infty$ , $V^+ = 5 V$   |       | 0.5     | 1           | mA    |
| Amplifier-to-Amplifier Coupling | $f = 1 \text{ kHz to } 20 \text{ kHz}$ , $T_A = 25^\circ\text{C}$ , Input Referred, (Note 9) |       | -100    |             | dB    |
| Input Offset Voltage            | (Note 6)   |       |         | $\pm 7$     | mV    |
| Input Bias Current              | IN(+) or IN(-)   |       |         | 400         | nA    |
| Input Offset Current            | IN(+) - IN(-)  |       |         | 150         | nA    |
| Input Common-Mode Voltage Range | $V^+ = 30 V_{DC}$ , (Note 8)   | 0     |         | $V^+ - 2$   | V     |
| Differential Input Voltage      | Keep All $V_{IN}^s \geq 0 V_{DC}$ (or $V^-$ , if used ) (Note 10)                            |       |         | 32          | V     |

## Electrical Characteristics (Continued)

( $V^+ = 5 V_{DC}$ ; specifications apply to both amplifiers unless otherwise stated) (Note 5)

| Parameter                    | Conditions   | LM392 |     |             | Units              |
|------------------------------|--|-------|-----|-------------|--------------------|
|                              |  | Min   | Typ | Max         |                    |
| <b>OP AMP ONLY</b>           |  |       |     |             |                    |
| Large Signal Voltage Gain    | $V^+ = 15 V_{DC}$ , $V_o$ swing = $1 V_{DC}$ to $11 V_{DC}$ ,<br>$R_L = 2 k\Omega$ , $T_A = 25^\circ C$              | 25    | 100 |             | V/mV               |
| Output Voltage Swing         | $R_L = 2 k\Omega$ , $T_A = 25^\circ C$   | 0     |     | $V^+ - 1.5$ | V                  |
| Common-Mode Rejection Ratio  | DC, $T_A = 25^\circ C$ , $V_{CM} = 0$ , $V_{DC}$ to $V^+ - 1.5 V_{DC}$   | 65    | 70  |             | dB                 |
| Power Supply Rejection Ratio | DC, $T_A = 25^\circ C$   | 65    | 100 |             | dB                 |
| Output Current Source        | $V_{IN(+)} = 1 V_{DC}$ , $V_{IN(-)} = 0 V_{DC}$ ,<br>$V^+ = 15 V_{DC}$ , $V_o = 2 V_{DC}$ , $T_A = 25^\circ C$       | 20    | 40  |             | mA                 |
| Output Current Sink          | $V_{IN(-)} = 1 V_{DC}$ , $V_{IN(+)} = 0 V_{DC}$ ,<br>$V^+ = 15 V_{DC}$ , $V_o = 2V_{DC}$ , $T_A = 25^\circ C$        | 10    | 20  |             | mA                 |
|                              | $V_{IN(-)} = 1 V_{DC}$ , $V_{IN(+)} = 0 V_{DC}$ ,<br>$V^+ = 15 V_{DC}$ , $V_o = 200 mV$ , $T_A = 25^\circ C$         | 12    | 50  |             | $\mu A$            |
| Input Offset Voltage Drift   | $R_S = 0\Omega$  |       | 7   |             | $\mu V/^\circ C$   |
| Input Offset Current Drift   | $R_S = 0\Omega$  |       | 10  |             | $pA_{DC}/^\circ C$ |
| <b>COMPARATOR ONLY</b>       |  |       |     |             |                    |
| Voltage Gain                 | $R_L \geq 15 k\Omega$ , $V^+ = 15 V_{DC}$ , $T_A = 25^\circ C$   | 50    | 200 |             | V/mV               |
| Large Signal Response Time   | $V_{IN} = TTL$ Logic Swing, $V_{REF} = 1.4 V_{DC}$<br>$V_{RL} = 5 V_{DC}$ , $R_L = 5.1 k\Omega$ , $T_A = 25^\circ C$ |       | 300 |             | ns                 |
| Response Time                | $V_{RL} = 5 V_{DC}$ , $R_L = 5.1 k\Omega$ , $T_A = 25^\circ C$   |       | 1.3 |             | $\mu s$            |
| Output Sink Current          | $V_{IN(-)} = 1 V_{DC}$ , $V_{IN(+)} = 0 V_{DC}$ ,<br>$V_o \geq 1.5 V_{DC}$ , $T_A = 25^\circ C$                      | 6     | 16  |             | mA                 |
| Saturation Voltage           | $V_{IN(-)} \geq 1 V_{DC}$ , $V_{IN(+)} = 0$ ,<br>$I_{SINK} \leq 4 mA$ , $T_A = 25^\circ C$                           |       | 250 | 400         | mV                 |
|                              | $V_{IN(-)} \geq 1 V_{DC}$ , $V_{IN(+)} = 0$ ,<br>$I_{SINK} \leq 4 mA$  |       |     | 700         | mV                 |
| Output Leakage Current       | $V_{IN(-)} = 0$ , $V_{IN(+)} \geq 1 V_{DC}$ ,<br>$V_o = 5 V_{DC}$ , $T_A = 25^\circ C$                               |       | 0.1 |             | nA                 |
|                              | $V_{IN(-)} = 0$ , $V_{IN(+)} \geq 1 V_{DC}$ ,<br>$V_o = 30 V_{DC}$   |       |     | 1.0         | $\mu A$            |

