



LM2904 Operational Amplifier

1 Introduction

LM2904 is an industrial standard operational amplifier, which consists of two independent, high gain and frequency compensation operational amplifiers. It can support up to 26V single power supply or use $\pm 13V$ dual power supply. The maximum offset voltage of each operational amplifier is 7mV, and the typical power supply current is 350 μ A, and can provide a 1MHz gain bandwidth product. The operating environment temperature of LM2904 can reach up to -40 to 125 $^{\circ}$ C, and its wide operating temperature range makes it suitable for most applications and environments. In a single power supply voltage system, it can easily implement various operational amplification circuits, and can directly use the standard 5V power supply in the digital system without requiring additional power equipment for operation.

2 Available Package

PART NUMBER	PACKAGE
LM2904	SOP8

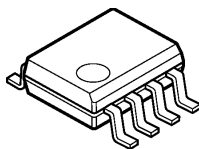


Figure 2-1. SOP8 Package



"LM2904": Device number.
 ".": Solid Dot: Green molding compound device.
 "lot num.": Lot number, code for production.

Figure 2-2. Marking Information

3 Features

- Wide Power Supply Range:
 Single Supply: 3.0V to 26V
 Dual Supplies: $\pm 1.5V$ to 13V
- Low Power Supply Current:
 350 μ A typical / per channel
- Unity-gain Bandwidth: 1MHz typical
- Slew Rate: 0.3V / μ s typical
- Operating Temperature Range:
 -40 ~ 125 $^{\circ}$ C
- Input Common-Mode Voltage Range
 Includes Ground

4 Applications

- AC, Series, Central Inverter and Frequency Converter
- Commercial Network and Server Power Supply Units
- Control of Various Types of Motors
- Desktop Computer and Motherboard
- Electronic Point of Sale System
- Indoor and Outdoor Air Conditioning
- Multifunctional Printer
- Programmable Logic Controller
- Power Supply and Mobile Charger
- Washing Machines, Dryers, Refrigerators

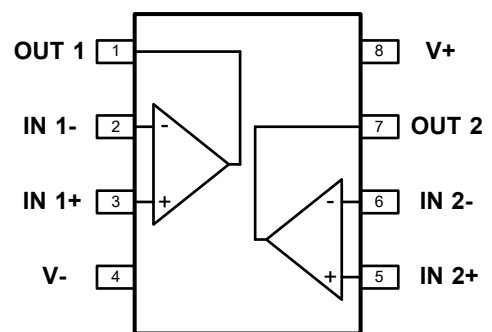


Figure 2-3. Pin Connections

5 Pin Configuration and Orderable Information

5.1 Pin Configuration and Function

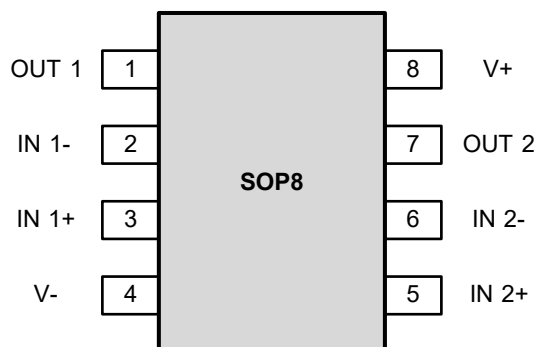


Figure 5-1. LM2904 Pin Map

PIN NAME	LM2904	I / O	DESCRIPTION
	SOP8		
OUT 1	1	O	Output of the operational amplifier 1.
IN 1-	2	I	Negative input of the operational amplifier 1.
IN 1+	3	I	Positive input of the operational amplifier 1.
V-	4	-	Negative (lowest) supply or ground for single supply.
IN 2+	5	I	Positive input of the operational amplifier 2.
IN 2-	6	I	Negative input of the operational amplifier 2.
OUT 2	7	O	Output of the operational amplifier 2.
V+	8	-	Positive (highest) supply.

5.2 Orderable Information

MODEL	DEVICE	PACKAGE	OP TEMP	ECO PLAN	MSL	PACKING OPTION	SORT
-	LM2904	SOP8	-40 ~ 125°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.

