Raytheon Electronics
Semiconductor Division

LM148

Low Power Quad 741 Operational Amplifier

Features

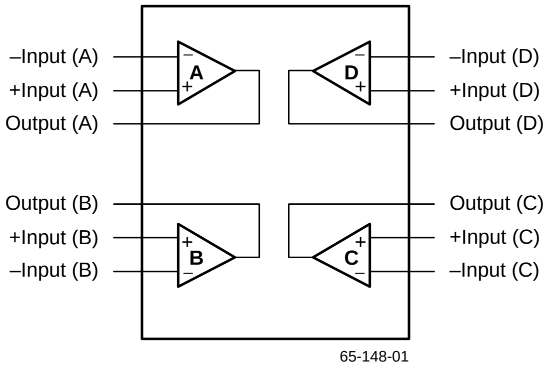
- 741 op amp operating characteristics
- Low supply current drain—0.6 mA/amplifier
- Class AB output stage—no crossover distortion
- Pin compatible with the LM124
- Low input offset voltage—1.0 mV
- Low input offset current—4.0 nA
- Low input bias current—30 nA
- Unity gain bandwidth—1.0 MHz
- Channel Separation—120 dB
- Input and output overload protection

Description

The LM148 is a true quad 741. 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 741 operational amplifier. In addition, the total supply current for all four amplifiers is comparable to the supply current of a single 741 type op amp. Other features include input offset currents and input bias currents which are much less than those of a standard 741. Also, excellent isolation between amplifiers has been achieved by independently biasing each amplifier and using layout techniques which minimize thermal coupling.

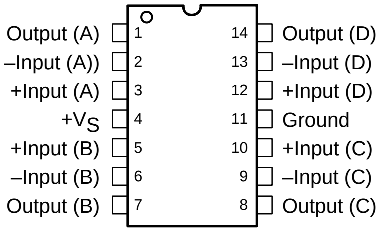
The LM148 can be used anywhere multiple 741 type amplifiers are being used and in applications where amplifier matching or high packing density is required.

Block Diagram



Rev. 1.0.0

Pin Assignments



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Absolute Maximum Ratings

Parameter	Min.	Max.	Unit
Supply Voltage	-22	+22	V
Differential Input Voltage		44	V
Input Voltage[1]	-22	+22	V
Output Short Circuit Duration[2]	Indefinite		
Storage Temperature Range	-65	+150	°C
Operating Temperature Range	-55	+125	°C
Lead Soldering Temperature (60 sec.)	+300°C		

Notes:

1. For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.
2. Short circuit to ground on one amplifier only.

Thermal Characteristics

Parameter	14-Lead Ceramic DIP
Maximum Junction Temperature	+175°C
Maximum P_D T_A < 50°C	1042 mW
Thermal Resistance, θ_{JC}	60°C/W
Thermal Resistance, θ_{JA}	120°C/W
For T_A > 50°C derate at	8.33 mW/°C

Electrical Characteristics

(V_S = ±15V and T_A = 25°C, unless otherwise noted)

Parameter	Test Conditions		Min.	Typ.	Max.	Unit
Input Offset Voltage	$R_S \leq 10K\Omega$			1.0	5.0	mV
Input Offset Current				4.0	25	nA
Input Bias Current				30	100	nA
Input Resistance (Differential Mode)[1]			0.8	2.5		MΩ
Supply Current, All Amplifiers	V_S = ±15V			2.4	3.6	mA
Large Signal Voltage Gain	V_S = ±15V, V_{OUT} = ±10V, $R_L \geq 2K\Omega$		50	160		V/mV
Channel Separation	F = 1 Hz 20 KHz			120		dB
Unity Gain Bandwidth				1.0		MHz
Phase Margin					60	Degrees
Slew Rate					0.5	V/µS
Short Circuit Current				25		mA
The following specifications apply for V_S = ±15V, -55°C ≤ T_A ≤ +125°C.						
Input Offset Voltage	$R_S \leq 10K\Omega$				6.0	mV
Input Offset Current					75	nA
Input Bias Current					325	nA
Large Signal Voltage Gain	V_S = ±15V, V_{OUT} = 10V, $R_L < 2K\Omega$		25			V/mV
Output Voltage Swing	V_S = ±15V	$R_L = 10K\Omega$	±12	±13		V
		$R_L = 2k\Omega$	±10	±12		
Input Voltage Range	V_S = ±15V		±12			V
Common Mode Rejection Ratio	$R_S \leq 10K\Omega$		70	90		dB
Power Supply Rejection Ratio	$R_S \leq 10K\Omega$		77	96		dB

Note:

1. Guaranteed by design but not tested.

Typical Performance Characteristics

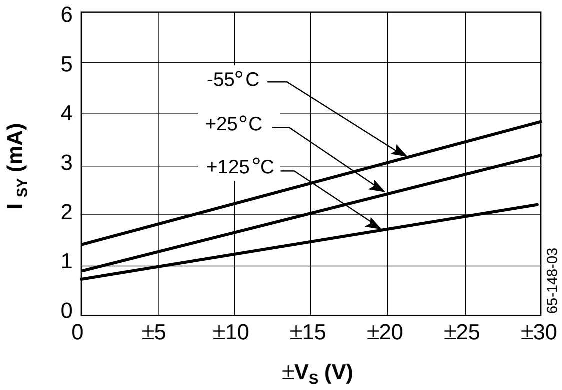


Figure 1. Supply Current vs. Supply Voltage

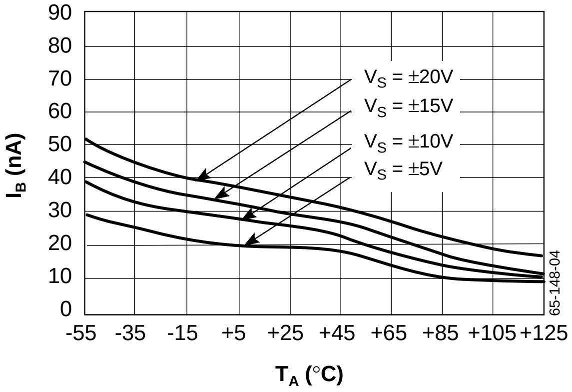


Figure 2. Input Bias Current vs. Temperature

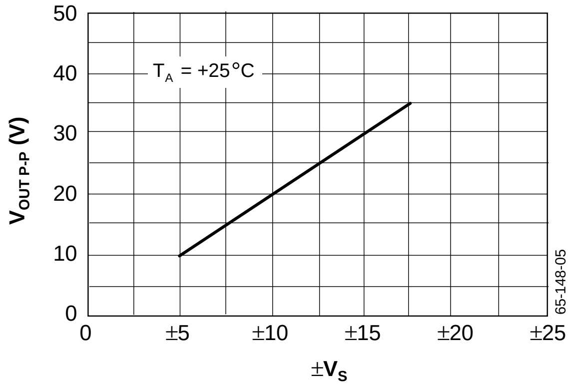


Figure 3. Output Voltage Swing vs. Supply Voltage

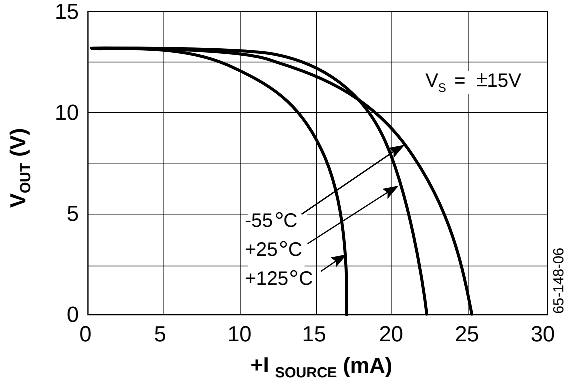


Figure 4. Positive Current Limit
Output Voltage vs. Output Source Current

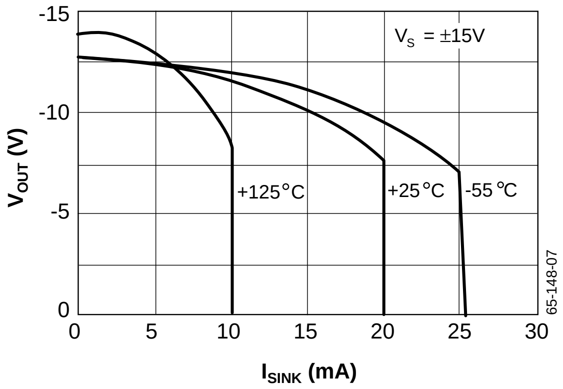


Figure 5. Negative Current Limit
Output Voltage vs. Output Sink Current

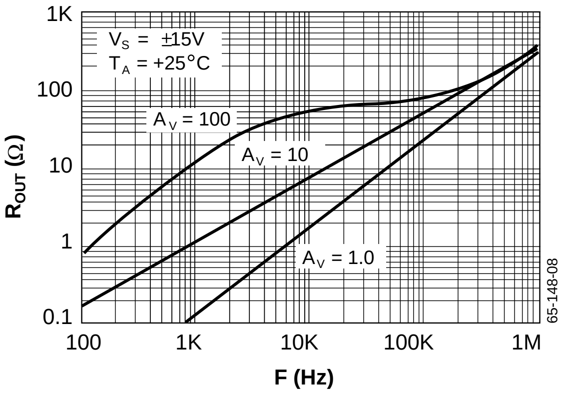


Figure 6. Output Impedance vs. Frequency

Typical Performance Characteristics (continued)