**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 temperatures above  $25^\circ C$ , the LM392 must be derated based on a  $125^\circ C$  maximum junction temperature and a thermal resistance of  $122^\circ C/W$  which applies for the device soldered in a printed circuit board, operating in still air ambient. The dissipation is the total of both amplifiers—use external resistors, where possible, to allow the amplifier to saturate or to reduce the power which is dissipated in the integrated circuit.

**Note 3:** Short circuits from the output to  $V^+$  can cause excessive heating and eventual destruction. When considering short circuits to ground, the maximum output current is approximately 40 mA for the op amp and 30 mA for the comparator independent of the magnitude of  $V^+$ . At values of supply voltage in excess of 15V, continuous short circuits can exceed the power dissipation ratings and cause eventual destruction.

**Note 4:** This input current will only exist when the voltage at any of the input leads is driven negative. It is due to the collector-base junction of the input PNP transistors becoming forward biased and thereby acting as input diode clamps. In addition to this diode action, there is also lateral NPN parasitic transistor action on the IC chip. This transistor action can cause the output voltages of the amplifiers to go to the  $V^+$  voltage level (or to ground for a large overdrive) for the time duration that an input is driven negative. This is not destructive and normal output states will re-establish when the input voltage, which was negative, again returns to a value greater than  $-0.3V$  (at  $25^\circ C$ ).

**Note 5:** These specifications apply for  $V^+ = 5V$ , unless otherwise stated. For the LM392, temperature specifications are limited to  $0^\circ C \leq T_A \leq +70^\circ C$ .

**Note 6:** At output switch point,  $V_o = 1.4V$ ,  $R_S = 0\Omega$  with  $V^+$  from 5V to 30V; and over the full input common-mode range (0V to  $V^+ - 1.5V$ ).

**Note 7:** The direction of the input current is out of the IC due to the PNP input stage. This current is essentially constant, independent of the state of the output so no loading change exists on the input lines.

