

LM148JAN Quad 741 Op Amps

Check for Samples: [LM148JAN](#)

FEATURES

- 741 Op Amp Operating Characteristics
- Class AB Output Stage—No Crossover Distortion
- Pin Compatible with the LM124
- Overload Protection for Inputs and Outputs
- Low Supply Current Drain: 0.6 mA/Amplifier
- Low Input Offset Voltage: 1 mV
- Low Input Offset Current: 4 nA
- Low Input Bias Current 30 nA
- High Degree of Isolation between Amplifiers: 120 dB
- Gain Bandwidth Product (Unity Gain): 1.0 MHz

DESCRIPTION

The LM148 is a true quad LM741. It consists of four independent, high gain, internally compensated, low power operational amplifiers which have been designed to provide functional characteristics identical to those of the familiar LM741 operational amplifier. In addition the total supply current for all four amplifiers is comparable to the supply current of a single LM741 type op amp. Other features include input offset currents and input bias current which are much less than those of a standard LM741. Also, excellent isolation between amplifiers has been achieved by independently biasing each amplifier and using layout techniques which minimize thermal coupling.

The LM148 can be used anywhere multiple LM741 or LM1558 type amplifiers are being used and in applications where amplifier matching or high packing density is required.

Connection Diagram

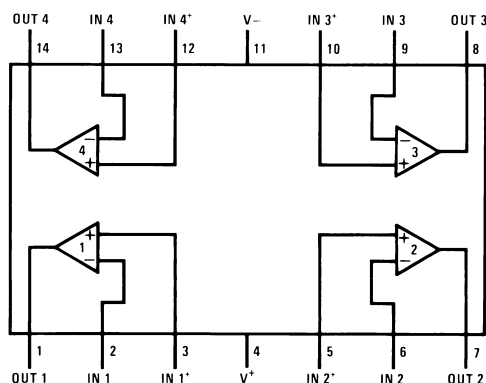


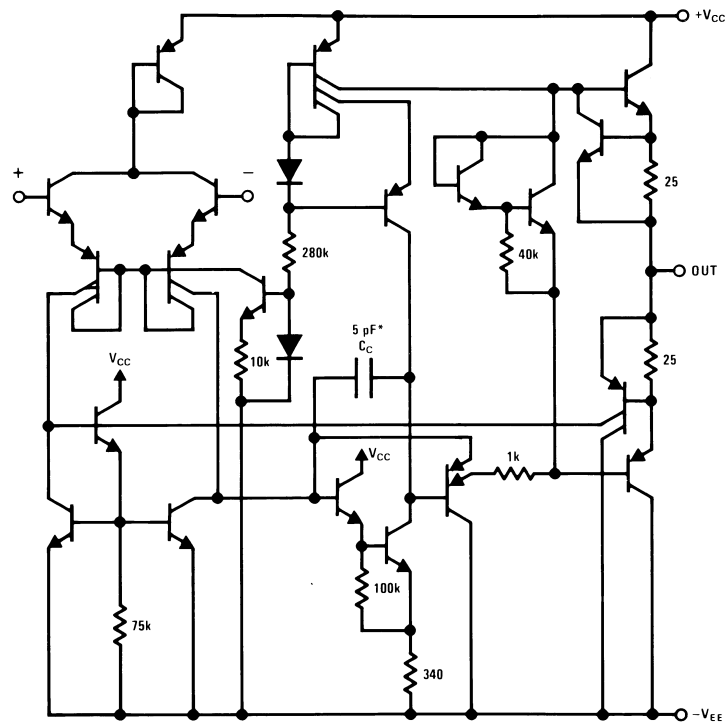
Figure 1. Top View
See Package Number J0014A, NAD0014B, NAC0014A



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

All trademarks are the property of their respective owners.

Schematic Diagram



* 1 pF in the LM149



These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

Absolute Maximum Ratings⁽¹⁾

| | | | |
|---------------------------------------------------|-----------------|---------------------------------------|---------|
| Supply Voltage | | ±22V | |
| Input Voltage Range | | ±20V | |
| Input Current Range | | -0.1mA to 10mA | |
| Differential Input Voltage ⁽²⁾ | | ±30V | |
| Output Short Circuit Duration ⁽³⁾ | | Continuous | |
| Power Dissipation (P_d at 25°C) ⁽⁴⁾ | | CDIP | 400mW |
| | | CLGA (NAD0014B) | 350mW |
| Thermal Resistance | θ_{JA} | CDIP (Still Air) | 103°C/W |
| | | CDIP (500LF/ Min Air flow) | 52°C/W |
| | | CLGA (NAD0014B) (Still Air) | 140°C/W |
| | | CLGA (NAD0014B) (500LF/ Min Air flow) | 100°C/W |
| | θ_{JC} | CLGA (NAC0014A) (Still Air) | 176°C/W |
| | | CLGA (NAC0014A) (500LF/ Min Air flow) | 116°C/W |
| | | CDIP | 19°C/W |
| | | CLGA (NAD0014B) | 25°C/W |
| Package Weight (typical) | | CLGA (NAC0014A) | 25°C/W |
| | CDIP | | TBD |
| | CLGA (NAD0014B) | | 465mg |
| | | CLGA (NAC0014A) | 415mg |
| Maximum Junction Temperature (T_{JMAX}) | | 175°C | |
| Operating Temperature Range | | -55°C ≤ T_A ≤ +125°C | |
| Storage Temperature Range | | -65°C ≤ T_A ≤ +150°C | |
| Lead Temperature (Soldering, 10 sec.) Ceramic | | 300°C | |
| ESD tolerance ⁽⁵⁾ | | 500V | |

- (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 ensure specific performance limits. For ensured specifications and test conditions, see the Electrical Characteristics. The ensured specifications apply only for the test conditions listed. Some performance characteristics may degrade when the device is not operated under the listed test conditions.
- (2) The differential input voltage range shall not exceed the supply voltage range.
- (3) Any of the amplifier outputs can be shorted to ground indefinitely; however, more than one should not be simultaneously shorted as the maximum junction temperature will be exceeded.
- (4) The maximum power dissipation for these devices must be derated at elevated temperatures and is dictated by T_{JMAX} , θ_{JA} , and the ambient temperature, T_A . The maximum available power dissipation at any temperature is $P_d = (T_{JMAX} - T_A)/\theta_{JA}$ or the number given in the Absolute Maximum Ratings, whichever is less.
- (5) Human body model, 1.5 kΩ in series with 100 pF.

Quality Conformance Inspection

MIL-STD-883, Method 5005 — Group A

| Subgroup | Description | Temp (°C) |
|----------|---------------------|------------|
| 1 | Static tests at | +25 |
| 2 | Static tests at | +125 |
| 3 | Static tests at | -55 |
| 4 | Dynamic tests at | +25 |
| 5 | Dynamic tests at | +125 |
| 6 | Dynamic tests at | -55 |
| 7 | Functional tests at | +25 |
| 8A | Functional tests at | +125 |
| 8B | Functional tests at | -55 |
| 9 | Switching tests at | +25 |

Quality Conformance Inspection (continued)

MIL-STD-883, Method 5005 — Group A

| Subgroup | Description | Temp (°C) |
|----------|--------------------|------------|
| 10 | Switching tests at | +125 |
| 11 | Switching tests at | -55 |

Electrical Characteristics

DC PARAMETERS (The following conditions apply to all parameters, unless otherwise specified.)

