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## LM392/LM2924 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

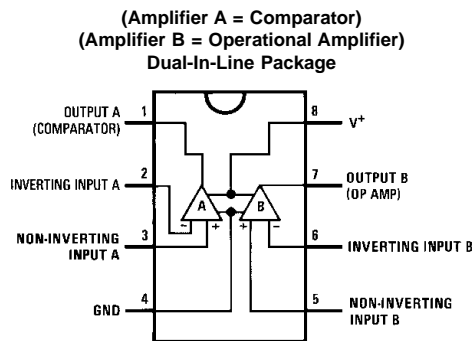
#### ADDITIONAL OP AMP FEATURES

- 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 LM2924M  
See NS Package Number M08A  
Order Number LM392N or LM2924N  
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.

	LM392	LM2924
Supply Voltage, $V^+$	32V or $\pm 16V$	26V or $\pm 13V$
Differential Input Voltage	32V	26V
Input Voltage	-0.3V to +32V	-0.3V to +26V
Power Dissipation (Note 2)		
Molded DIP (LM392N, LM2924N)	820 mW	820 mW
Small Outline Package (LM392M, LM2924M)	530 mW	530 mW
Output Short-Circuit to Ground (Note 3)	Continuous	Continuous
Input Current ( $V_{IN} < -0.3 V_{DC}$ ) (Note 4)	50 mA	50 mA
Operating Temperature Range	0°C to +70°C	-40°C to +85°C
Storage Temperature Range	-65°C to +150°C	-65°C to +150°C
Lead Temperature (Soldering, 10 seconds)	260°C	260°C
ESD rating to be determined.		
Soldering Information		
Dual-in-Line Package		
Soldering (10 seconds)	260°C	260°C
Small Outline Package		
Vapor Phase (60 seconds)	215°C	215°C
Infrared (15 seconds)	220°C	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			LM2924			Units
		Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage	$T_A = 25^\circ\text{C}$ , (Note 6)		$\pm 2$	$\pm 5$		$\pm 2$	$\pm 7$	mV
Input Bias Current	IN(+) or IN(-), $T_A = 25^\circ\text{C}$ , (Note 7), $V_{CM} = 0V$		50	250		50	250	nA
Input Offset Current	IN(+) - IN(-), $T_A = 25^\circ\text{C}$		$\pm 5$	$\pm 50$		$\pm 5$	$\pm 50$	nA
Input Common-Mode Voltage Range	$V^+ = 30 V_{DC}$ , $T_A = 25^\circ\text{C}$ , (Note 8) (LM2924, $V^+ = 26 V_{DC}$ )	0		$V^+ - 1.5$	0		$V^+ - 1.5$	V
Supply Current	$R_L = \infty$ , $V^+ = 30V$ , (LM2924, $V^+ = 26V$ )		1	2		1	2	mA
Supply Current	$R_L = \infty$ , $V^+ = 5V$		0.5	1		0.5	1	mA
Amplifier-to-Amplifier Coupling	$f = 1 \text{ kHz}$ to 20 kHz, $T_A = 25^\circ\text{C}$ , Input Referred, (Note 9)		-100			-100		dB
Input Offset Voltage	(Note 6)			$\pm 7$			$\pm 10$	mV
Input Bias Current	IN(+) or IN(-)			400			500	nA
Input Offset Current	IN(+) - IN(-)			150			200	nA
Input Common-Mode Voltage Range	$V^+ = 30 V_{DC}$ , (Note 8) (LM2924, $V^+ = 26 V_{DC}$ )	0		$V^+ - 2$	0		$V^+ - 2$	V
Differential Input Voltage	Keep All $V_{IN}$ 's $\geq 0 V_{DC}$ (or $V^-$ , if Used), (Note 10)			32			26	V