6 Specifications

6.1 Absolute Maximum Ratings

(over operating ambient temperature range, unless otherwise specified)⁽¹⁾

CHARACTERISTIC		SYMBOL	VALUE	UNIT
Maximum power supply	Single supply	V_S	32	V
	Dual supplies		± 16	
Maximum differential input range ⁽²⁾		V_{ID}	-32 ~ 32	V
Maximum input range (either input)		V_{IN}	-0.3 ~ 32	V
Duration of output short circuit (one amplifier) to ground (or below) at $T_A = 25^\circ\text{C}$, $V_S \leq 15\text{V}$		t_{sc}	Continuous ⁽³⁾	s
Maximum junction temperature		$T_{J\text{MAX}}$	150	$^\circ\text{C}$
Storage temperature		T_{stg}	-65 ~ 150	$^\circ\text{C}$
Soldering temperature & time		T_{solder}	260 $^\circ\text{C}$, 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.

6.2 Recommend Operating Conditions

PARAMETER		SYMBOL	MIN.	NOM.	MAX.	UNIT
Power supply range	Single supply	V_S	3.0	-	26	V
	Dual supplies		± 1.5	-	± 13	
Differential input voltage		V_{ID}	-26	-	26	V
Common-mode voltage range		V_{CM}	V-	-	(V+) - 2.0	V
Operating ambient temperature		T_A	-40	-	125	$^\circ\text{C}$

6 Specifications

6.3 ESD Ratings

ESD RATINGS		SYMBOL	VALUE	UNIT
Electrostatic discharge ⁽⁴⁾	Human body model	$V_{ESD-HBM}$	500	V

(4) 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.

6.4 Thermal Information

THERMAL METRIC ⁽⁵⁾	SYMBOL	LM2904	UNIT
		SOP8	
Junction-to-ambient thermal resistance	$R_{\theta JA}$	159.6	°C/W
Junction-to-case thermal resistance	$R_{\theta JC}$	44.1	°C/W
Reference maximum power dissipation (continuous)	$P_{D Ref}$	0.61	W

(5) $T_A = 25^\circ\text{C}$, measured on evaluation board with 1oz. copper traces of minimum pad size, all device outputs were active.

6 Specifications

6.5 Electrical Characteristics

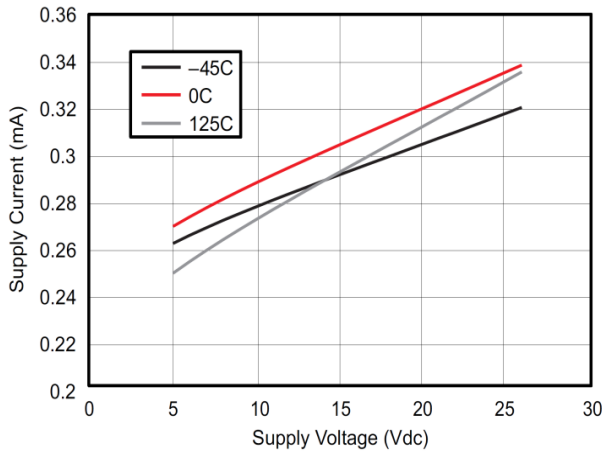
LM2904 (for $V_S = (V+) - (V-) = 5.0V$, $V_{CM} = 0V$, $T_A = 25^\circ C$, unless otherwise specified)

