LM224 Operational Amplifier

1 Introduction

LM224 is an industry standard operational amplifier, which consists of four independent operational amplifiers, each with the ability to have low offset input voltage, common mode input range to ground, and high differential input voltage, and includes a phase compensation circuit. These operational amplifiers have a wide power supply voltage range, which can be powered by either a single power supply or a dual power supply, and their quiescent current is independent of the power supply voltage. Therefore, LM224 is very suitable for use in tone equalization network circuits in radio recorders and tone systems, and can also be used in other situations where high gain signal amplification is required.

2 Available Package

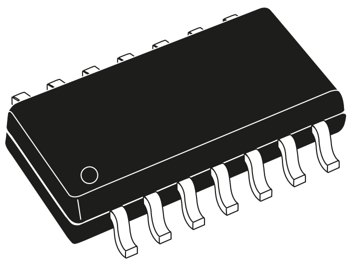
PART NUMBER	PACKAGE
LM224	SOP14

3 Features

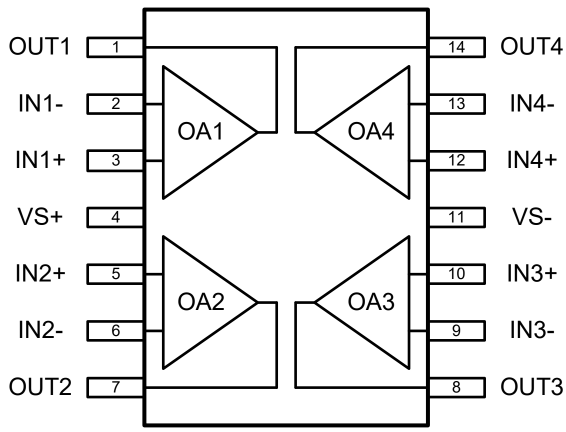
- Power Supply Voltage:
  - Single Power Supply: 3.0 ~ 30V
  - Dual Power Supply: ±1.5 ~ ±15V
- Built-in Four Independent Operational Amplifiers
- Power Supply Current: 600μA typ.
- Input Offset Voltage: 5mV Max
- Gain Bandwidth: 1.2MHz
- Common Mode Voltage Input Range includes Ground
- No Need for External Phase Compensation Circuit

4 Applications

- Air-conditioning
- Inverter
- PC and Server Power Supply
- Refrigerator
- Washing Machine
- Uninterruptible Power Supply



SOP14 Package



Pin Connections

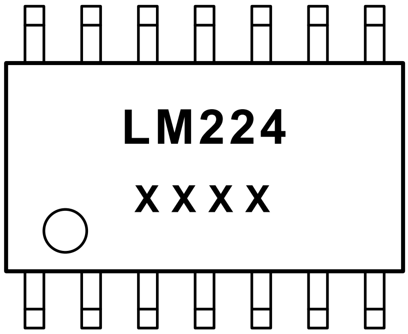
5 Orderable and Marking Information

5.1 Orderable Information

MODEL	DEVICE	PACKAGE	OP TEMP	ECO PLAN	MSL	PACKING OPTION	SORT
-	LM224	SOP14	-40 ~ 85°C	RoHS & Green	Level 3 168 HR	Tape and Reel 2500 Units / Reel	Active
Others	-	-	-	-	-	-	Customized

Note:
ECO PLAN: For the RoHS and Green certification standards of this product, please refer to the official report provided by JSCJ.
MSL: Moisture Sensitivity Level. Determined according to JEDEC industry standard classification.
SORT: Specifically defined as follows:
Active: Recommended for new products;
Customized: Products manufactured to meet the specific needs of customers;
Preview: The device has been released and has not been fully mass produced. The sample may or may not be available;
NoRD: It is not recommended to use the device for new design. The device is only produced for the needs of existing customers;
Obsolete: The device has been discontinued.

5.2 Marking Information



"**LM224**": Device serial number.
"**XXXX**": Code of production.