 $\pm V_{CC} = \pm 20V$, $V_{CM} = 0V$, measure each amplifier.

| Symbol | Parameter | Conditions | Notes | Min | Max | Units | Sub-groups | | |
|--------------|-----------------------------|--------------------------------------------------------|--------------------------------------------|----------------------------------------------|--------------------|-------|------------|-------------------|---------|
| V_{IO} | Input Offset Voltage | $+V_{CC} = 35V$, $-V_{CC} = -5V$, $V_{CM} = -15V$ | | -5.0 | +5.0 | mV | 1 | | |
| | | | | -6.0 | +6.0 | mV | 2, 3 | | |
| | | $+V_{CC} = 5V$, $-V_{CC} = -35V$, $V_{CM} = +15V$ | | -5.0 | +5.0 | mV | 1 | | |
| | | | | -6.0 | +6.0 | mV | 2, 3 | | |
| | | $+V_{CC} = 5V$, $-V_{CC} = -5V$, | | -5.0 | +5.0 | mV | 1 | | |
| | | | | -6.0 | +6.0 | mV | 2, 3 | | |
| | | Delta V_{IO} / Delta T | Input Offset Voltage Temperature Stability | $25^{\circ}C \leq T_A \leq 125^{\circ}C$ | See ⁽¹⁾ | -25 | 25 | $\mu V/^{\circ}C$ | 2 |
| | | | | $-55^{\circ}C \leq T_A \leq 25^{\circ}C$ | See ⁽¹⁾ | -25 | 25 | $\mu V/^{\circ}C$ | 3 |
| I_{IO} | Input Offset Current | $+V_{CC} = 35V$, $-V_{CC} = -5V$, $V_{CM} = -15V$ | | -25 | +25 | nA | 1, 2 | | |
| | | | | -75 | +75 | nA | 3 | | |
| | | $+V_{CC} = 5V$, $-V_{CC} = -35V$, $V_{CM} = +15V$ | | -25 | +25 | nA | 1, 2 | | |
| | | | | -75 | +75 | nA | 3 | | |
| | | $+V_{CC} = 5V$, $-V_{CC} = -5V$, | | -25 | +25 | nA | 1, 2 | | |
| | | | | -75 | +75 | nA | 3 | | |
| | | Delta I_{IO} / Delta T | Input Offset Current Temperature Stability | $25^{\circ}C \leq T_A \leq 125^{\circ}C$ | See ⁽¹⁾ | -200 | 200 | $\mu A/^{\circ}C$ | 2 |
| | | | | $-55^{\circ}C \leq T_A \leq 25^{\circ}C$ | See ⁽¹⁾ | -400 | 400 | $\mu A/^{\circ}C$ | 3 |
| $\pm I_{IB}$ | Input Bias Current | $+V_{CC} = 35V$, $-V_{CC} = -5V$, $V_{CM} = -15V$ | | -0.1 | 100 | nA | 1, 2 | | |
| | | | | -0.1 | 325 | nA | 3 | | |
| | | $+V_{CC} = 5V$, $-V_{CC} = -35V$, $V_{CM} = +15V$ | | -0.1 | 100 | nA | 1, 2 | | |
| | | | | -0.1 | 325 | nA | 3 | | |
| | | $+V_{CC} = 5V$, $-V_{CC} = -5V$, | | -0.1 | 100 | nA | 1, 2 | | |
| | | | | -0.1 | 325 | nA | 3 | | |
| | | PSRR+ | Power Supply Rejection Ratio | $-V_{CC} = -20V$, $+V_{CC} = 20V$ to $10V$ | See ⁽²⁾ | -100 | 100 | $\mu V/V$ | 1, 2, 3 |
| | | PSRR- | Power Supply Rejection Ratio | $+V_{CC} = 20V$, $-V_{CC} = -20V$ to $-10V$ | See ⁽²⁾ | -100 | 100 | $\mu V/V$ | 1, 2, 3 |
| CMRR | Common Mode Rejection Ratio | $V_{CM} = \pm 15V$, $\pm 5V \leq V_{CC} \leq \pm 35V$ | | 76 | | dB | 1, 2, 3 | | |

(1) Calculated parameter.

(2) Datalogs as μV

Electrical Characteristics

AC / DC PARAMETERS (The following conditions apply to all parameters, unless otherwise specified.)

 $\pm V_{CC} = \pm 20V$, $V_{CM} = 0V$, measure each amplifier.

| Symbol | Parameter | Conditions | Notes | Min | Max | Units | Sub-groups |
|-------------------|-------------------------|----------------------------------------------------------------------------|-------|-----|-----|-------|------------|
| + I _{OS} | Short Circuit Current | +V _{CC} = 15V, -V _{CC} = -15V, V _{CM} = -10V | | -55 | | mA | 1, 2 |
| | | | | -75 | | mA | 3 |
| - I _{OS} | Short Circuit Current | +V _{CC} = 15V, -V _{CC} = -15V, V _{CM} = +10V | | | 55 | mA | 1, 2 |
| | | | | | 75 | mA | 3 |
| I _{CC} | Power Supply Current | +V _{CC} = 15V, -V _{CC} = -15V | | | 3.6 | mA | 1 |
| | | | | | 4.5 | mA | 2, 3 |
| -A _{VS} | Open Loop Voltage Gain | V _{OUT} = -15V, R _L = 10KΩ | | 50 | | V/mV | 4 |
| | | | | 25 | | V/mV | 5, 6 |
| | | V _{OUT} = -15V, R _L = 2KΩ | | 50 | | V/mV | 4 |
| | | | | 25 | | V/mV | 5, 6 |
| +A _{VS} | Open Loop Voltage Gain | V _{OUT} = +15V, R _L = 10KΩ | | 50 | | V/mV | 4 |
| | | | | 25 | | V/mV | 5, 6 |
| | | V _{OUT} = +15V, R _L = 2KΩ | | 50 | | V/mV | 4 |
| | | | | 25 | | V/mV | 5, 6 |
| A _{VS} | Open Loop Voltage Gain | V _{CC} = ±5V, V _{OUT} = ±2V, R _L = 10KΩ | | 10 | | V/mV | 4, 5, 6 |
| | | V _{CC} = ±5V, V _{OUT} = ±2V, R _L = 2KΩ | | 10 | | V/mV | 4, 5, 6 |
| +V _{OP} | Output Voltage Swing | R _L = 10KΩ | | +16 | | V | 4, 5, 6 |
| | | R _L = 2KΩ | | +15 | | V | 4, 5, 6 |
| -V _{OP} | Output Voltage Swing | R _L = 10KΩ | | | -16 | V | 4, 5, 6 |
| | | R _L = 2KΩ | | | -15 | V | 4, 5, 6 |
| TR _{TR} | Transient Response Time | V _{IN} = 50mV, A _V = 1 | | | 1 | μS | 7, 8A, 8B |
| TR _{OS} | Transient Response Time | V _{IN} = 50mV, A _V = 1 | | | 25 | % | 7, 8A, 8B |
| ±SR | Slew Rate | V _{IN} = -5V to +5V, A _V = 1 | | 0.2 | | V/μS | 7, 8A, 8B |
| | | V _{IN} = +5V to -5V, A _V = 1 | | 0.2 | | V/μS | 7, 8A, 8B |

Electrical Characteristics

AC PARAMETERS (The following conditions apply to all parameters, unless otherwise specified.)