CHARACTERISTIC	SYMBOL	TEST CONDITIONS	MIN.	TYP.	MAX.	UNIT		
Offset Voltage								
Input offset voltage	V_{OS}	$V_S = 5.0$ to $26V$, $V_{CM} = 0V$, $V_{OUT} = 1.4V$	-	± 3.0	± 7.0	mV		
Input offset voltage drift	dV_{OS} / dT	-	$T_A = -40$ to $125^\circ C$	-	7.0	$\mu V / ^\circ C$		
Input offset voltage vs power supply ($\Delta V_{IO} / \Delta V_S$)	PSRR	$V_S = 5.0$ to $26V$	65	100	-	dB		
Channel separation, dc	CS	$f = 1k$ to $20kHz$	-	120	-	dB		
Input Voltage Range								
Common-mode voltage range	V_{CM}	$V_S = 5.0$ to $26V$	$T_A = 25^\circ C$	V-	-	$(V+) - 1.5$	V	
			$T_A = -40$ to $125^\circ C$	V-	-	$(V+) - 2.0$		
Common-mode rejection ratio	CMRR	$V_S = 5.0$ to $26V$; $V_{CM} = 0V$	65	80	-	dB		
Power Supply								
Quiescent current per amplifier	I_Q	$V_O = 2.5V$, $R_L = \infty$	-	350	600	μA		
Input Bias Current								
Input bias current	I_{IB}	$V_{CM} = 0V$, $V_{OUT} = 1.4V$	-	-20	-250	nA		
Input offset current	I_{OS}	$V_{CM} = 0V$, $V_{OUT} = 1.4V$	-	2	50	nA		
Frequency Response								
Gain bandwidth product	GBW	-	-	1.0	-	MHz		
Slew rate	SR	$G = +1$	-	0.3	-	$V / \mu s$		
Output								
Voltage output swing from rail	V_O	$V_S = 26V$, $R_L = 2k\Omega$	Positive rail	-	-	4.0	V	
		$V_S = 26V$, $R_L \geq 10k\Omega$		-	2.0	3.0		
		$V_S = 5.0V$, $R_L \leq 10k\Omega$	Negative rail	-	5.0	20	mV	
Output current	I_O	$V_S = 15V$	$V_O = 0V$, $V_{ID} = 1V$	Source	-20	-30	-	mA
			$V_O = 15V$, $V_{ID} = -1V$	Sink	10	20	-	mA
		$V_O = 0.2V$, $V_{ID} = -1V$	-	-	30	-	μA	
Short-circuit current	I_{SC}	$V_S = 15V$	-	± 40	± 60	mA		
Noise								
Input voltage noise density	e_N	$f = 1kHz$	-	40	-	nV / \sqrt{Hz}		
Open-loop Gain								
Open-loop voltage gain	A_{OL}	$V_S = 15V$, $V_{OUT} = 1.0$ to $11V$, $R_L \geq 2k\Omega$	25	100	-	V / mV		