6 Pin Configuration and Function

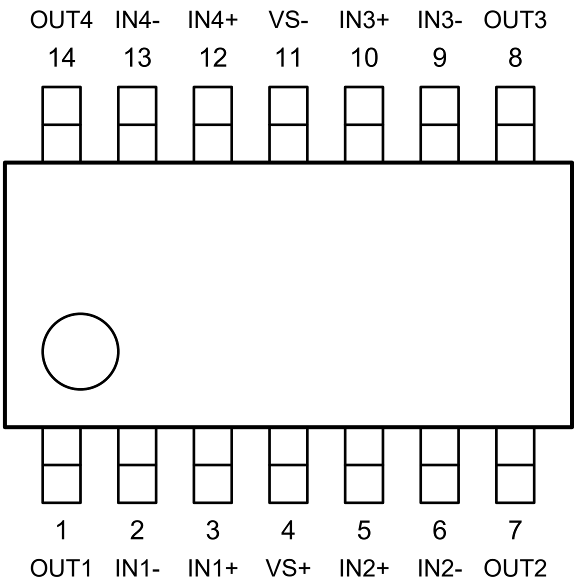


Figure 6-1. LM224 Pin Configuration

PIN NAME	LM224 SOP14	I / O	DESCRIPTION
OUT1	1	O	Output of the operational amplifier 1.
IN1-	2	I	Negative input of the operational amplifier 1.
IN1+	3	I	Positive input of the operational amplifier 1.
VS+	4	-	Positive (highest) supply.
IN2+	5	I	Positive input of the operational amplifier 2.
IN2-	6	I	Negative input of the operational amplifier 2.
OUT2	7	O	Output of the operational amplifier 2.
OUT3	8	O	Output of the operational amplifier 3.
IN3-	9	I	Negative input of the operational amplifier 3.
IN3+	10	I	Positive input of the operational amplifier 3.
VS-	11	-	Negative (lowest) supply or ground for single supply.
IN4+	12	I	Positive input of the operational amplifier 4.
IN4-	13	I	Negative input of the operational amplifier 4.
OUT4	14	O	Output of the operational amplifier 4.

7 Specifications

7.1 Absolute Maximum Ratings

(T_A = 25°C, unless otherwise specified)

CHARACTERISTIC		SYMBOL	VALUE	UNIT
Power supply	Single supply	V_S	32	V
	Dual supplies		±16	
Differential input range(2)		V_{ID}	-32 ~ 32	V
Input range (either input)		V_{IN}	-0.3 ~ 32	V
Duration of output short circuit (one amplifier) to ground (or below) at T_A = 25°C, V_S ≤ 15V		t_{SC}	Continuous(3)	s
Maximum input pin current (V_{IN} < -0.3V)(4)		I_{IN}	50	mA
Maximum junction temperature		$T_{J\ Max}$	125	°C
Storage temperature		T_{stg}	-55 ~ 125	°C
Soldering temperature & time		T_{solder}	260°C, 10s	-

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum rated conditions for extended periods may affect device reliability.
(2) Differential voltages are at IN+, with respect to IN−.
(3) Short circuits from outputs to V_S can cause excessive heating and eventual destruction. A heat sink may be required to keep the junction temperature below the absolute maximum. This depends on the power supply voltage and how many amplifiers are shorted. Thermal resistance varies with the amount of PC board metal connected to the package. The specified values are for short traces connected to the leads.
(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 op amps to go to the V_S- 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).

7.2 Recommend Operating Conditions

PARAMETER		SYMBOL	MIN.	NOM.	MAX.	UNIT
Power supply range	Single supply	V_S	3.0	-	30	V
	Dual supplies		±1.5		±15	
Common-mode voltage range		V_{CM}	V_S-	-	(V_S+) -2.0	V
Operating ambient temperature		T_A	-40	-	85	°C

7 Specifications

7.3 ESD Ratings

ESD RATINGS		SYMBOL	VALUE	UNIT
Electrostatic discharge[5]	Human body model	$V_{ESD-HBM}$	500	V

(5) ESD testing is conducted in accordance with the relevant specifications formulated by the Joint Electronic Equipment Engineering Commission (JEDEC). The human body model (HBM) electrostatic discharge test is based on the JESD22-114D test standard, using a 100pF capacitor and discharging to each pin of the device through a resistance of 1.5kΩ.

7.4 Thermal Information

THERMAL METRIC[6]		SYMBOL	LM224	UNIT
			SOP14	
Thermal resistance	Junction-to-ambient	$R_{\Theta JA}$	155.1	°C/W
	Junction-to-case	$R_{\Theta JC}$	40.6	
Reference maximum power dissipation for continuous operation		$P_{D\ Ref}$	0.65	W

(6) Thermal metric is measured in still air with T_A = 25°C and installed on a 1 in^2 FR-4 board covered with 2 ounces of copper.

7 Specifications

7.5 Electrical Characteristics

LM224 (V_S = 5V, T_A = 25°C, unless otherwise specified)