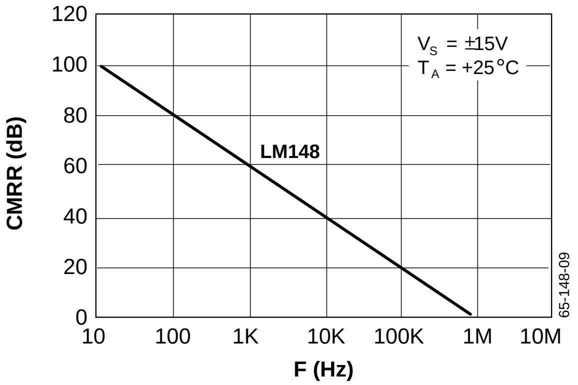


Figure 7. CMRR vs. Frequency

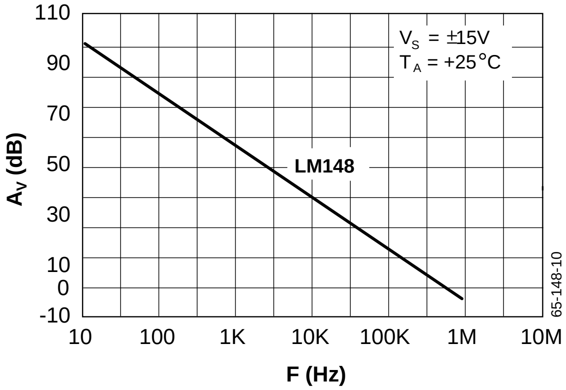


Figure 8. Open Loop Gain vs. Frequency

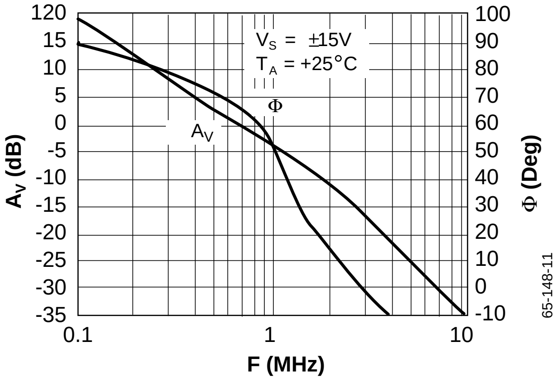


Figure 9. Gain, Phase vs. Frequency

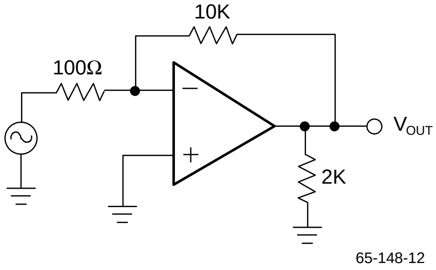


Figure 10. Gain, Phase Test Circuit

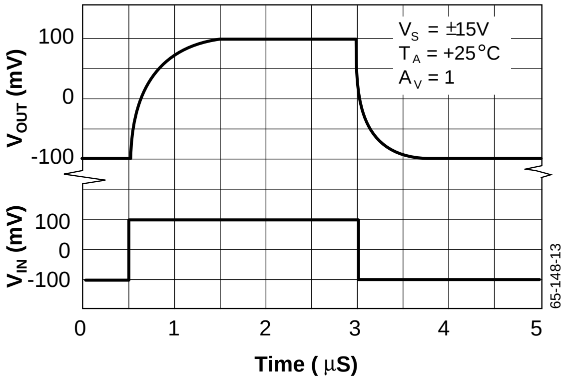


Figure 11. Small Signal Pulse Response
Input, Output Voltage vs. Time

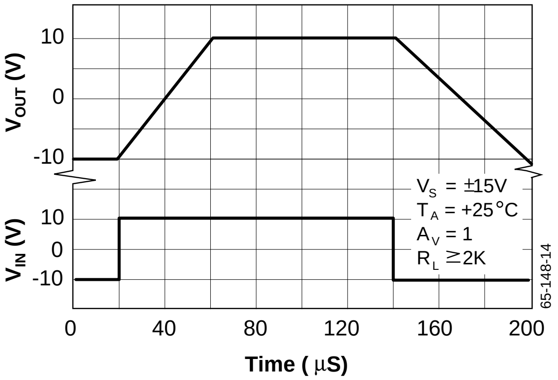


Figure 12. Large Signal Pulse Response
Output Voltage vs. Time

Typical Performance Characteristics (continued)