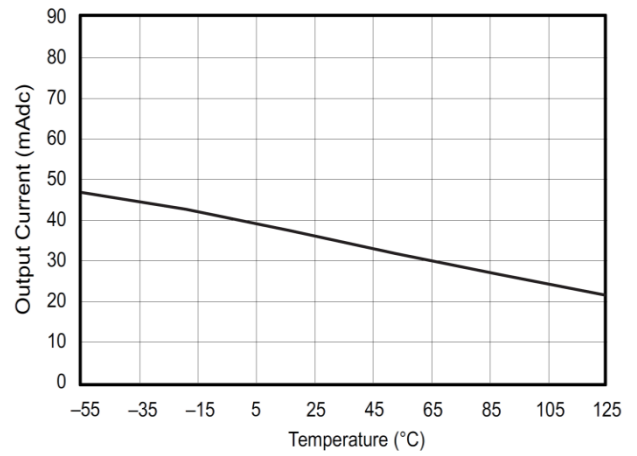
6 Specifications

6.6 Typical Characteristics

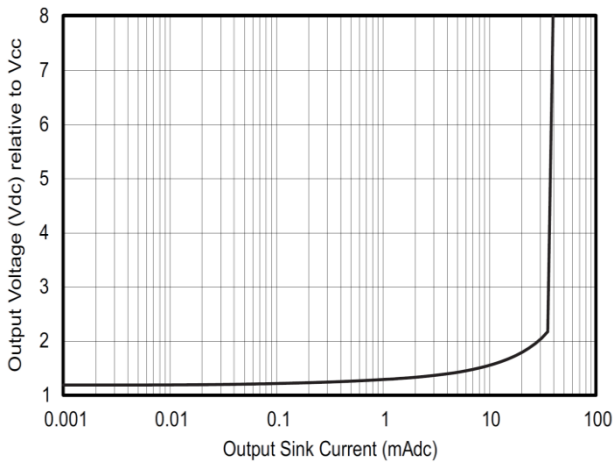
Quiescent Current vs. Supply Voltage



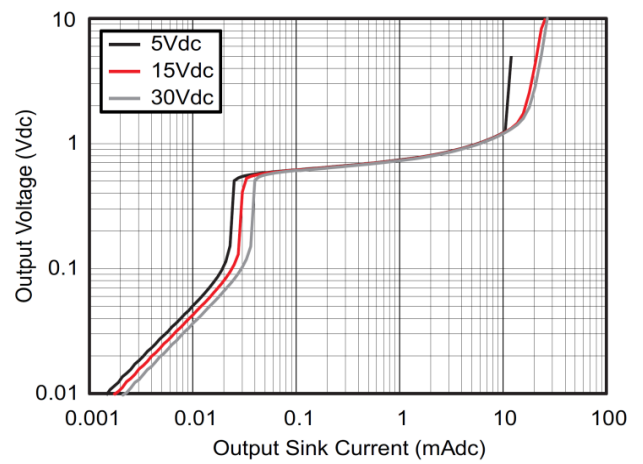
Output Current vs. Temperature



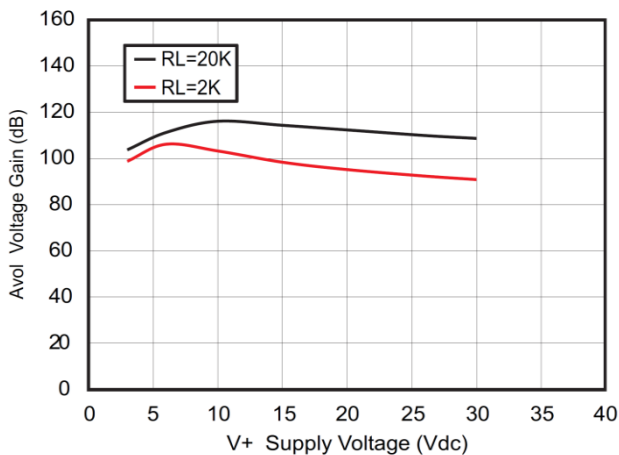
Output Voltage vs. Output Sink Current



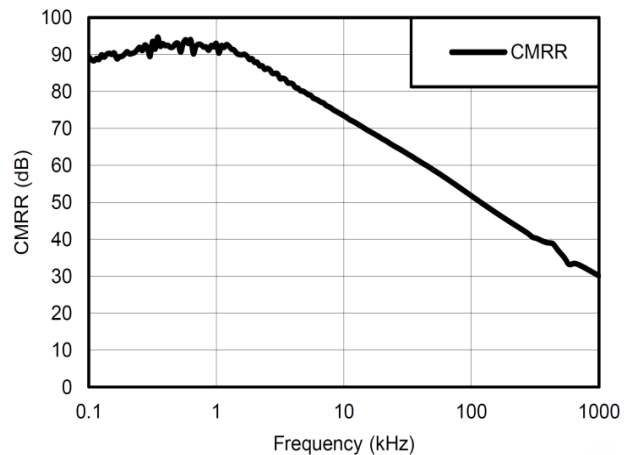
Output Voltage vs. Output Sink Current



Open Gain Voltage vs. Supply Voltage



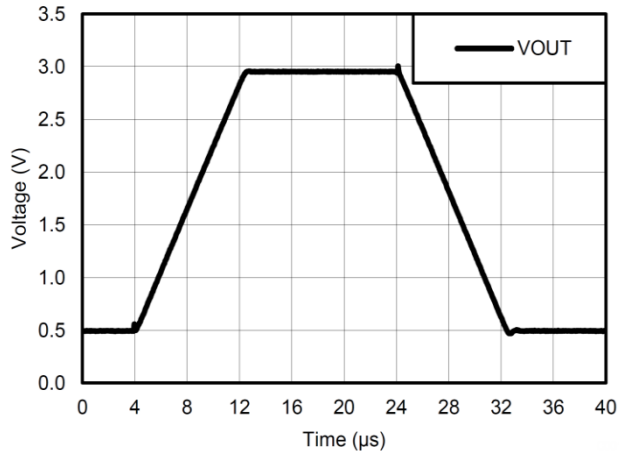
CMRR vs. Frequency



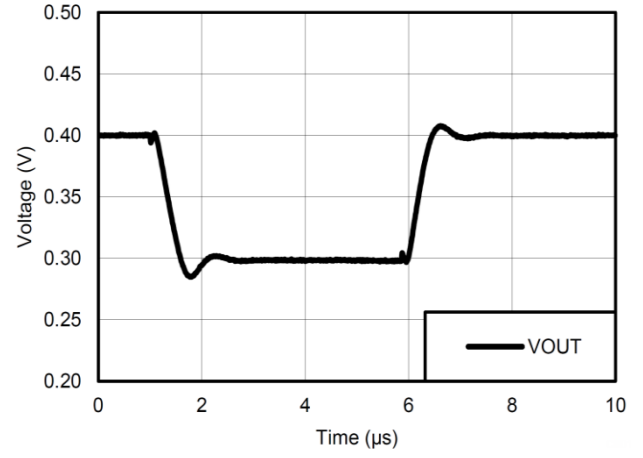
6 Specifications

6.6 Typical Characteristics (continued)

Large-Signal Step Response (50pF)



Small-Signal Step Response (50pF)