CHARACTERISTIC	SYMBOL	TEST CONDITIONS(7)			MIN.	TYP.(8)	MAX.	UNIT
Offset Voltage								
Input offset voltage	V_{IO}	V_S = 5 to 30V, V_{CM} = 0V			-	±2.0	±5.0	mV
Input offset voltage vs. power supply (ΔV_{IO} / ΔV_S)	PSRR	V_S = 5 to 30V			65	100	-	dB
Channel separation(9)	CS	f = 1k to 20kHz			-	120	-	dB
Input Voltage Range								
Common-mode voltage range	V_{CM}	V_S = 5 to 30V		T_A = 25°C	0	-	V_{S+} - 1.5	V
				T_A = -40 ~ 85°C	0	-	V_{S+} - 2.0	
Common-mode rejection ratio	CMRR	V_S = 5 to 30V			65	80	-	dB
Input Current								
Input bias current	I_B	-			-	45	250	nA
Input offset current	I_{IO}	-			-	±5.0	±80	nA
Power Supply								
Supply current (all amplifiers)	I_{SS}	V_S = 5.0V, no load			-	0.6	2.0	mA
		V_S = 30V, no load			-	1.5	3.0	
Frequency Response								
Gain bandwidth product	GBW	-			-	1.2	-	MHz
Slew rate	SR	G = ±1			-	0.5	-	V / µs
Output								
High-level output voltage	V_{OH}	V_S = 30V	V_{ID} = +3V	R_L ≥ 10kΩ	27	28	-	V
				R_L = 2kΩ	26	-	-	
Low-level output voltage	V_{OL}	V_S = 5V	V_{ID} = -3V	R_L = 10kΩ	-	5.0	20	mV
Output current	I_{OUT}	V_S = 15V, V_O = 2V	V_{ID} = +1V	Source	20	35	-	mA
			V_{ID} = -1V	Sink	10	13	-	
Open-loop Gain								
Large-signal differential voltage amplification	A_{vd}	V_S = 15V, R_L ≥ 2kΩ			25	100	-	V / mV

Note:

(7) All characteristics are measured under open-loop conditions, with zero common-mode input voltage, unless otherwise specified. $V_{S\,MAX}$ for testing purposes is 30V.

(8) All typical values are at T_A = 25°C.

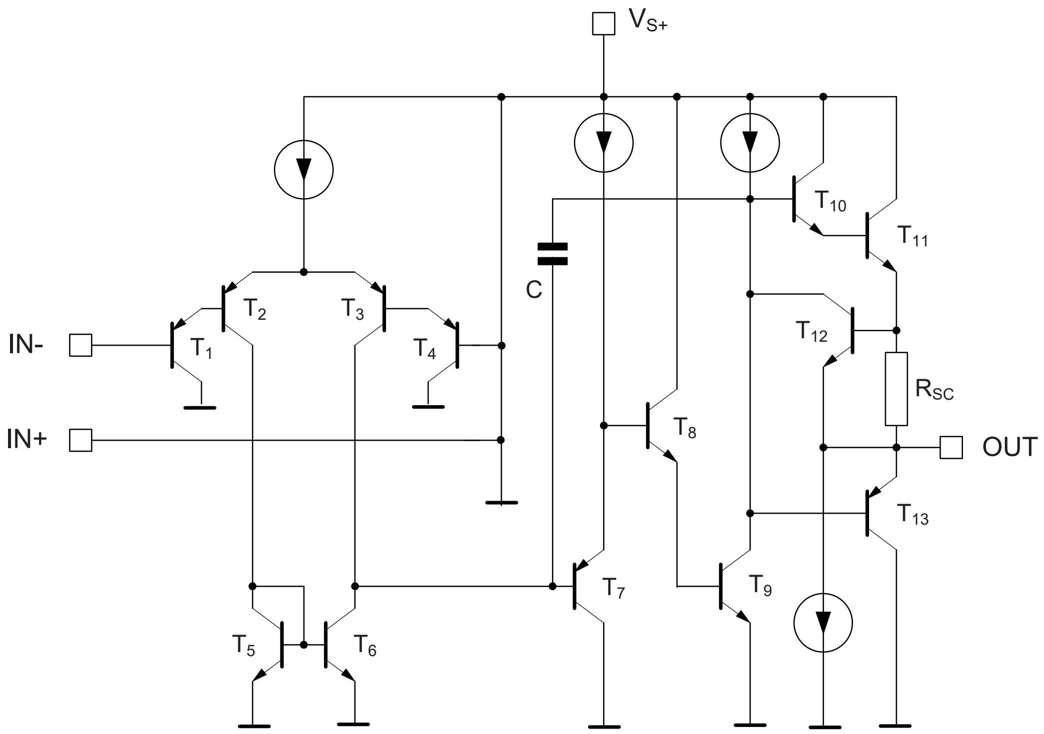
(9) Due to the proximity of external components, ensure that there is no coupling originating from stray capacitance between these external parts. Typically, this can be detected at higher frequencies because this type of capacitance increases.

7 Detail Description

7.1 Description

The LM224 consists of four high gain, low-power consumption operational amplifiers, which can be powered by either a single power supply or a dual power supply. The V_S should be at least 1.5V higher than the input common mode voltage. The low power supply current is independent of the power supply voltage, with a wide operating temperature range of -40 to 85°C. The LM224 can be directly powered from a standard 5V power supply used in digital systems without the need for an additional ± 5V power supply.