 $\pm V_{CC} = \pm 20V$, $V_{CM} = 0V$, measure each amplifier.

| Symbol | Parameter | Conditions | Notes | Min | Max | Units | Sub-groups |
|------------------|--------------------|------------------------------------------------------|-------|-----|-----|-------------------|------------|
| NI _{BB} | Noise (Broadband) | BW = 10Hz to 5KHz | | | 15 | μV _{RMS} | 7 |
| NI _{PC} | Noise (Popcorn) | R _S = 20KΩ | | | 40 | μV _{PK} | 7 |
| C _S | Channel Separation | V _{IN} = ±10V, A to B, R _L = 2KΩ | | 80 | | dB | 7 |
| | | V _{IN} = ±10V, A to C, R _L = 2KΩ | | 80 | | dB | 7 |
| | | V _{IN} = ±10V, A to D, R _L = 2KΩ | | 80 | | dB | 7 |
| | | V _{IN} = ±10V, B to A, R _L = 2KΩ | | 80 | | dB | 7 |
| | | V _{IN} = ±10V, B to C, R _L = 2KΩ | | 80 | | dB | 7 |
| | | V _{IN} = ±10V, B to D, R _L = 2KΩ | | 80 | | dB | 7 |
| | | V _{IN} = ±10V, C to A, R _L = 2KΩ | | 80 | | dB | 7 |
| | | V _{IN} = ±10V, C to B, R _L = 2KΩ | | 80 | | dB | 7 |
| | | V _{IN} = ±10V, C to D, R _L = 2KΩ | | 80 | | dB | 7 |
| | | V _{IN} = ±10V, D to A, R _L = 2KΩ | | 80 | | dB | 7 |
| | | V _{IN} = ±10V, D to B, R _L = 2KΩ | | 80 | | dB | 7 |
| | | V _{IN} = ±10V, D to C, R _L = 2KΩ | | 80 | | dB | 7 |

Electrical Characteristics

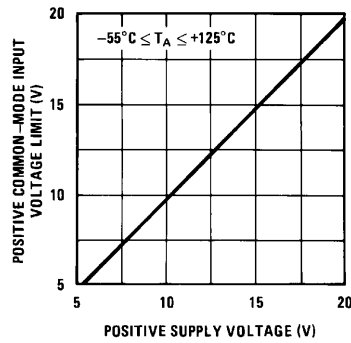
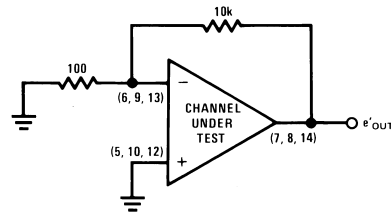
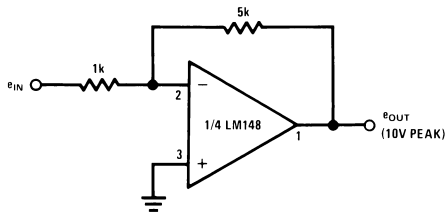
DC DRIFT PARAMETERS (The following conditions apply to all parameters, unless otherwise specified.)

$\pm V_{CC} = \pm 20V$, $V_{CM} = 0V$, measure each amplifier. Delta calculations performed on JAN S and QMLV devices at group B, subgroup 5 only.

| Symbol | Parameter | Conditions | Notes | Min | Max | Units | Sub-groups |
|--------------|----------------------|------------|-------|-----|-----|-------|------------|
| V_{IO} | Input Offset Voltage | | | -1 | 1 | mV | 1 |
| $\pm I_{IB}$ | Input Bias Current | | | -15 | 15 | nA | 1 |

Cross Talk Test Circuit

$V_S = \pm 15V$



Typical Performance Characteristics

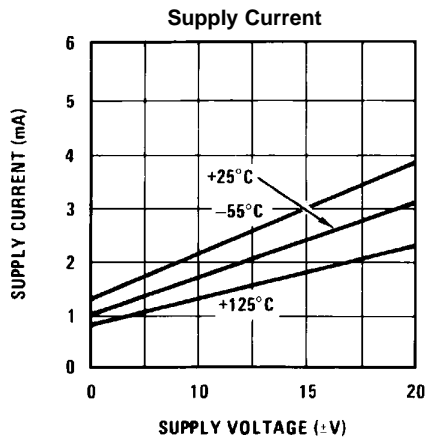


Figure 2.

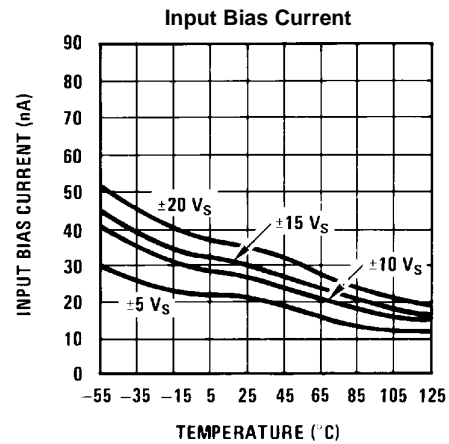


Figure 3.

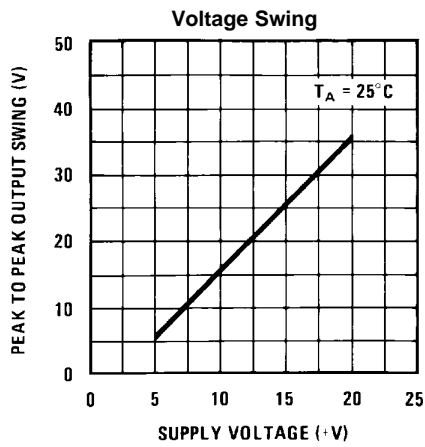


Figure 4.

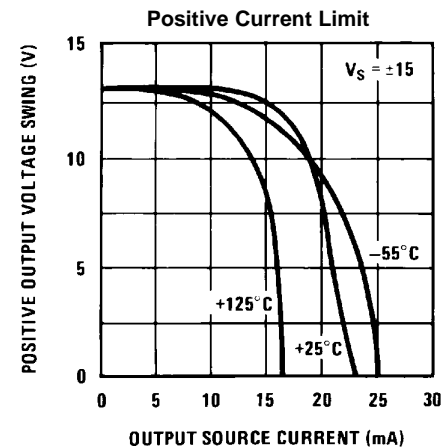


Figure 5.

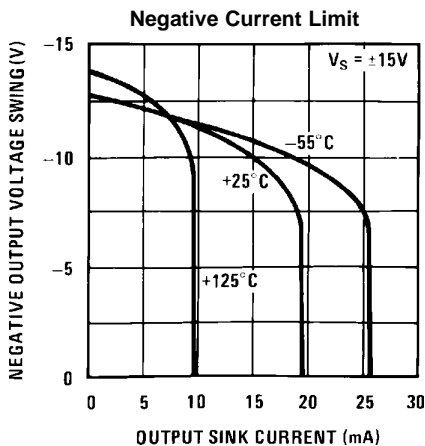


Figure 6.

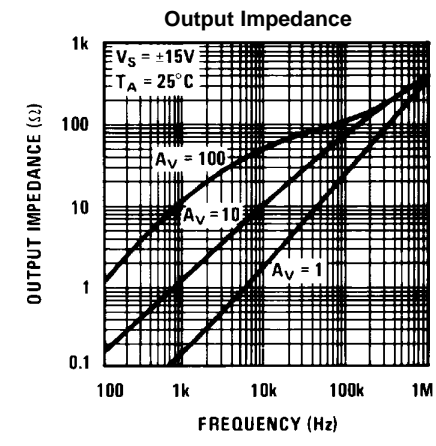


Figure 7.

Typical Performance Characteristics (continued)

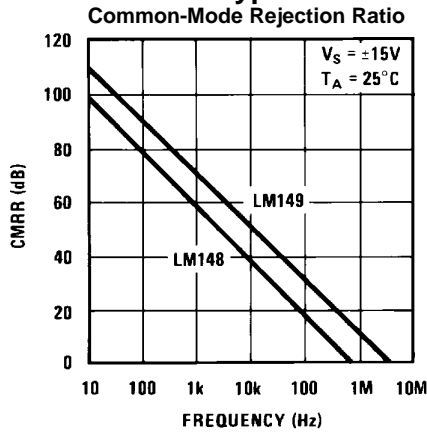


Figure 8.