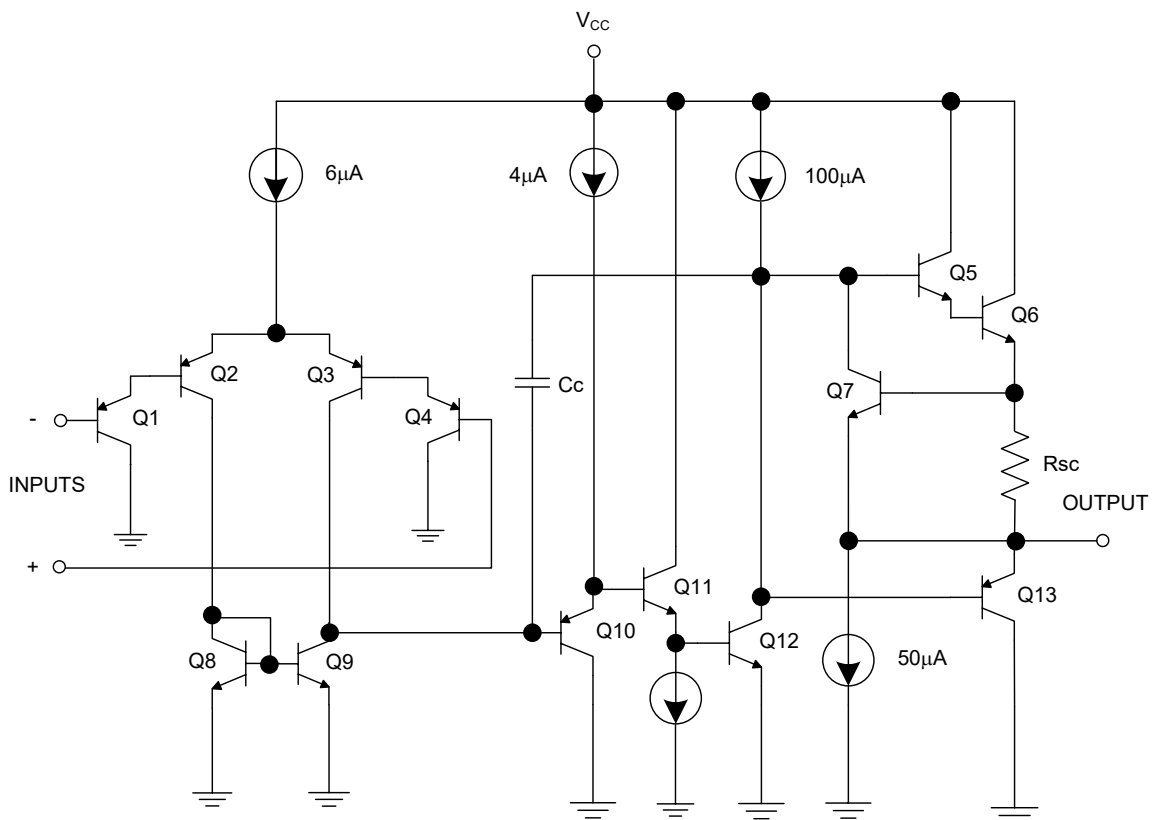


7 Detail Description

7.1 Description

The LM2904 consists of two 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. The LM2904 can be directly powered from a standard 5V power supply used in digital systems without the need for an additional $\pm 5V$ power supply.

7.2 Representative Schematic Diagram



Each Amplifier

8 Application and Implementation

8.1 Typical Application Circuits

The LM2904 is composed of two independent high gain operational amplifiers and supports the use of single or dual power supplies. The maximum supply voltage V_S can reach 26V and it has low power consumption current. Therefore, the LM2904 is widely used in various operational amplifier circuits.

Basic Circuit

Figure 9-1 shows a typical application of LM2904, 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.

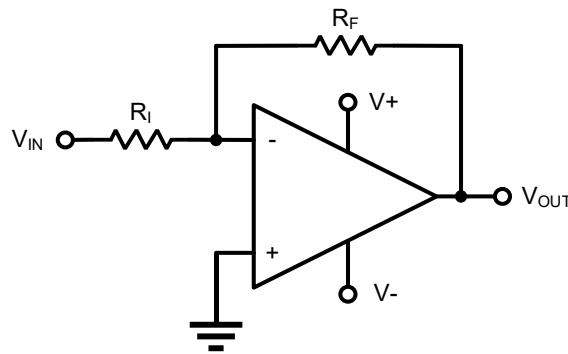


Figure 8-1. Basic Circuit

Power Supply

The LM2904 can be powered by either a single power supply or a dual power supply, as shown in Figures 9-2 and 9-3. 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*.