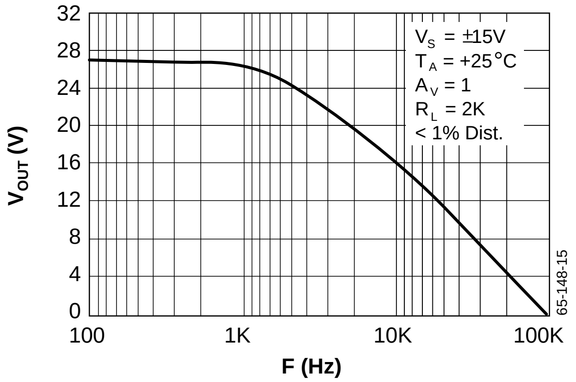


Figure 13. Undistorted Output Voltage Swing vs. Frequency

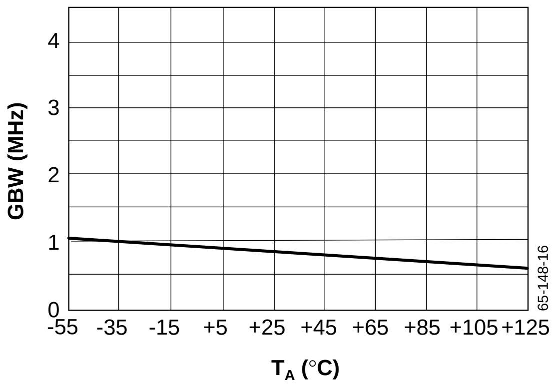


Figure 14. Gain Bandwidth Product vs. Temperature

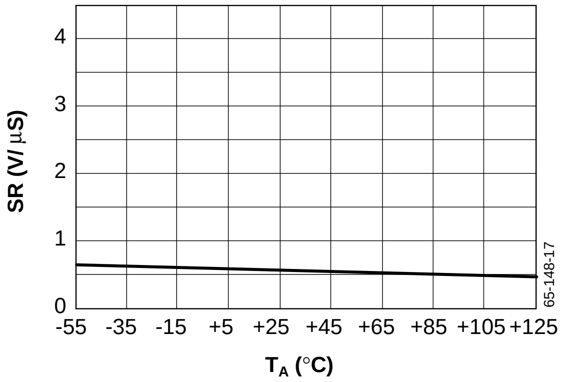


Figure 15. Slew Rate vs. Temperature

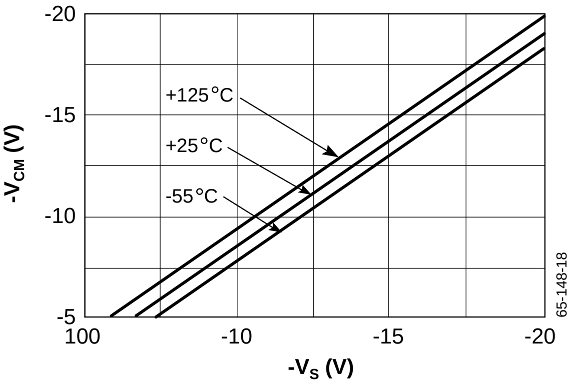


Figure 16. Negative Common Mode Input Voltage vs. Supply Voltage

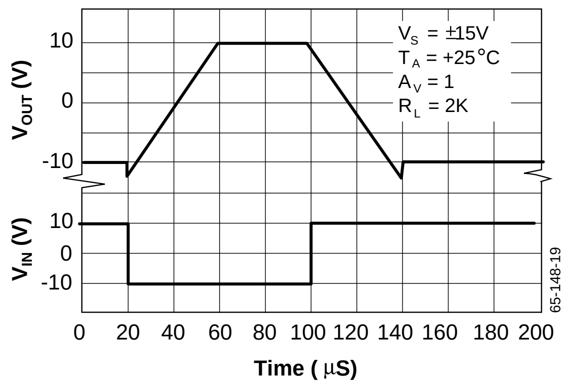


Figure 17. Inverting Large Signal Pulse Response Input, Output Voltage vs. Time

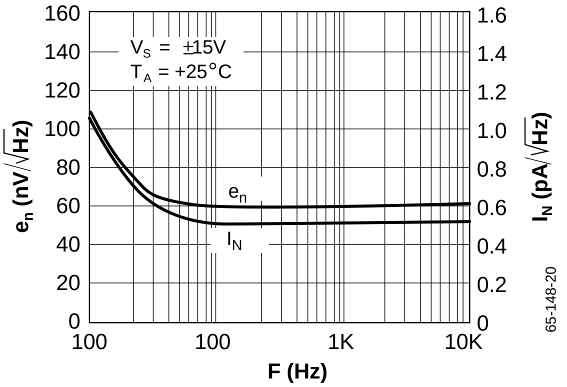


Figure 18. Input Noise Voltage, Current Densities vs. Frequency

Typical Performance Characteristics (continued)