## Electrical Characteristics (Continued)

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

Parameter	Conditions	LM392			LM2924			Units
		Min	Typ	Max	Min	Typ	Max	
<b>OP AMP ONLY</b>								
Large Signal Voltage Gain	$V^+ = 15 V_{DC}$ , $V_o$ swing = $1 V_{DC}$ to $11 V_{DC}$ , $R_L = 2 k\Omega$ , $T_A = 25^\circ C$	25	100		25	100		V/mV
Output Voltage Swing	$R_L = 2 k\Omega$ , $T_A = 25^\circ C$ , (LM2924, $R_L \geq 10 k\Omega$ )	0		$V^+ - 1.5$	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		50	70		dB
Power Supply Rejection Ratio	DC, $T_A = 25^\circ C$	65	100		50	100		dB
Output Current Source	$V_{IN(+)} = 1 V_{DC}$ , $V_{IN(-)} = 0 V_{DC}$ , $V^+ = 15 V_{DC}$ , $V_o =$ $2 V_{DC}$ , $T_A = 25^\circ C$	20	40		20	40		mA
Output Current Sink	$V_{IN(-)} = 1 V_{DC}$ , $V_{IN(+)} = 0 V_{DC}$ , $V^+ = 15 V_{DC}$ , $V_o =$ $2 V_{DC}$ , $T_A = 25^\circ C$	10	20		10	20		mA
	$V_{IN(-)} = 1 V_{DC}$ , $V_{IN(+)} = 0 V_{DC}$ , $V^+ = 15 V_{DC}$ , $V_o =$ $200 mV$ , $T_A = 25^\circ C$	12	50		12	50		$\mu A$
Input Offset Voltage Drift	$R_S = 0\Omega$		7			7		$\mu V/^\circ C$
Input Offset Current Drift	$R_S = 0\Omega$		10			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		25	100		V/mV
Large Signal Response Time	$V_{IN} = TTL$ Logic Swing, $V_{REF} = 1.4 V_{DC}$ $V_{RL} = 5 V_{DC}$ , $R_L = 5.1 k\Omega$ , $T_A = 25^\circ C$		300			300		ns
Response Time	$V_{RL} = 5 V_{DC}$ , $R_L = 5.1 k\Omega$ , $T_A = 25^\circ C$ , (Note 11)		1.3			1.5		$\mu s$
Output Sink Current	$V_{IN(-)} = 1 V_{DC}$ , $V_{IN(+)} = 0 V_{DC}$ , $V_o \geq 1.5 V_{DC}$ , $T_A = 25^\circ C$	6	16		6	16		mA
Saturation Voltage	$V_{IN(-)} \geq 1 V_{DC}$ , $V_{IN(+)} = 0$ , $I_{SINK} \leq 4 mA$ , $T_A = 25^\circ C$		250	400			400	mV
	$V_{IN(-)} \geq 1 V_{DC}$ , $V_{IN(+)} = 0$ , $I_{SINK} \leq 4 mA$			700			700	mV
Output Leakage Current	$V_{IN(-)} = 0$ , $V_{IN(+)} \geq 1 V_{DC}$ , $V_o = 5 V_{DC}$ , $T_A = 25^\circ C$		0.1			0.1		nA
	$V_{IN(-)} = 0$ , $V_{IN(+)} \geq 1 V_{DC}$ , $V_o = 30 V_{DC}$			1.0			1.0	$\mu A$

## Electrical Characteristics (Continued)

**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°C, the LM392 and the LM2924 must be derated based on a 125°C maximum junction temperature and a thermal resistance of 122°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°C).

**Note 5:** These specifications apply for  $V^+ = 5V$ , unless otherwise stated. For the LM392, temperature specifications are limited to  $0^\circ\text{C} \leq T_A \leq +70^\circ\text{C}$  and the LM2924 temperature specifications are limited to  $-40^\circ\text{C} \leq T_A \leq +85^\circ\text{C}$ .

**Note 6:** At output switch point,  $V_O \cong 1.4V$ ,  $R_S = 0\Omega$  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.