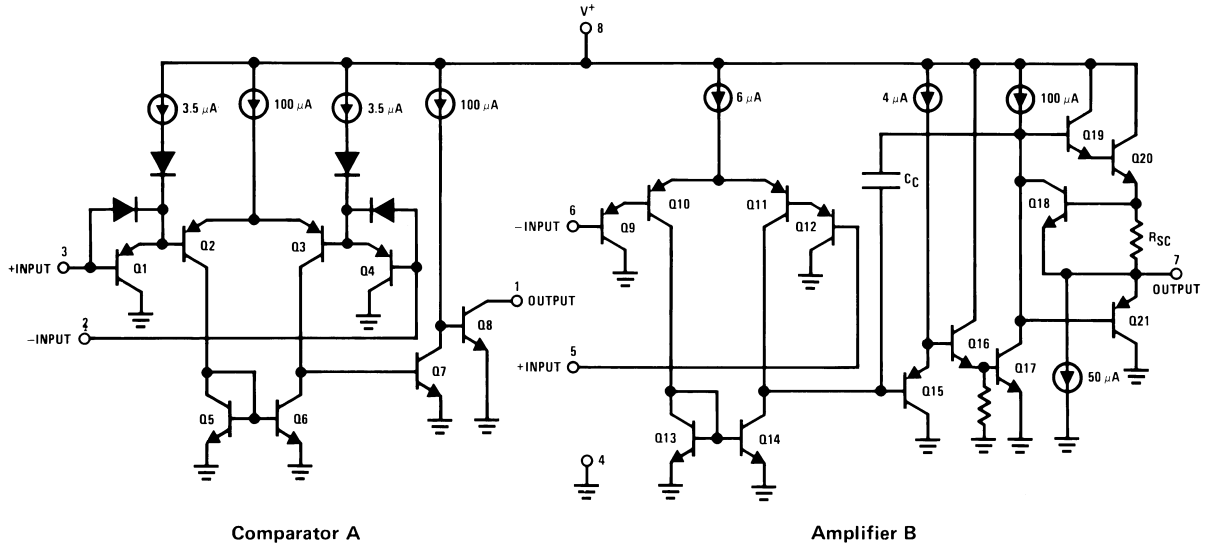
**Note 8:** The input common-mode voltage or either input signal voltage should not be allowed to go negative by more than 0.3V. The upper end of the common-mode voltage range is  $V^+ - 1.5V$ , but either or both inputs can go to 32V without damage.

**Note 9:** Due to proximity of external components, insure that coupling is not originating via the stray capacitance between these external parts. This typically can be detected as this type of capacitive coupling increases at higher frequencies.

**Note 10:** Positive excursions of input voltage may exceed the power supply level. As long as the other input voltage remains within the common-mode range, the comparator will provide a proper output state. The input voltage to the op amp should not exceed the power supply level. The input voltage state must not be less than  $-0.3V$  (or 0.3V below the magnitude of the negative power supply, if used) on either amplifier.

**Note 11:** The response time specified is for a 100 mV input step with 5 mV overdrive. For larger overdrive signals 300 ns can be obtained.