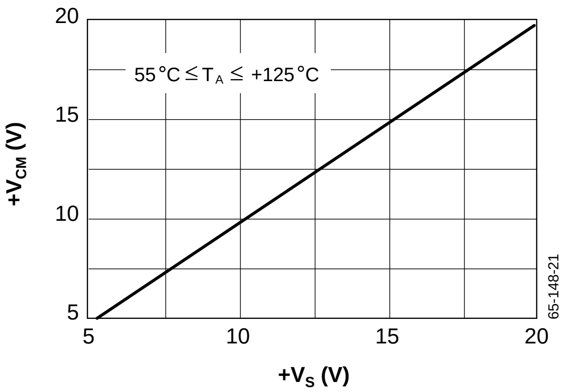


Figure 19. Positive Common Mode, Input Voltage vs. Supply Voltage

Typical Simulation

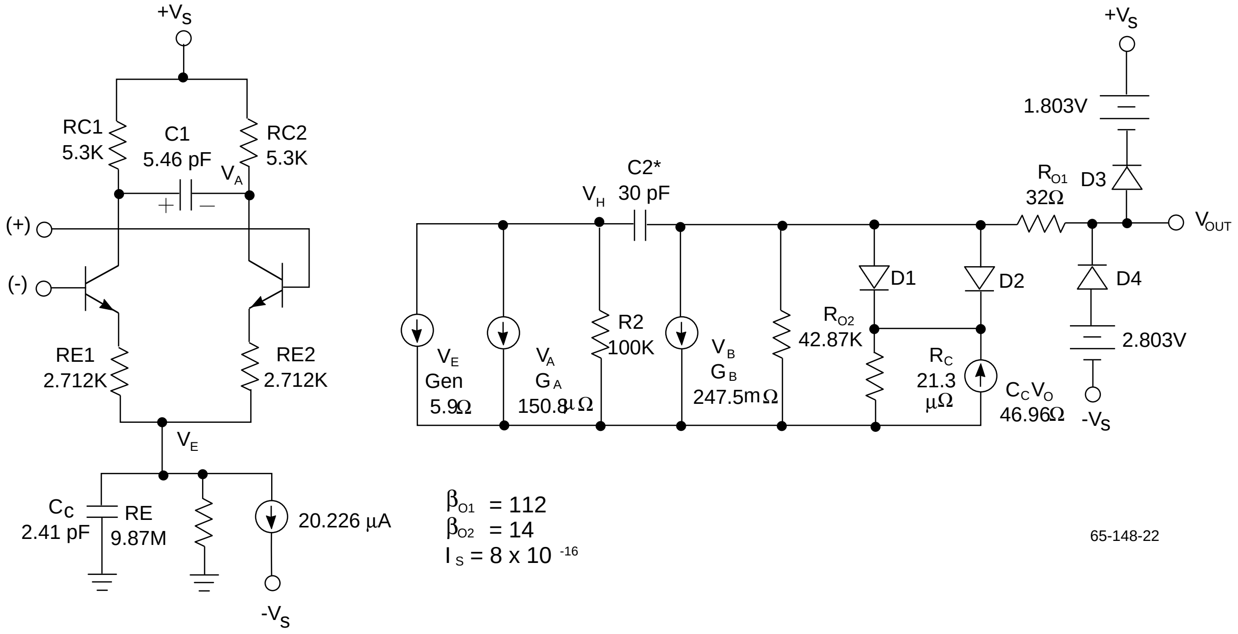


Figure 20. LM148 Macromodel for Computer Simulation

Applications Discussion

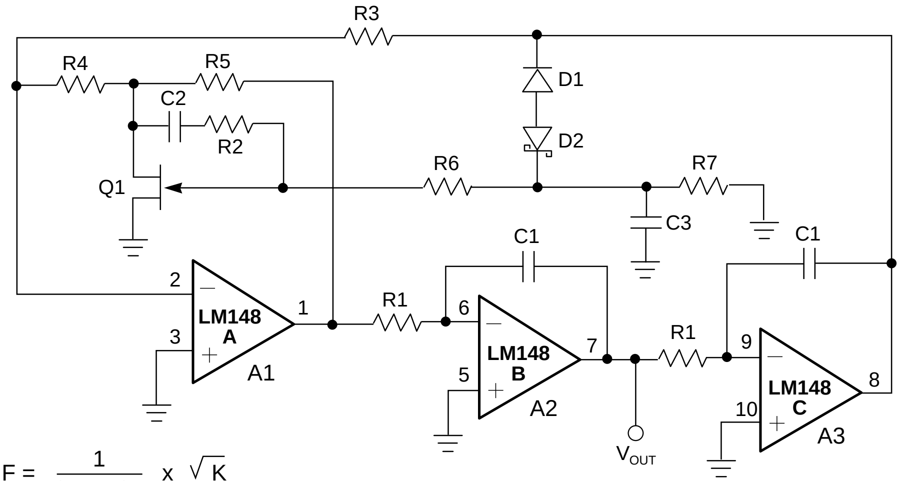
The LM148 low power quad operational amplifier exhibits performance comparable to the popular 741. Substitution can therefore be made with no change in circuit behavior.

The input characteristics of these devices allow differential voltages which exceed the supplies. Output phase will be correct as long as one of the inputs is within the operating common mode range. If both exceed the negative limit, the output will latch positive. Current limiting resistors should be used on the inputs in case voltages become excessive.

When capacitive loading becomes much greater than 100pF, a resistor should be placed between the output and feedback connection in order to reduce phase shift.

The LM148 is short circuit protected to ground and supplies continuously when only one of the four amplifiers is shorted. If multiple shorts occur simultaneously, the unit can be destroyed due to excessive power dissipation.

To assure stability and to minimize pickup, feedback resistors should be placed close to the input to maximize the feedback pole frequency (a function of input to ground capacitance). A good rule of thumb is that the feedback pole frequency should be 6 times the operating -3.0B frequency. If less, a lead capacitor should be placed between the output and input.



$$F = \frac{1}{2\pi R1C1} \times \sqrt{K}$$

$$K = \frac{R4R5}{R3}\left(\frac{1}{R_{DS}} + \frac{1}{R4} + \frac{1}{R5}\right)$$

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$$R_{DS} \cong \frac{R_{ON}}{\left(1 - \frac{V_{GS}}{V_P}\right)^{1/2}}$$