7.2 Representative Schematic Diagram



(One-Quarter of the Circuit Shown)

8 Application and Implementation

8.1 Typical Application Circuits

The LM224 is composed of four independent high gain operational amplifiers and supports the use of single or dual power supplies. The maximum supply voltage V_S can reach 30V and it has low power consumption current and -40 to 85°C operating ambient temperature. Therefore, the LM224 is widely used in various operational amplifier circuits.

Basic Circuit

Figure 8-1 shows a typical application of LM224, where a positive voltage V_{IN} is input from IN and then output from OUT after passing through the circuit. The output voltage V_{OUT} of OUT has the opposite polarity to V_{IN}. At this point, the ratio of output voltage to input voltage is the gain A_V. Their relationship is shown by the following equation:

$$\frac{V_{IN}}{R_I} = \frac{-V_{OUT}}{R_F}$$

$$A_V = \frac{V_{OUT}}{V_{IN}} = -\frac{R_F}{R_I}$$

Once the required gain for circuit design is determined, a value can be selected for R_I and R_F based on the above formula. It is recommended to use a kilo-ohm level resistor to reduce the current consumed by the device in circuit use.

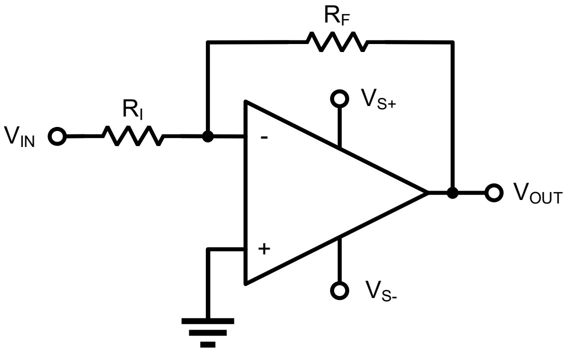


Figure 8-1. Basic Circuit

Power Supply

The LM224 can be powered by either a single power supply or a dual power supply, as shown in Figures 8-2 and 8-3. It is recommended to use a 0.1μF bypass capacitor and place it near the power pin to reduce noise or errors in high impedance power coupling. For more information, please refer to *Layout Guidelines*.

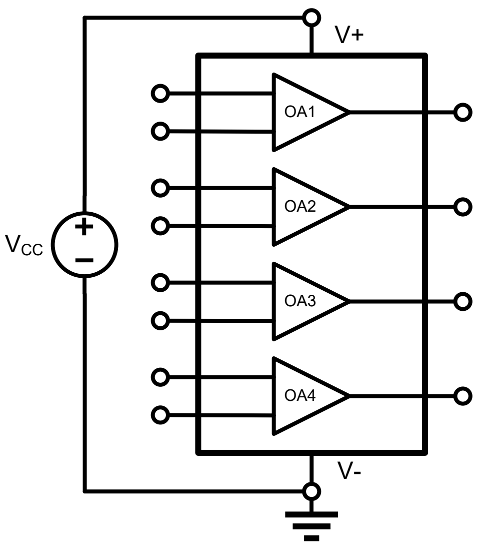


Figure 8-2. Single Power Supply

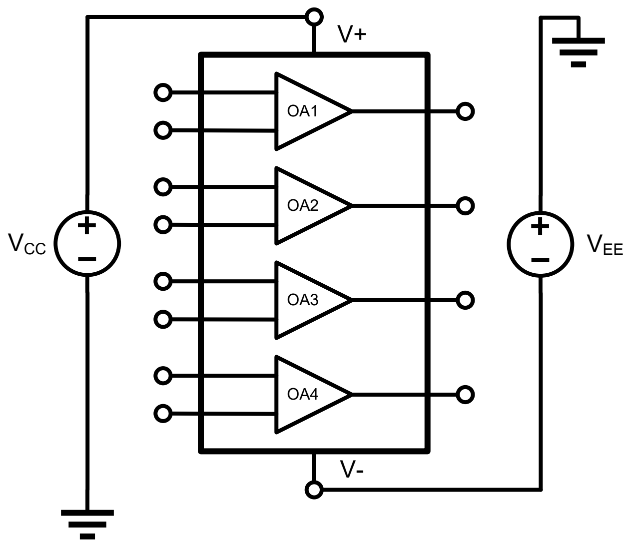
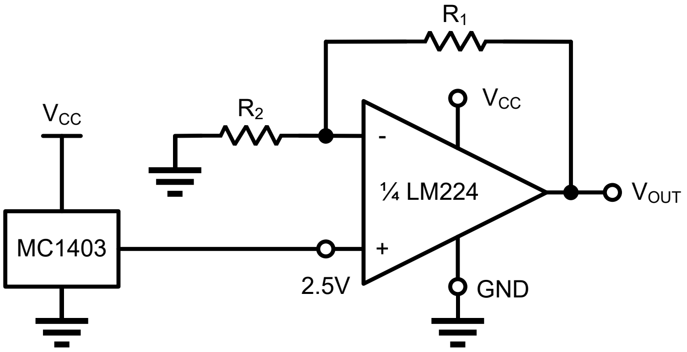