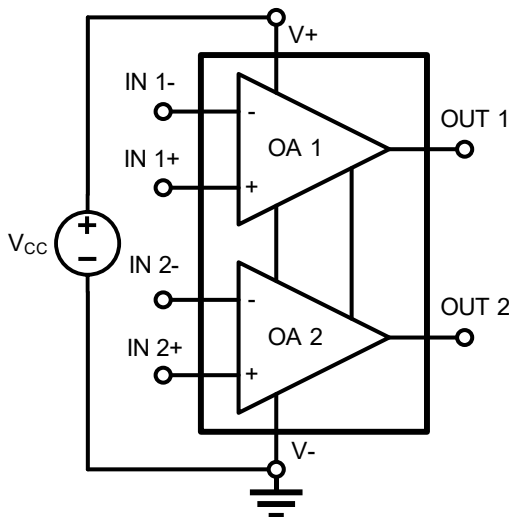


Figure 8-2. Single Power Supply

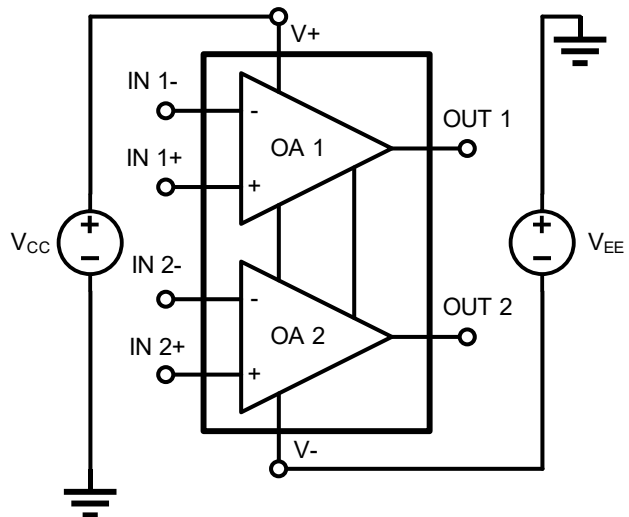


Figure 8-3. Dual Power Supply

8 Application and Implementation

8.1 Typical Application Circuits (continued)