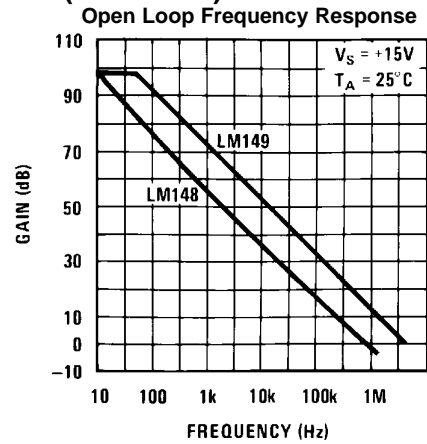


Figure 9.

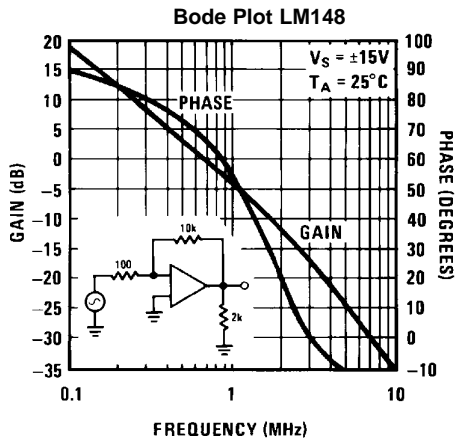


Figure 10.

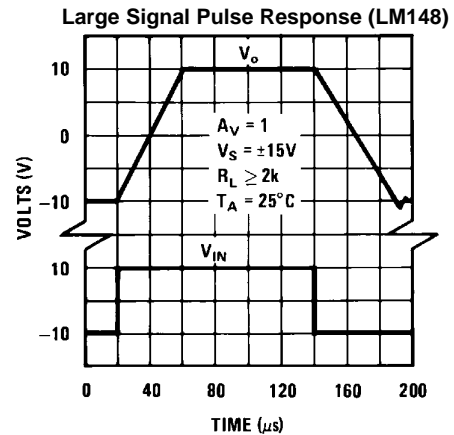


Figure 11.

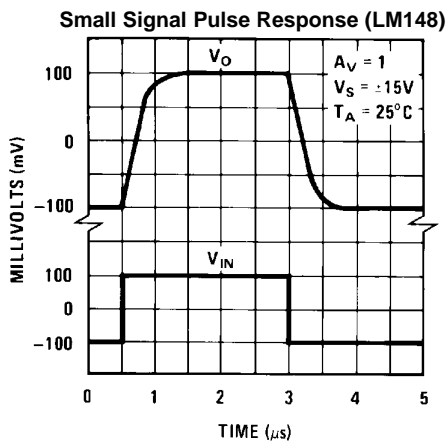


Figure 12.

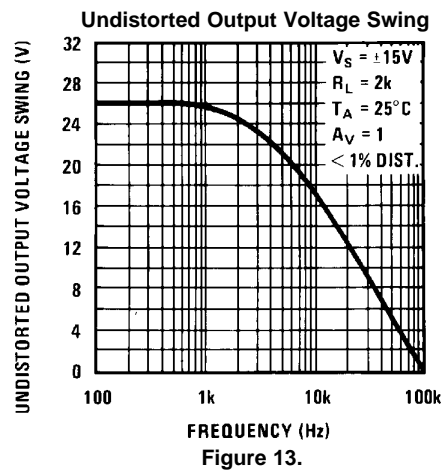


Figure 13.

Typical Performance Characteristics (continued)

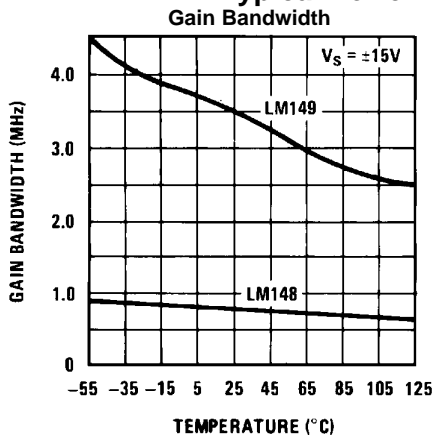


Figure 14.

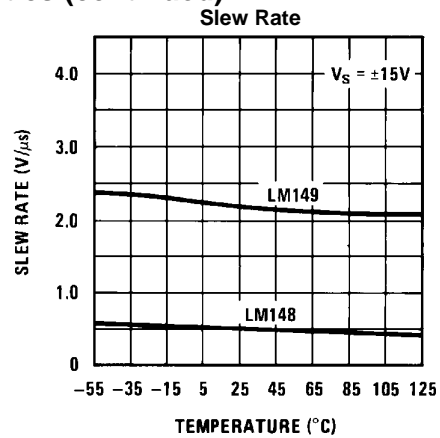


Figure 15.

Inverting Large Signal Pulse Response (LM148)

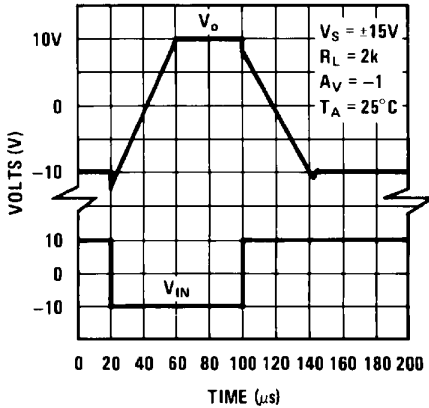


Figure 16.

Input Noise Voltage and Noise Current

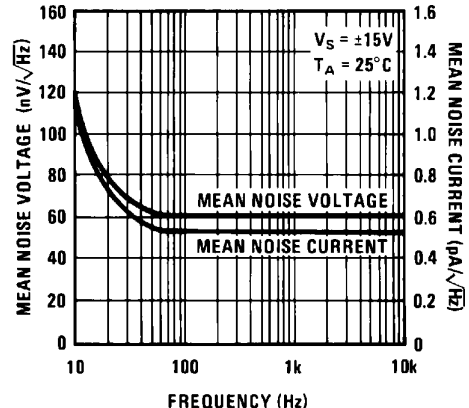


Figure 17.

Positive Common-Mode Input Voltage Limit

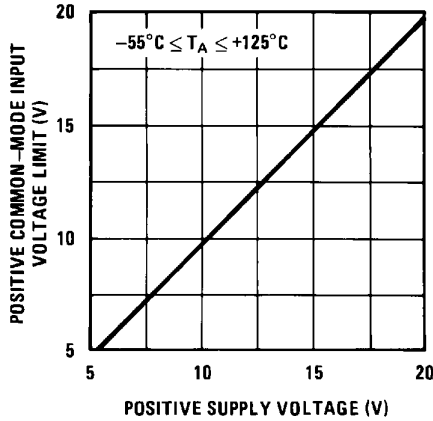


Figure 18.

Negative Common-Mode Input Voltage Limit

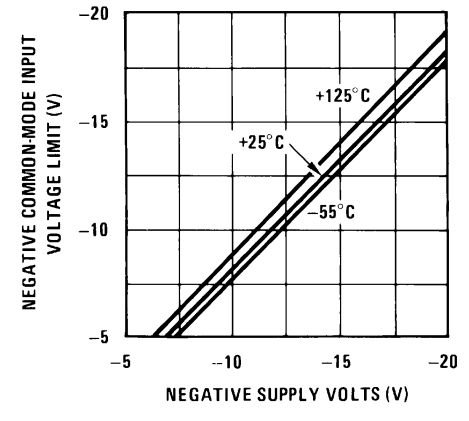


Figure 19.