## Schematic Diagram

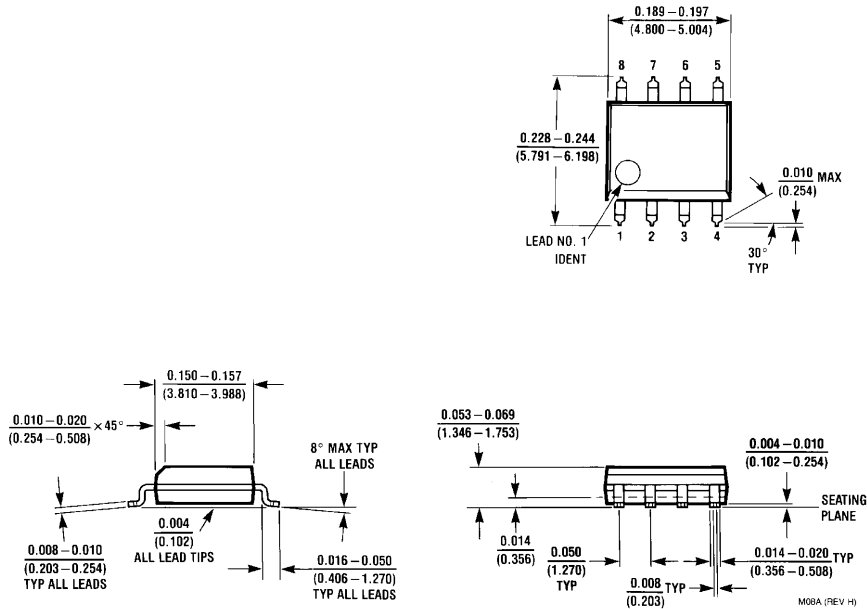


DS007793-2

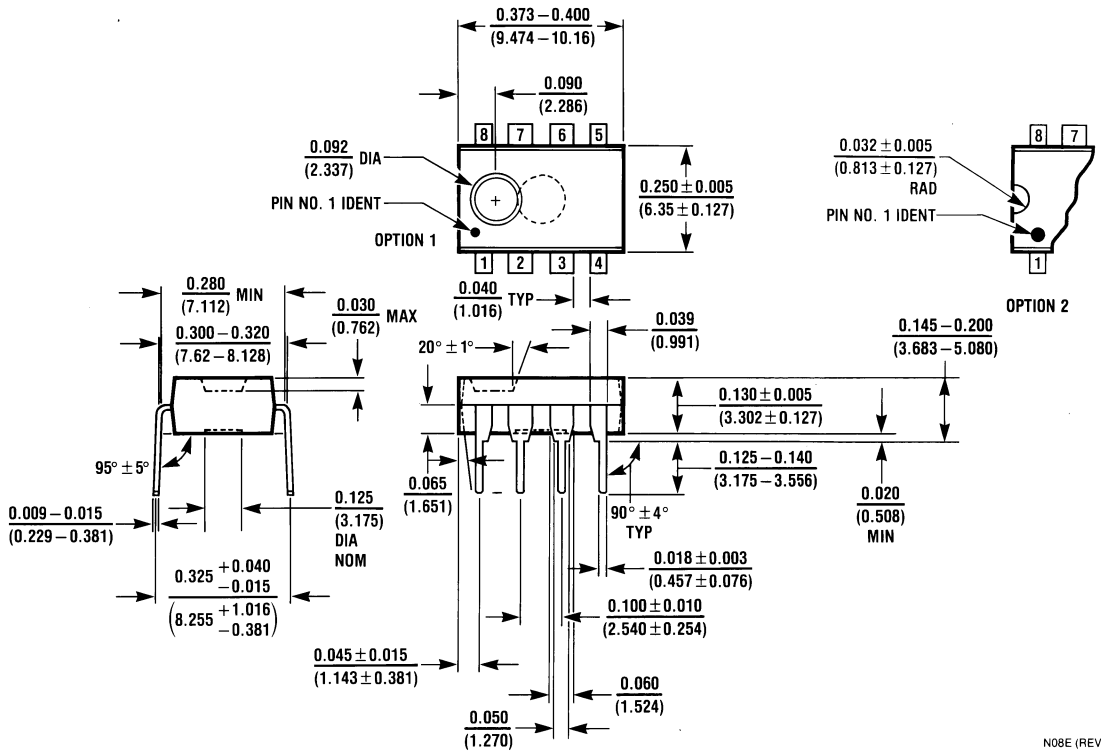
## Application Hints

Please refer to the application hints section of the LM193 and the LM158 datasheets.

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



**S.O. Package (M)**  
**Order Number LM392M or LM392MX**  
**NS Package Number M08A**



**Molded Dual-In-Line Package (N)**  
**Order Number LM392N**  
**NS Package Number N08E**

## Notes

**LIFE SUPPORT POLICY**

NATIONAL'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE PRESIDENT AND GENERAL COUNSEL OF NATIONAL SEMICONDUCTOR CORPORATION. As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and whose failure to perform when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury to the user.
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.



**National Semiconductor Corporation**  
Americas  
Tel: 1-800-272-9959  
Fax: 1-800-737-7018  
Email: support@nsc.com  
www.national.com

**National Semiconductor Europe**  
Fax: +49 (0) 180-530 85 86  
Email: europe.support@nsc.com  
Deutsch Tel: +49 (0) 69 9508 6208  
English Tel: +44 (0) 870 24 0 2171  
Français Tel: +33 (0) 1 41 91 8790

**National Semiconductor Asia Pacific Customer Response Group**  
Tel: 65-2544466  
Fax: 65-2504466  
Email: ap.support@nsc.com

**National Semiconductor Japan Ltd.**  
Tel: 81-3-5639-7560  
Fax: 81-3-5639-7507