F_{MAX} = 5.0 KHz, THD $\leq$ 0.03%

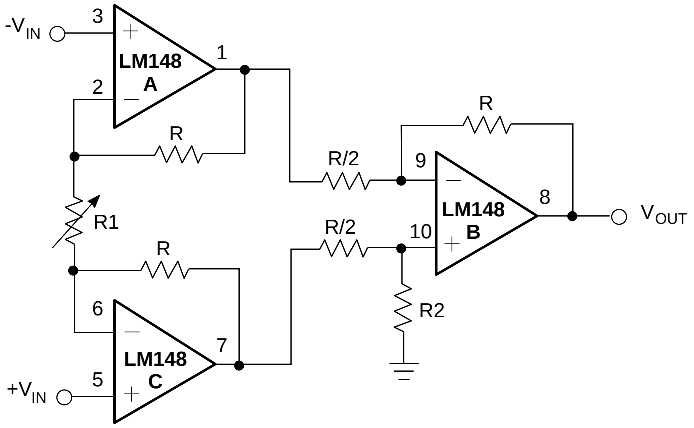
R1 = 100K pot., C1 = 0.0047µF, C2 = 0.01µF, C3 = 0.1µF, R2 = R6 = R7 = 1M, R3 = 5.1K, R4 = 12Ω.

R5 = 240Ω, Q1 = NS5102, D1 = 1N914, D2 = 3.6V avalanche diode (ex. LM103), V_S = ±15V

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 feedback loop of A3.

Figure 21. One Decade Low Distortion Sinewave Generator

Applications Discussion (continued)



$V_{OUT} = 2\left(\frac{2R}{R1} + 1\right)$, $\left(-V_S - 3V\right) \leq V_{IN\,CM} \leq \left(+V_S - 3V\right)$

$V_S = \pm 15V$

R = R2, trim R2 to boost CMRR

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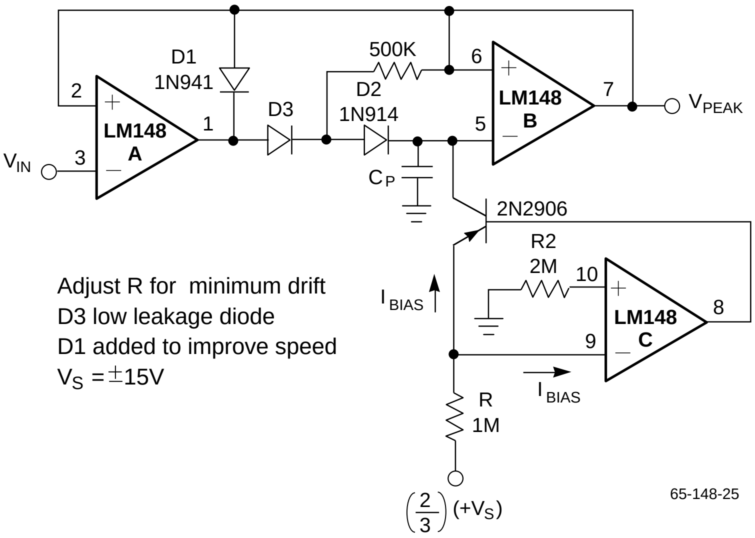
Figure 22. Low Cost Instrumentation Amplifier

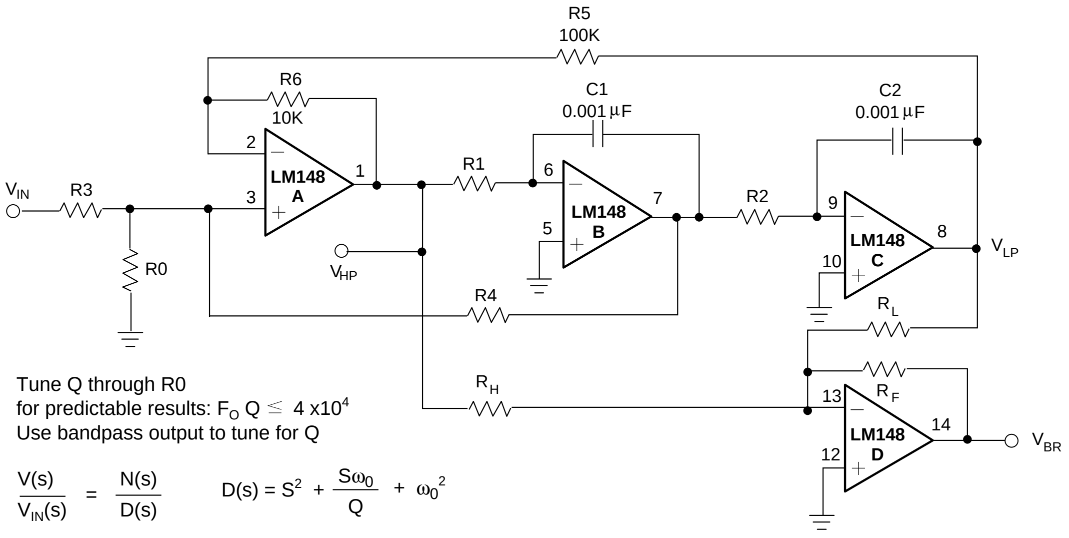


Adjust R for minimum drift
D3 low leakage diode
D1 added to improve speed
$V_S = \pm 15V$

65-148-25

Figure 23. Low Voltage Peak Detector with Bias Current Compensation

Applications Discussion (continued)



Tune Q through R0
for predictable results: $F_O\,Q \leq 4 \times 10^4$
Use bandpass output to tune for Q