Figure 8-3. Dual Power Supply

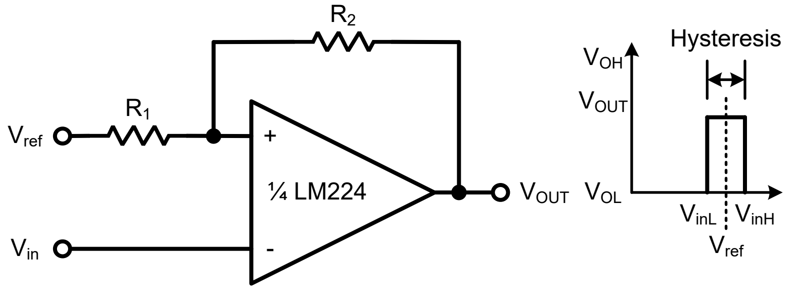
8 Application and Implementation

8.1 Typical Application Circuits (continued)



$$V_{OUT} = 2.5V \times (1 + \frac{R_1}{R_2})$$

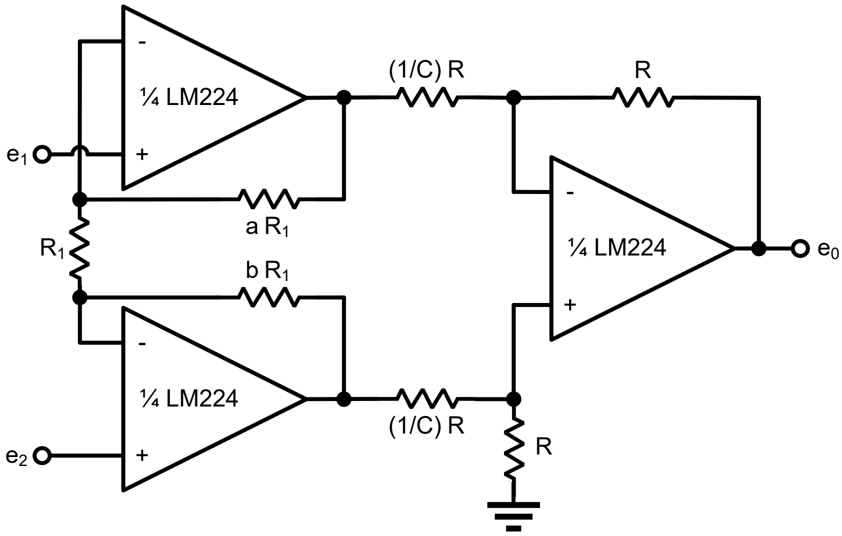
Figure 8-4. Voltage Reference



$$V_{inL} = \frac{R_1}{R_1 + R_2} \times (V_{OL} - V_{ref}) + V_{ref} \qquad V_{inH} = \frac{R_1}{R_1 + R_2} \times (V_{OH} - V_{ref}) + V_{ref}$$

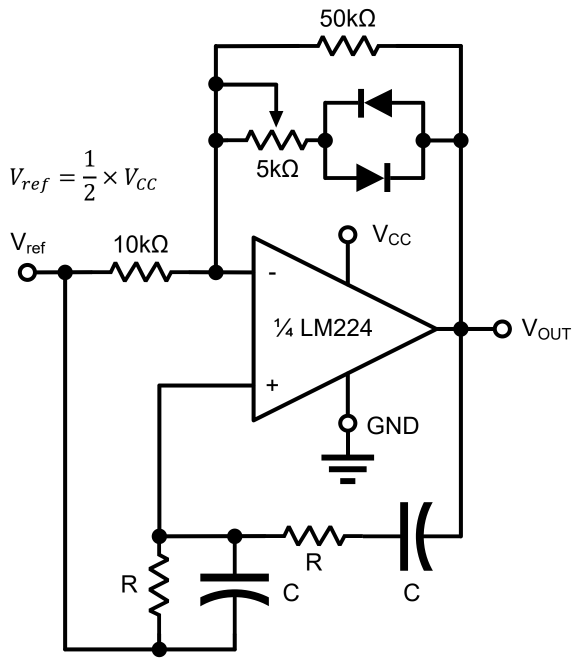
$$H = \frac{R_1}{R_1 + R_2} \times (V_{OH} - V_{OL})$$