APPLICATION HINTS

The LM148 series are quad low power LM741 op amps. In the proliferation of quad op amps, these are the first to offer the convenience of familiar, easy to use operating characteristics of the LM741 op amp. In those applications where LM741 op amps have been employed, the LM148 series op amps can be employed directly with no change in circuit performance.

The package pin-outs are such that the inverting input of each amplifier is adjacent to its output. In addition, the amplifier outputs are located in the corners of the package which simplifies PC board layout and minimizes package related capacitive coupling between amplifiers.

The input characteristics of these amplifiers allow differential input voltages which can exceed the supply voltages. In addition, if either of the input voltages is within the operating common-mode range, the phase of the output remains correct. If the negative limit of the operating common-mode is exceeded at both inputs, the output voltage will be positive. For input voltages which greatly exceed the maximum supply voltages, either differentially or common-mode, resistors should be placed in series with the inputs to limit the current.

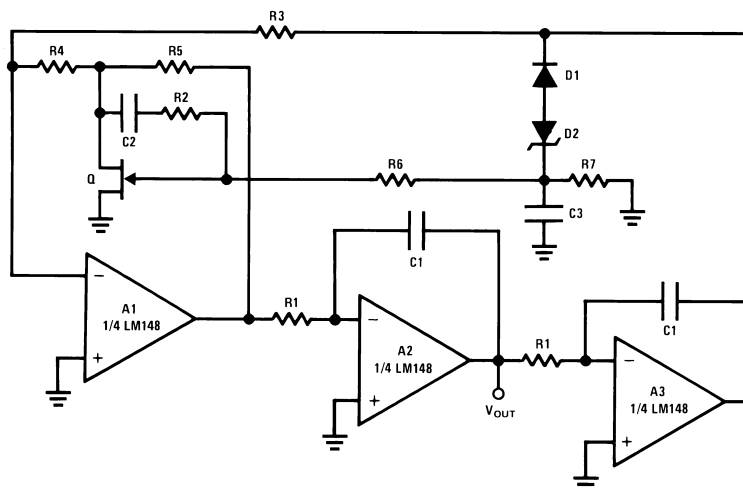
Like the LM741, these amplifiers can easily drive a 100 pF capacitive load throughout the entire dynamic output voltage and current range. However, if very large capacitive loads must be driven by a non-inverting unity gain amplifier, a resistor should be placed between the output (and feedback connection) and the capacitance to reduce the phase shift resulting from the capacitive loading.

The output current of each amplifier in the package is limited. Short circuits from an output to either ground or the power supplies will not destroy the unit. However, if multiple output shorts occur simultaneously, the time duration should be short to prevent the unit from being destroyed as a result of excessive power dissipation in the IC chip.

As with most amplifiers, care should be taken lead dress, component placement and supply decoupling in order to ensure stability. For example, resistors from the output to an input should be placed with the body close to the input to minimize "pickup" and maximize the frequency of the feedback pole which capacitance from the input to ground creates.

A feedback pole is created when the feedback around any amplifier is resistive. The parallel resistance and capacitance from the input of the device (usually the inverting input) to AC ground set the frequency of the pole. In many instances the frequency of this pole is much greater than the expected 3 dB frequency of the closed loop gain and consequently there is negligible effect on stability margin. However, if the feedback pole is less than approximately six times the expected 3 dB frequency a lead capacitor should be placed from the output to the input of the op amp. The value of the added capacitor should be such that the RC time constant of this capacitor and the resistance it parallels is greater than or equal to the original feedback pole time constant.

Typical Applications—LM148



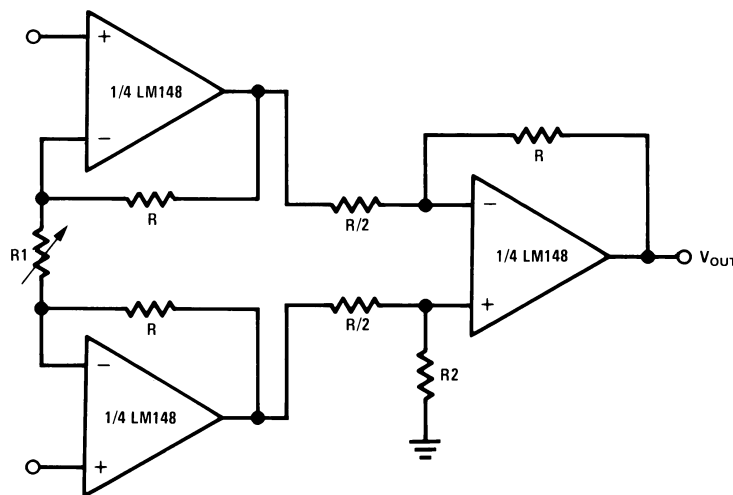
$$f = \frac{1}{2\pi R_1 C_1} \times \sqrt{K}, K = \frac{R_4 R_5}{R_3} \left(\frac{1}{r_{DS}} + \frac{1}{R_4} + \frac{1}{R_5} \right), r_{DS} \approx \frac{R_{ON}}{\left(1 - \frac{V_{GS}}{V_P} \right)^{1/2}}$$

$f_{MAX} = 5 \text{ kHz}$, $THD \leq 0.03\%$

$R_1 = 100\text{k pot}$, $C_1 = 0.0047 \mu\text{F}$, $C_2 = 0.01 \mu\text{F}$, $C_3 = 0.1 \mu\text{F}$, $R_2 = R_6 = R_7 = 1\text{M}$,
 $R_3 = 5.1\text{k}$, $R_4 = 12\Omega$, $R_5 = 240\Omega$, $Q = \text{NS5102}$, $D_1 = 1\text{N914}$, $D_2 = 3.6\text{V avalanche diode (ex. LM103)}$, $V_S = \pm 15\text{V}$

A simpler version with some distortion degradation at high frequencies can be made by using A1 as a simple inverting amplifier, and by putting back to back zeners in the feedback loop of A3.

Figure 20. One Decade Low Distortion Sine Wave Generator

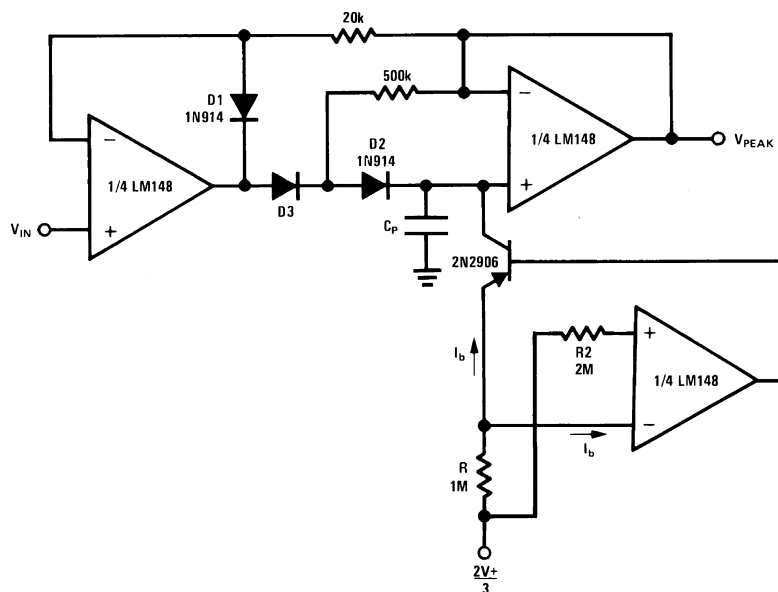


$$V_{OUT} = 2 \left(\frac{2R}{R_1} + 1 \right), V_S - 3\text{V} \leq V_{IN CM} \leq V_S^+ - 3\text{V}$$