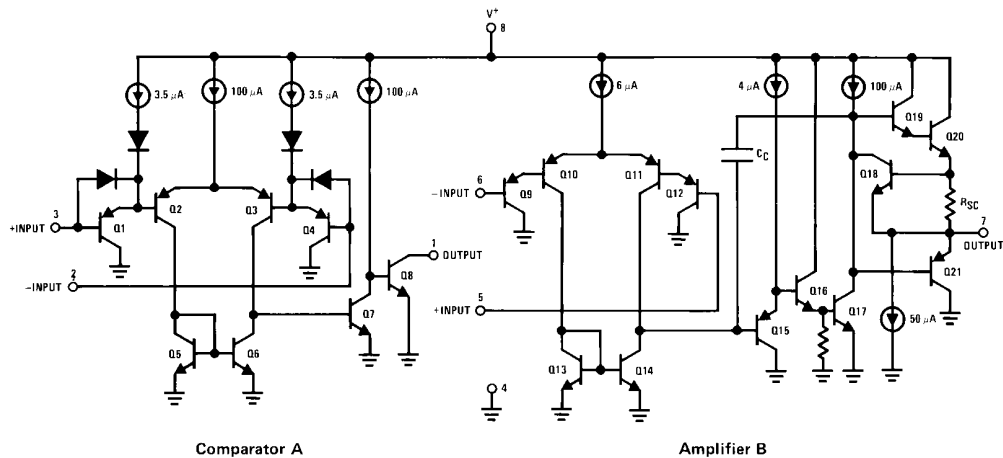
**Note 8:** The input common-mode voltage or either input signal voltage should not be allowed to go negative by more than 0.3V. The upper end of the common-mode voltage range is  $V^+ - 1.5V$ , but either or both inputs can go to 32V without damage (26V for LM2924).

**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 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

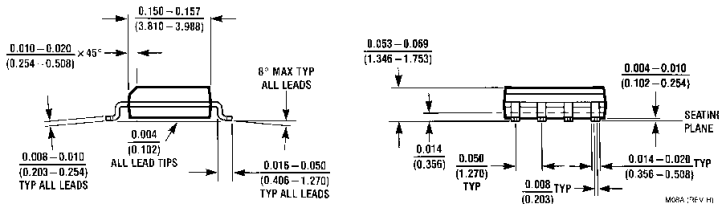
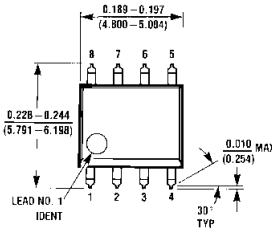


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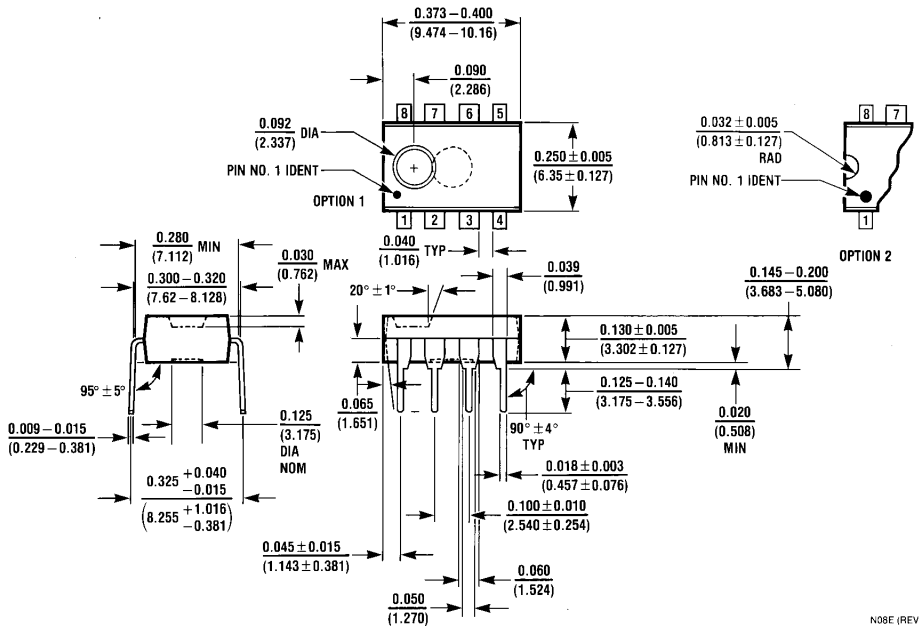
## Application Hints