Figure 8-5. Comparator with Hysteresis



$$e_0 = C \times (1 + a + b) \times (e_2 - e_1)$$

Figure 8-6. High Impedance Differential Amplifier

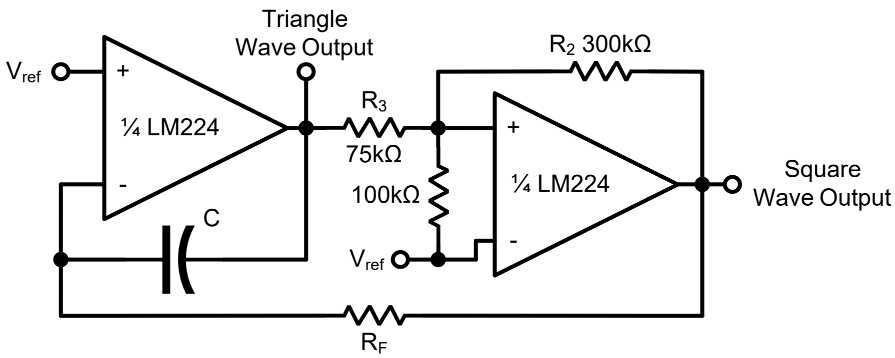


$$V_{ref} = \frac{1}{2} \times V_{CC}$$

$$f_{OUT} = \frac{1}{2\pi RC}$$

For f_{OUT} = 1kHz, R = 16kΩ, C = 0.01µF

Figure 8-8. Wien Bridge Oscillator

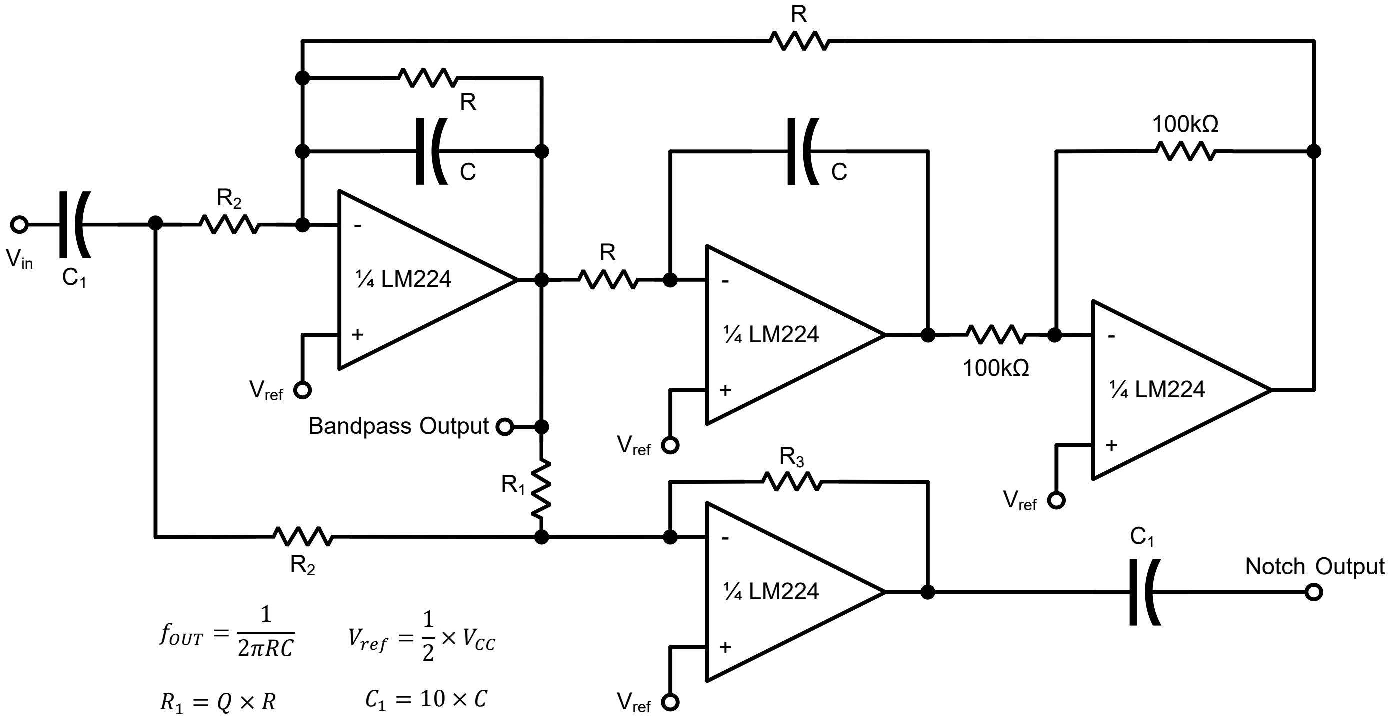


$$f = \frac{R_1 + R_C}{4 \times C \times R_F \times R_1} \quad \text{if } R_3 = \frac{R_2 \times R_1}{R_2 + R_1}$$