$V_S = \pm 15\text{V}$

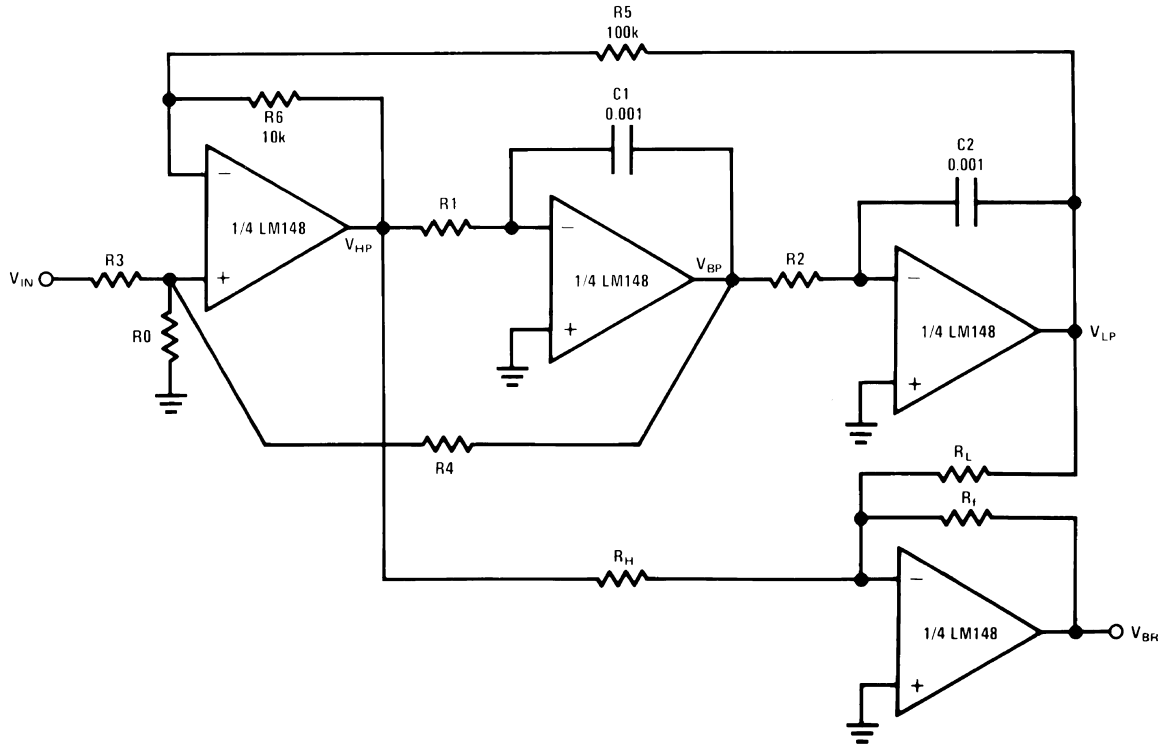
$R = R_2$, trim R_2 to boost CMRR

Figure 21. Low Cost Instrumentation Amplifier



Adjust R for minimum drift
 D3 low leakage diode
 D1 added to improve speed
 $V_S = \pm 15V$

Figure 22. Low Drift Peak Detector with Bias Current Compensation



Tune Q through R0,
For predictable results: $f_0 Q \leq 4 \times 10^4$
Use Band Pass output to tune for Q

$$\frac{V(s)}{V_{IN}(s)} = \frac{N(s)}{D(s)}, D(s) = S^2 + \frac{S\omega_0}{Q} + \omega_0^2$$

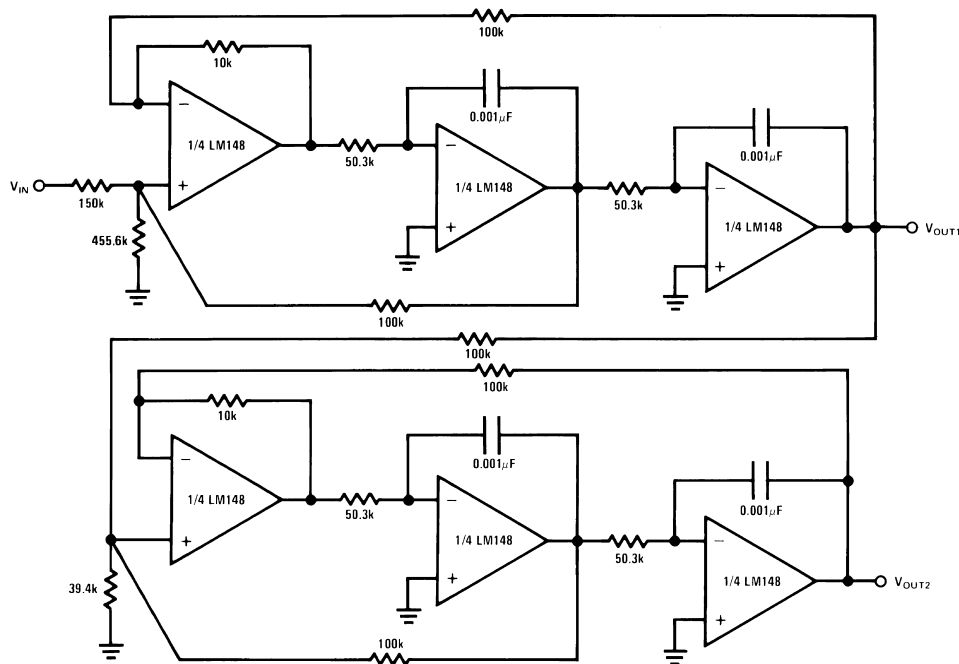
$$N_{HP}(s) = S^2 H_{OHP}, N_{BP}(s) = \frac{-s\omega_0 H_{OBP}}{Q}, N_{LP} = \omega_0^2 H_{OLP}$$

$$f_0 = \frac{1}{2\pi} \sqrt{\frac{R6}{R5} \sqrt{\frac{1}{t_1 t_2}}}, t_1 = R_1 C_1, Q = \left(\frac{1 + R4|R3 + R4|R0}{1 + R6|R5} \right) \left(\frac{R6 t_1}{R5 t_2} \right)^{1/2}$$

$$f_{NOTCH} = \frac{1}{2\pi} \left(\frac{R_H}{R_L t_1 t_2} \right)^{1/2}, H_{OHP} = \frac{1 + R6|R5}{1 + R3|R0 + R3|R4}, H_{OBP} = \frac{1 + R4|R3 + R4|R0}{1 + R3|R0 + R3|R4}$$

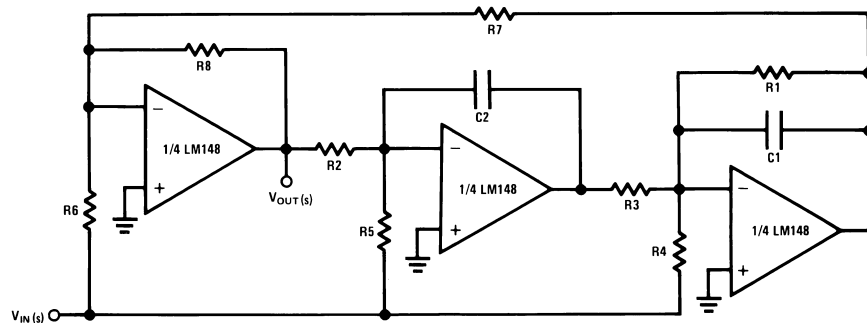
$$H_{OLP} = \frac{1 + R5|R6}{1 + R3|R0 + R3|R4}$$