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 LM2924M**  
**NS Package Number M08A**



**Molded Dual-In-Line Package (N)**  
**Order Number LM392N or LM2924N**  
**NS Package Number N08E**

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Product Folder

## LM392 Low Power Operational Amplifier/Voltage Comparator

Generic P/N 392

### Contents

- [General Description](#)
- [Features](#)
- [Applications](#)
- [Datasheet](#)
- [Package Availability, Models, Samples & Pricing](#)
- [Design Tools](#)
- [Application Notes](#)

Parametric Table	
Channels (Channels)	2
Input Output Type	Vcm to V-,Not R-R Out
Bandwidth, typ (MHz)	1
Slew Rate, typ (Volts/usec)	.10
Supply Current per Channel, typ (mA)	.50
Minimum Supply Voltage (Volt)	3
Maximum Supply Voltage (Volt)	32
Offset Voltage, Max (mV)	5
Input Bias Current, Temp Max (nA)	400
Output Current, typ (mA)	20
Voltage Noise, typ (nV/Hz)	38
Shut down	No
Special Features	w/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



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## Features

- Wide power supply voltage range Single supply: 3V to 32V Dual supply:  $\pm 1.5V$  to  $\pm 16V$
- Low supply current drain-essentially independent of supply voltage: 600  $\mu A$
- 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
- 

## Applications

- 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

## Datasheet

Title	Size (in Kbytes)	Date	View Online	Download	Receive via Email
LM392/LM2924 Low Power Operational Amplifier/Voltage Comparator	98 Kbytes	30-Mar-99	<a href="#">View Online</a>	<a href="#">Download</a>	<a href="#">Receive via Email</a>

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## Package Availability, Models, Samples & Pricing

Part Number	Package		Status	Models		Samples & Electronic Orders	Budgetary Pricing		Std Pack Size
	Type	# pins		SPICE	IBIS		Quantity	\$US each	
LM392M	<a href="#">SOIC NARROW</a>	8	Full production	N/A	N/A	<a href="#">Samples</a> Order Parts	1K+	\$0.5500	tube of 95
LM392MX	<a href="#">SOIC NARROW</a>	8	Full production	N/A	N/A	<a href="#">Samples</a> Order Parts	1K+	\$0.5800	reel of 2500
LM392N	<a href="#">MDIP</a>	8	Full production	N/A	N/A	<a href="#">Samples</a> Order Parts	1K+	\$0.5500	tube of 40 [lc
LM392 MDA	die		Full production	N/A	N/A	.			N/A

## Design Tools

Title	Size (in Kbytes)	Date	View Online	Download	Receive via Email
Amplifiers Selection Guide software for Windows	8 Kbytes	26-May-2000		<a href="#">View</a>	

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## Application Notes

Title	Size (in Kbytes)	Date	View Online	Download	Receive via Email
<b>AN-286:</b> Applications of the LM392 Comparator Op Amp IC	135 Kbytes	4-Nov-95	<a href="#">View Online</a>	<a href="#">Download</a>	<a href="#">Receive via Email</a>
<b>AN-274:</b> CMOS A/D Converter Interfaces Easily with Many Microprocessors	99 Kbytes	4-Nov-95	<a href="#">View Online</a>	<a href="#">Download</a>	<a href="#">Receive via Email</a>

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