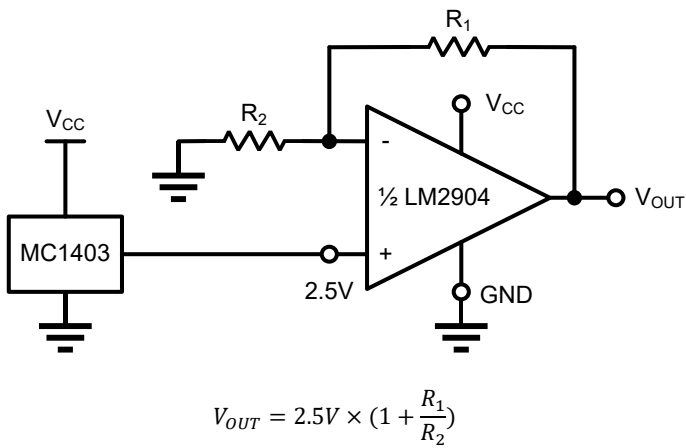


Figure 8-4. Voltage Reference

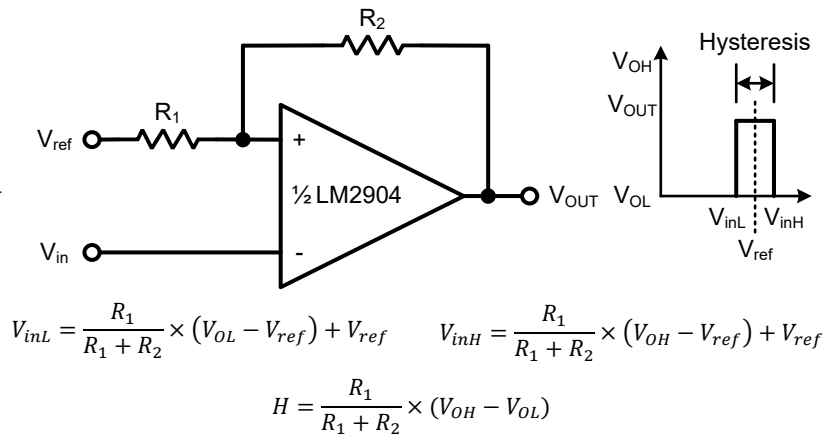


Figure 8-5. Comparator with Hysteresis

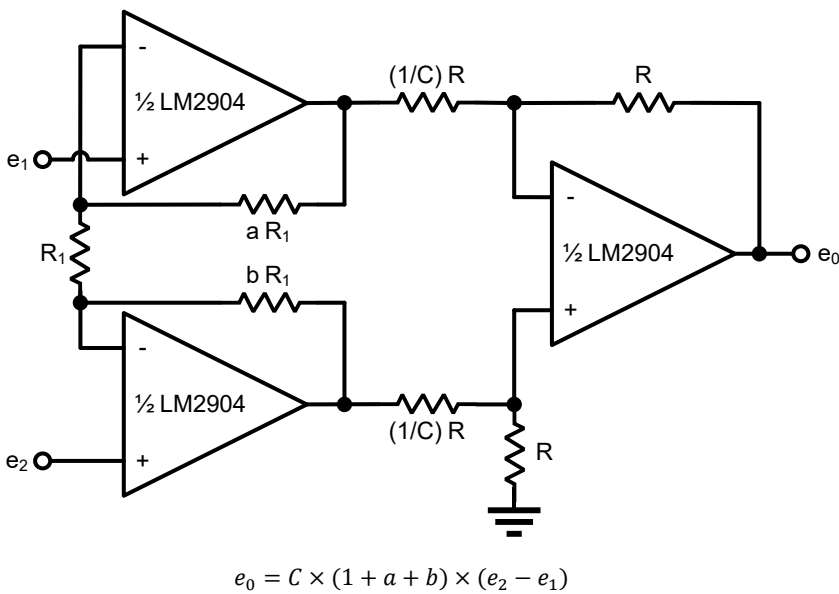
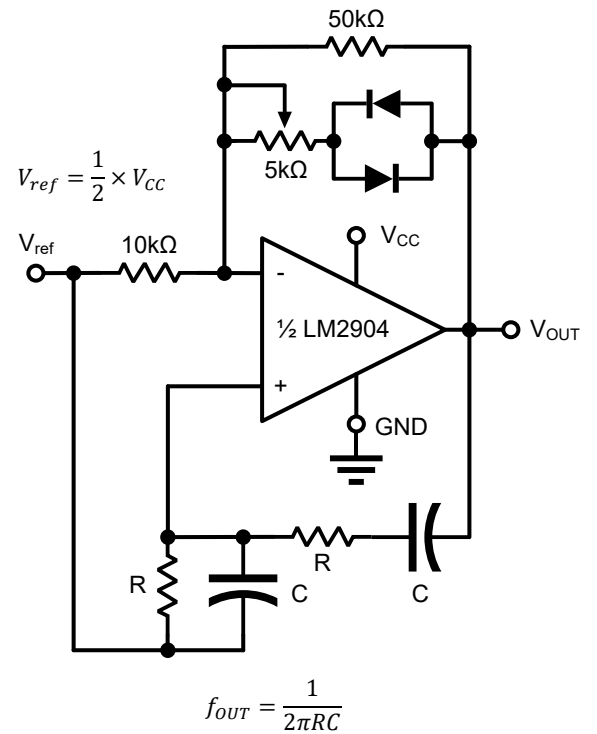