Figure 23. Universal State-Variable Filter



Use general equations, and tune each section separately
 $Q_{1stSECTION} = 0.541$, $Q_{2ndSECTION} = 1.306$
 The response should have 0 dB peaking

Figure 24. A 1 kHz 4 Pole Butterworth

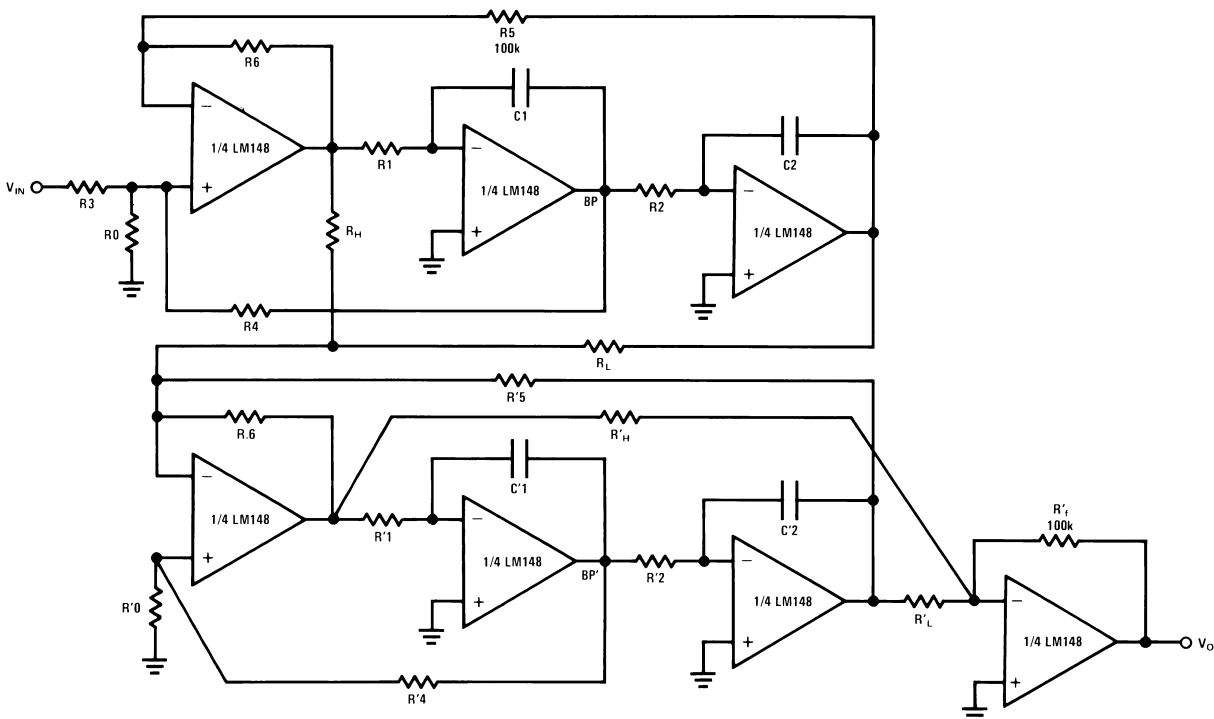


$$Q = \sqrt{\frac{R8}{R7}} \times \frac{R1C1}{\sqrt{R3C2R2C1}}, f_o = \frac{1}{2\pi} \sqrt{\frac{R8}{R7}} \times \frac{1}{\sqrt{R2R3C1C2}}, f_{NOTCH} = \frac{1}{2\pi} \sqrt{\frac{R6}{R3R5R7C1C2}}$$

Necessary condition for notch: $\frac{1}{R6} = \frac{R1}{R4R7}$

Ex: $f_{NOTCH} = 3$ kHz, $Q = 5$, $R1 = 270k$, $R2 = R3 = 20k$, $R4 = 27k$, $R5 = 20k$, $R6 = R8 = 10k$, $R7 = 100k$, $C1 = C2 = 0.001 \mu F$
 Better noise performance than the state-space approach.

Figure 25. A 3 Amplifier Bi-Quad Notch Filter



$R1C1 = R2C2 = t$
 $R'1C'1 = R'2C'2 = t'$
 $f_c = 1 \text{ kHz}$, $f_s = 2 \text{ kHz}$, $f_p = 0.543$, $f_z = 2.14$, $Q = 0.841$, $f'_p = 0.987$, $f'_z = 4.92$, $Q' = 4.403$, normalized to ripple BW

$$f = \frac{1}{2\pi R1C1} \times \sqrt{K}, K = \frac{R4R5}{R3} \left(\frac{1}{r_{DS}} + \frac{1}{R4} + \frac{1}{R5} \right), r_{DS} \approx \frac{R_{ON}}{\left(1 - \frac{V_{GS}}{V_P} \right)^{1/2}}$$

Use the BP outputs to tune Q, Q', tune the 2 sections separately
 $R1 = R2 = 92.6k$, $R3 = R4 = R5 = 100k$, $R6 = 10k$, $R0 = 107.8k$, $R_L = 100k$, $R_H = 155.1k$,
 $R'1 = R'2 = 50.9k$, $R'4 = R'5 = 100k$, $R'6 = 10k$, $R'0 = 5.78k$, $R'_L = 100k$, $R'_H = 248.12k$, $R'_f = 100k$. All capacitors are $0.001 \mu F$.

Figure 26. A 4th Order 1 kHz Elliptic Filter (4 Poles, 4 Zeros)

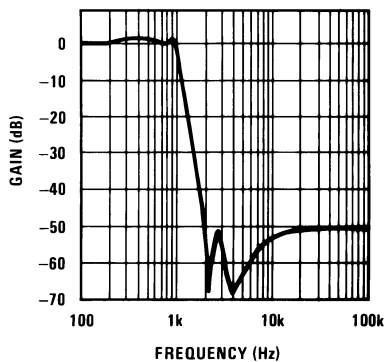
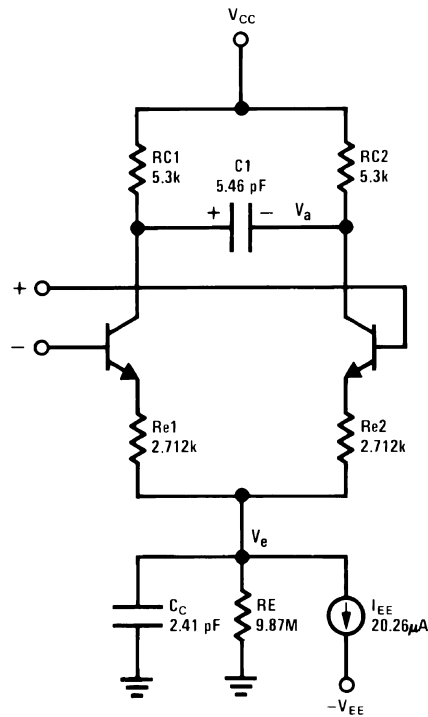