Figure 8-7. Function Generator

8 Application and Implementation

8.1 Typical Application Circuits (continued)



$f_{OUT} = \frac{1}{2\pi RC}$ $V_{ref} = \frac{1}{2} \times V_{CC}$

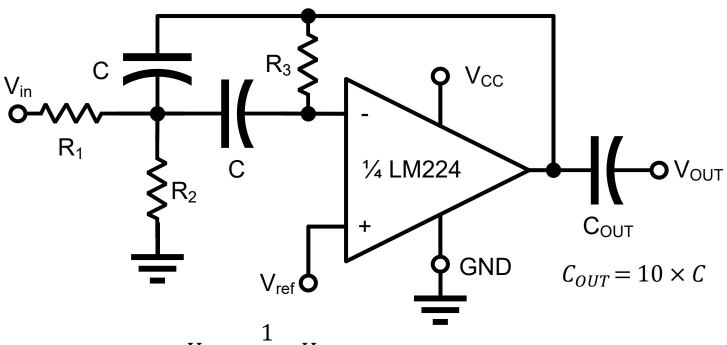
$R_1 = Q \times R$ $C_1 = 10 \times C$

$R_2 = \frac{R_1}{T_{BP}}$

$R_3 = T_N \times R_2$

For f_{OUT} = 1kHz, Q = 10, T_{BP} = 1, T_N = 1
R = 160kΩ, C = 0.001μF, R_1 = 1.6MΩ, R_2 = 1.6MΩ, R_3 = 1.6MΩ
Where T_{BP} = Center Frequency Gain, T_N = Passband Notch Gain

Figure 8-9. Bi-Quad Filter



$V_{ref} = \frac{1}{2} \times V_{CC}$

Given: f_{OUT} = Center Frequency
$A(f_{OUT})$ = Gain at Center Frequency
Choose value f_{OUT}, C, then:

$R_3 = \frac{Q}{\pi \times f_{OUT} \times C}$ $R_1 = \frac{R_3}{2 \times A(F_{OUT})}$ $R_2 = \frac{R_1 \times R_3}{4 \times Q^2 \times R_1 + R_3}$

For less than 10% error from operational amplifier.

$$\frac{Q_{OUT} \times f_{OUT}}{BW} < 0.1$$

Where f_{OUT} and BW are expressed in HZ.
If source impedance varies, filter may be preceded with voltage follower buffer to stabilize filter parameters.

Figure 8-10. Multiple Feedback Bandpass Filter

8 Application and Implementation

8.2 Layout Guidelines

LM224 is widely used in various operational amplifier circuits. The following points should be taken in circuit design and PCB layout to help devices obtain the best operating performance:

1. Signal transmission traces should be as far away as possible from power supply traces to reduce parasitic coupling. It is recommended that signal traces be kept at least 5mm away from power supply lines. If the layout of the circuit does not allow this, it is better to lay out these traces vertically to avoid being parallel to each other as much as possible;
2. The length of the power supply traces should be as short as possible and bypass the power supply appropriately so as to reduce the power disturbance caused by current changes, such as when driving an AC signal to a heavy load;
3. It is recommended to use a bypass capacitor between each power supply pin (single power supply is V_{S+}, dual power supply is V_{S+} and V_{S-}) and ground to reduce coupling noise transmitted through the power supply pins and operational amplifiers to the entire circuit. It is recommended to use ceramic bypass capacitors with low ESR and 0.1μF, and ensure that they are placed as close as possible to the corresponding pins of the device;
4. External components should be placed as close as possible to the device, and keeping R_I and R_F close to the input can minimize parasitic capacitance;
5. Analog grounding and digital grounding should be physically separated. Grounding the analog and digital parts of the circuit separately is a very simple but effective method for suppressing noise. When designing and laying out a multi-layer PCB circuit, one or more layers can be dedicated to a grounding layer, which can reduce EMI noise and help distribute appropriate heat on the circuit board;
6. Make sure the surface of the printed circuit board is clean and moisture-free. Use a surface coating to prevent moisture accumulation and help reduce parasitic resistance on the printed circuit board. Consider setting a low impedance guard ring (as shown in Figure 8-11) for the driver around the critical trace. The guard ring can significantly reduce the leakage current of nearby traces at different potentials.