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

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

$$F_O = \frac{1}{2\pi}\sqrt{\frac{R6}{R5}}\sqrt{\frac{1}{t1t2}}\ , \qquad t1 = R1C1,\ Q = \left(\frac{1 + R4 \mid R3 + R4 \mid R0}{1 + R6 \mid R5}\right)\left(\frac{R6}{R5}\ \frac{t1}{t2}\right)^{1/2}$$

$$F_{NOTCH} = \frac{1}{2\pi}\left(\frac{R_H}{R_L\, t1\, t2}\right)^{1/2},\ H_{OHP} = \frac{1 + R6 \mid R5}{1 + R3 \mid R0 + R3 \mid R4},\ H_{OBP} = \frac{1 + R4 \mid R3 + R4 \mid R0}{1 + R3 \mid R0 + R3 \mid R4}$$

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

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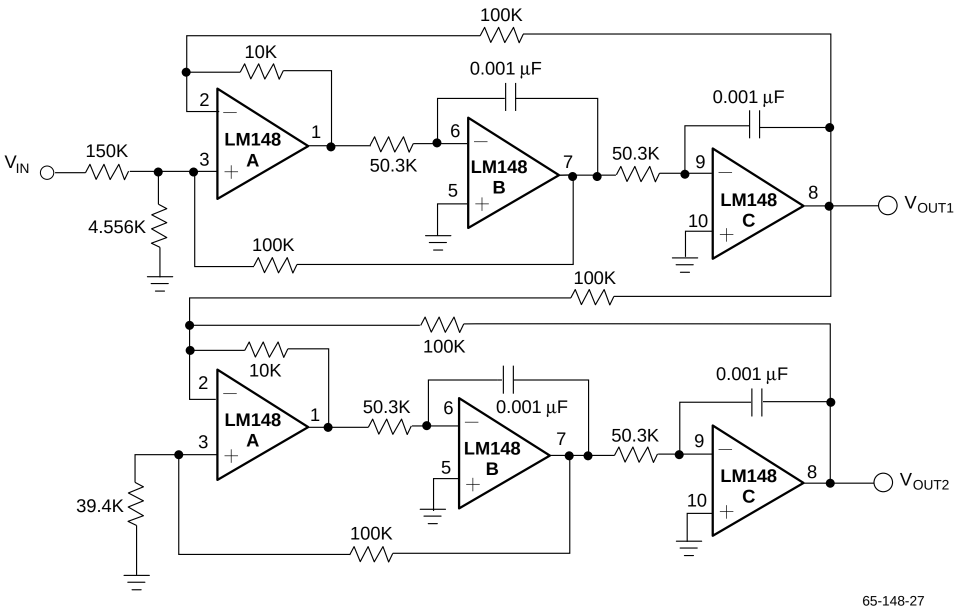
Figure 24. Universal State-Space Filter

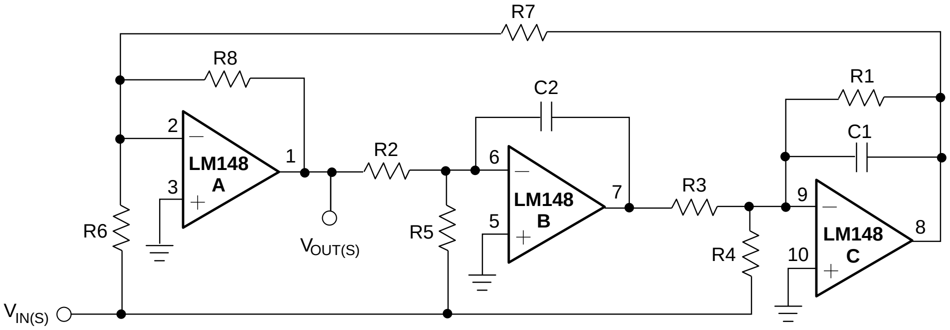


65-148-27

Use general equations, and tune each section separately.
Q_{1st} Section = 0.541, Q_{2nd} Section = 1.306.
The response should have 0 dB peaking.

Figure 25. 1 KHz 4-Pole Butterworth Filter

Applications Discussion (continued)