Figure 27. Lowpass Response

Typical Simulation



For more details, see IEEE Journal of Solid-State Circuits, Vol. SC-9, No. 6, December 1974

$$\omega_1 = 112I_S = 8 \times 10^{-16}$$

$$\omega_2 = 144 \cdot C_2 = 6 \text{ pF for LM149}$$

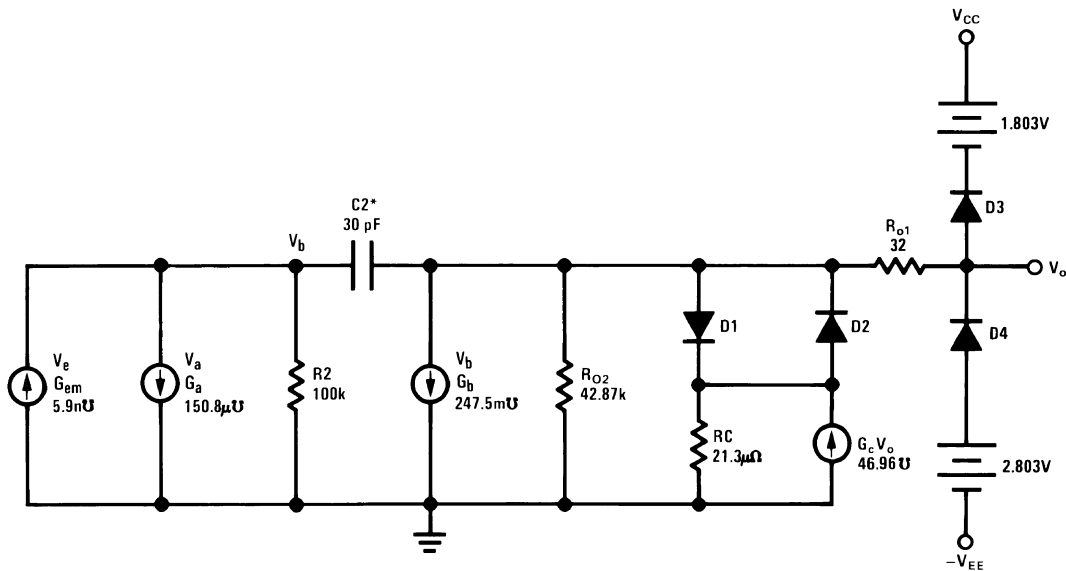


Figure 28. LM148, LM741 Macromodel for Computer Simulation

REVISION HISTORY SECTION

| Date Released | Revision | Section | Originator | Changes |
|----------------------|-----------------|-------------------------------|-------------------|--------------------------------------------------------------------------------------------------------------------|
| 02/15/05 | A | New Release, Corporate format | L. Lytle | 1 MDS data sheet converted into one Corp. data sheet format. MJLM148-X, Rev. 0C1. MDS data sheet will be archived. |
| 03/20/13 | A | All | | Changed layout of National Data Sheet to TI format |

PACKAGING INFORMATION

| Orderable part number | Status (1) | Material type (2) | Package Pins | Package qty Carrier | RoHS (3) | Lead finish/ Ball material (4) | MSL rating/ Peak reflow (5) | Op temp (°C) | Part marking (6) |
|----------------------------------|---------------|----------------------|----------------|-----------------------|-------------|--------------------------------------|-----------------------------------|--------------|--------------------------------|
| JL148BCA | Active | Production | CDIP (J) 14 | 25 TUBE | No | SNPB | Level-1-NA-UNLIM | -55 to 125 | JL148BCA JM38510/11001BCA Q |
| JL148SCA | Active | Production | CDIP (J) 14 | 25 TUBE | No | SNPB | Level-1-NA-UNLIM | -55 to 125 | JL148SCA JM38510/11001SCA Q |
| JM38510/11001BCA | Active | Production | CDIP (J) 14 | 25 TUBE | No | SNPB | Level-1-NA-UNLIM | -55 to 125 | JL148BCA JM38510/11001BCA Q |
| JM38510/11001SCA | Active | Production | CDIP (J) 14 | 25 TUBE | No | SNPB | Level-1-NA-UNLIM | -55 to 125 | JL148SCA JM38510/11001SCA Q |
| M38510/11001BCA | Active | Production | CDIP (J) 14 | 25 TUBE | No | SNPB | Level-1-NA-UNLIM | -55 to 125 | JL148BCA JM38510/11001BCA Q |

(1) **Status:** For more details on status, see our [product life cycle](#).

(2) **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

(4) **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

Important Information and Disclaimer: The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

OTHER QUALIFIED VERSIONS OF LM148JAN, LM148JAN-SP :

- Military : [LM148JAN](#)
- Space : [LM148JAN-SP](#)

NOTE: Qualified Version Definitions:

- Military - QML certified for Military and Defense Applications
- Space - Radiation tolerant, ceramic packaging and qualified for use in Space-based application

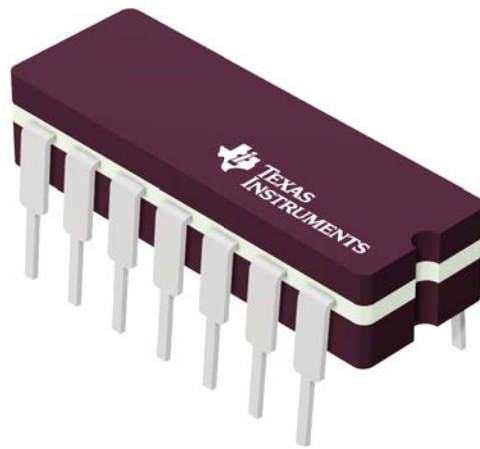
TUBE


*All dimensions are nominal

| Device | Package Name | Package Type | Pins | SPQ | L (mm) | W (mm) | T (μm) | B (mm) |
|------------------|--------------|--------------|------|-----|--------|--------|--------|--------|
| JL148BCA | J | CDIP | 14 | 25 | 506.98 | 15.24 | 13440 | NA |
| JL148SCA | J | CDIP | 14 | 25 | 506.98 | 15.24 | 13440 | NA |
| JM38510/11001BCA | J | CDIP | 14 | 25 | 506.98 | 15.24 | 13440 | NA |
| JM38510/11001SCA | J | CDIP | 14 | 25 | 506.98 | 15.24 | 13440 | NA |
| M38510/11001BCA | J | CDIP | 14 | 25 | 506.98 | 15.24 | 13440 | NA |

J 14

GENERIC PACKAGE VIEW
CDIP - 5.08 mm max height
CERAMIC DUAL IN LINE PACKAGE



Images above are just a representation of the package family, actual package may vary.
Refer to the product data sheet for package details.

4040083-5/G

J0014A



PACKAGE OUTLINE

CDIP - 5.08 mm max height

CERAMIC DUAL IN LINE PACKAGE



4214771/A 05/2017

NOTES:

1. All controlling linear dimensions are in inches. Dimensions in brackets are in millimeters. Any dimension in brackets or parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This package is hermetically sealed with a ceramic lid using glass frit.
4. Index point is provided on cap for terminal identification only and on press ceramic glass frit seal only.
5. Falls within MIL-STD-1835 and GDIP1-T14.

EXAMPLE BOARD LAYOUT

J0014A

CDIP - 5.08 mm max height

CERAMIC DUAL IN LINE PACKAGE



LAND PATTERN EXAMPLE
NON-SOLDER MASK DEFINED
SCALE: 5X



4214771/A 05/2017

IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATASHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you fully indemnify TI and its representatives against any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to [TI's Terms of Sale](#), [TI's General Quality Guidelines](#), or other applicable terms available either on ti.com or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products. Unless TI explicitly designates a product as custom or customer-specified, TI products are standard, catalog, general purpose devices.

TI objects to and rejects any additional or different terms you may propose.

Copyright © 2026, Texas Instruments Incorporated

Last updated 10/2025