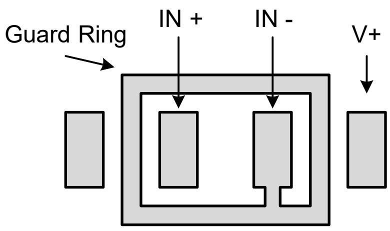


Figure 8-11. Guard Ring

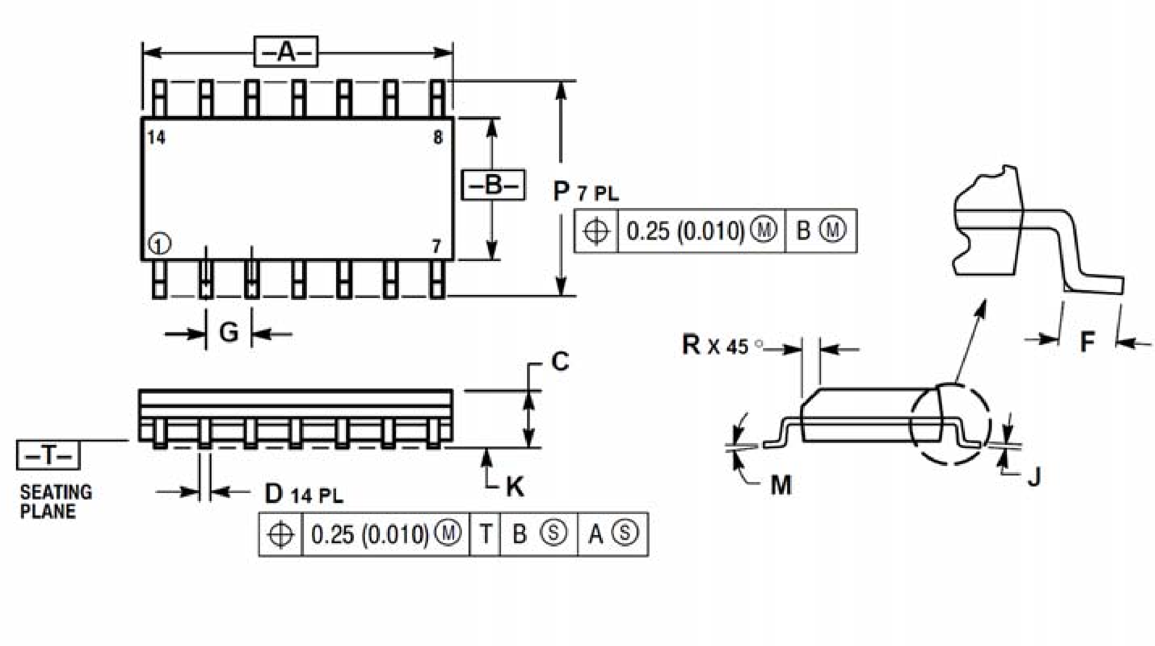
NOTE

The application information in this section is not part of the data sheet component specification, and JSCJ makes no commitment or statement to guarantee its accuracy or completeness. Customers are responsible for determining the rationality of corresponding components in their circuit design and making tests and verifications to ensure the normal realization of their circuit design.

9 Mechanical Information

SOP14 Mechanical Information

Outline Dimensions



SYMBOL	DISMENSIONS IN MILLIMETERS			DISMENSIONS IN INCHES		
	MIN	NOM	MAX	MIN	NOM	MAX
A	8.550	-	8.750	0.337	-	0.344
B	3.800	-	4.000	0.150	-	0.157
C	1.350	-	1.750	0.053	-	0.069
D	0.350	-	0.490	0.014	-	0.019
F	0.400	-	1.250	0.016	-	0.049
G	1.270 BSC.			0.050 BSC.		
J	0.190	-	0.250	0.007	-	0.010
K	0.100	-	0.250	0.004	-	0.010
M	0°	-	7°	0°	-	7°
P	5.800	-	6.200	0.228	-	0.244
R	0.250	-	0.500	0.010	-	0.020

10 Notes and Revision History

10.1 Associated Product Family and Others

To view other products of the same type or IC products of other types, click the official website of JSCJ -- https: ***www.jscj-elec.com*** for more details.

10.2 Notes

Electrostatic Discharge Caution

This IC may be damaged by ESD. Relevant personnel shall comply with correct installation and use specifications to avoid ESD damage to the IC. If appropriate measures are not taken to prevent ESD damage, the hazards caused by ESD include but are not limited to degradation of integrated circuit performance or complete damage of integrated circuit. For some precision integrated circuits, a very small parameter change may cause the whole device to be inconsistent with its published specifications.

10.3 Revision History

September, 2023: released LM224 rev - 1.0.

DISCLAIMER

IMPORTANT NOTICE, PLEASE READ CAREFULLY

The information in this data sheet is intended to describe the operation and characteristics of our products. JSCJ has the right to make any modification, enhancement, improvement, correction or other changes to any content in this data sheet, including but not limited to specification parameters, circuit design and application information, without prior notice.

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