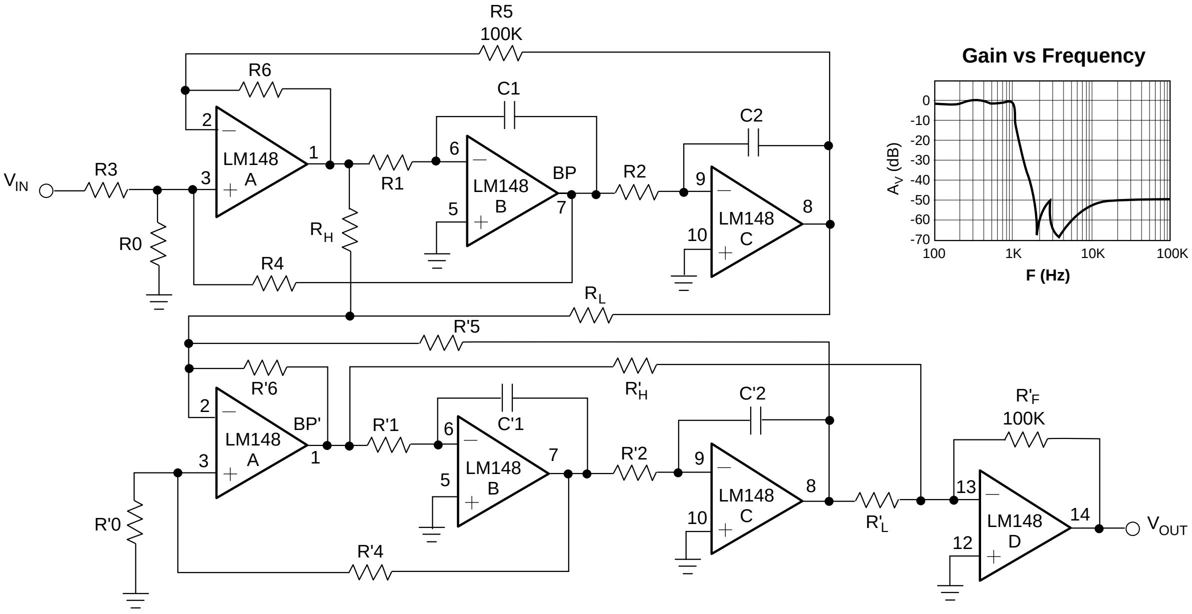
$$Q = \sqrt{\frac{R8}{R7}}\left(\frac{R1C1}{\sqrt{R3C2R2C1}}\right), F_O = \frac{1}{2\pi}\sqrt{\frac{R8}{R7}}\left(\frac{1}{\sqrt{R2R3C1C2}}\right), F_{NOTCH} = \frac{1}{2\pi}\sqrt{\frac{R6}{R3R5R7C1C2}}$$

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

Examples: F_{NOTCH} = 3 kHz, Q = 5, R1 = 270K, R2 = R3 = 20K, R4 = 27K, R5 = 20K, R6 = R8 = 10K, R7 = 100K.
C1 = C2 = 0.001 µF.
Better noise performance than the state-space approach.

65-148-28

Figure 26. 3 Amplifier Bi-Quad Notch Filter



F_C = 1 kHz, F_S = 2 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.

$$F_P = \frac{1}{2\pi}\sqrt{\frac{R6}{R5}}\left(\frac{1}{t}\right), F_Z = \frac{1}{2\pi}\sqrt{\frac{R_H}{R_L}}\left(\frac{1}{t}\right), Q = \frac{1 + R4/R3 + R4/R0}{1 + R6/R5} \times \sqrt{\frac{R6}{R5}}, Q' = \sqrt{\frac{R'6}{R'5}} \times \frac{1 + R'4/R'0}{1 + R'6/R'5 + R'6/R_P}$$

$$R_P = \frac{R_H R_L}{R_H + R_L}$$

Use the B'P 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.

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All capacitors are 0.001µF.

Figure 27. 4th Order 1 KHz Elliptic Filter (4 Poles, 4 Zeros)

Notes:

Notes:

Notes:

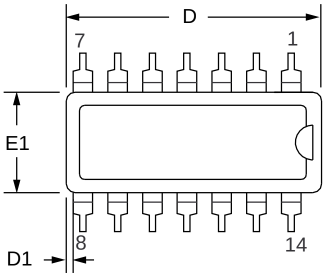
Mechanical Dimensions

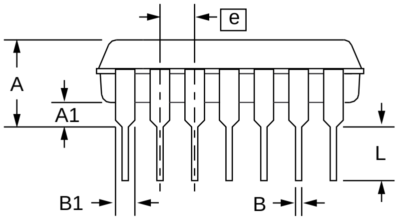
14-Pin Plastic DIP

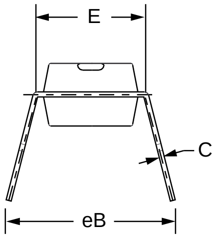
Symbol	Inches		Millimeters		Notes
	Min.	Max.	Min.	Max.	
A	—	.210	—	5.33	
A1	.015	—	.38	—	
A2	.115	.195	2.93	4.95	
B	.014	.022	.36	.56	
B1	.045	.070	1.14	1.78	
C	.008	.015	.20	.38	4
D	.725	.795	18.42	20.19	2
D1	.005	—	.13	—	
E	.300	.325	7.62	8.26	
E1	.240	.280	6.10	7.11	2
e	.100 BSC		2.54 BSC		
eB	—	.430	—	10.92	
L	.115	.200	2.92	5.08	
N	14		14		5

Notes:

1. Dimensioning and tolerancing per ANSI Y14.5M-1982.
2. "D" and "E1" do not include mold flashing. Mold flash or protrusions shall not exceed .010 inch (0.25mm).
3. Terminal numbers are shown for reference only.
4. "C" dimension does not include solder finish thickness.
5. Symbol "N" is the maximum number of terminals.







Ordering Information

Part Number	Package	Operating Temperature Range
LM148D	14-Lead Ceramic DIP	-55°C to +125°C
LM148D/883B	14-Lead Ceramic DIP	-55°C to +125°C

Note:

1. 883B suffix denotes Mil-Std-883, Level B processing

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