Figure 8-6. High Impedance Differential Amplifier



For $f_{OUT} = 1\text{kHz}$, $R = 16\text{k}\Omega$, $C = 0.01\mu\text{F}$

Figure 8-8. Wien Bridge Oscillator

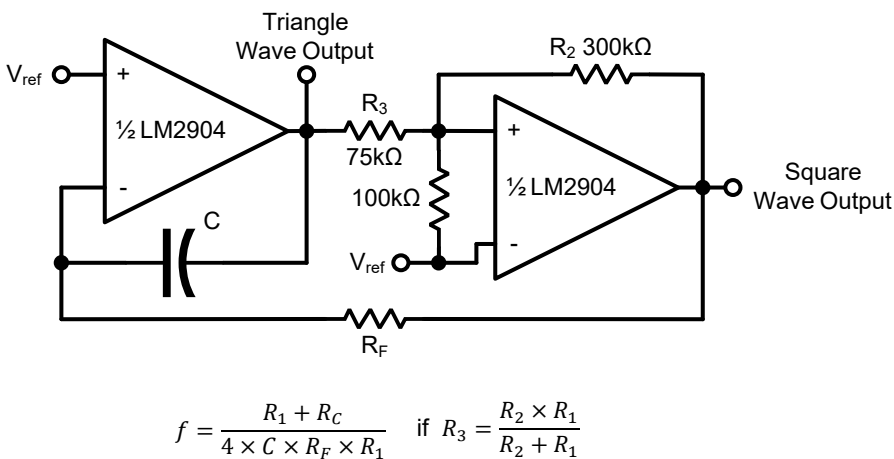


Figure 8-7. Function Generator

8 Application and Implementation

8.1 Typical Application Circuits (continued)

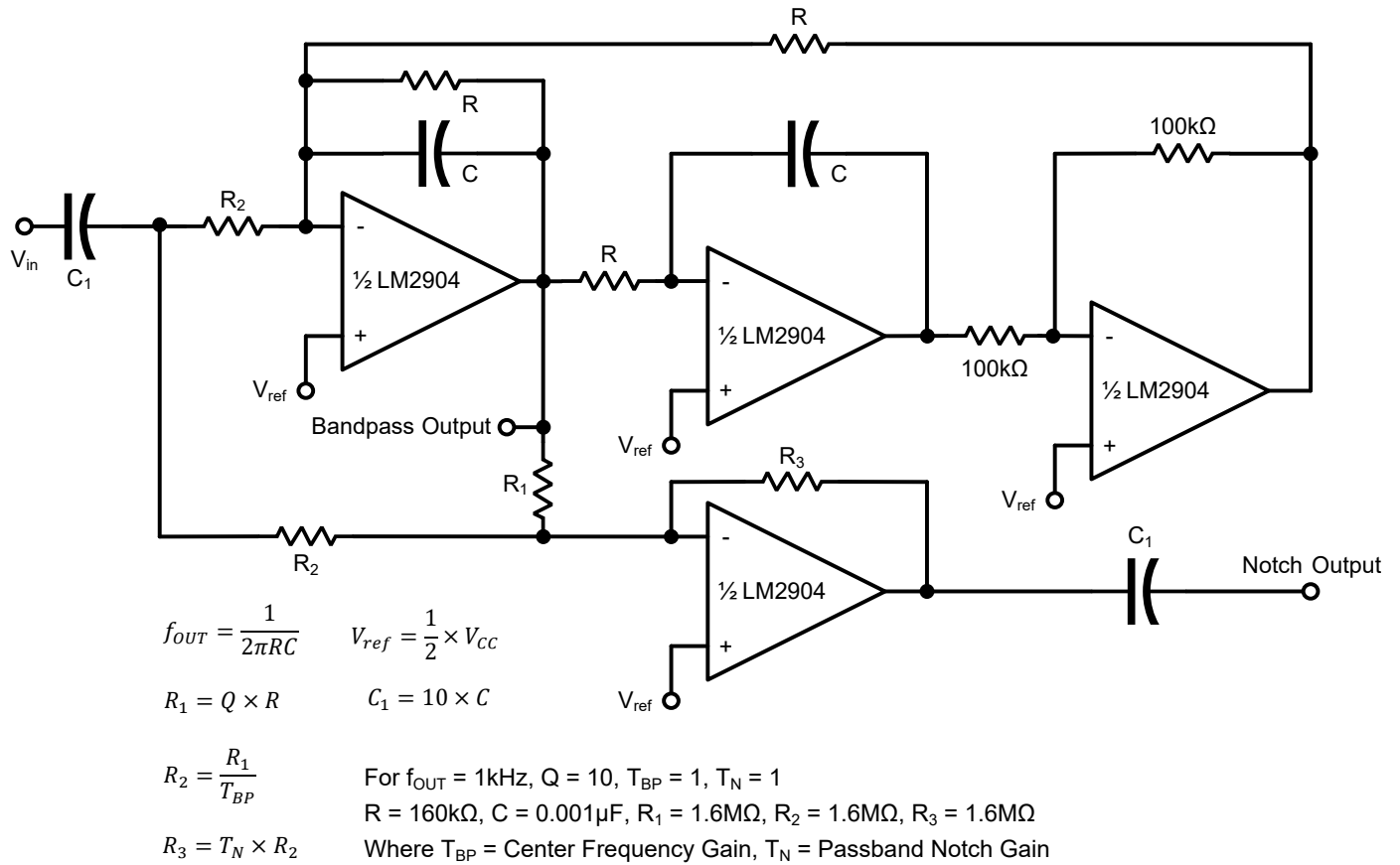
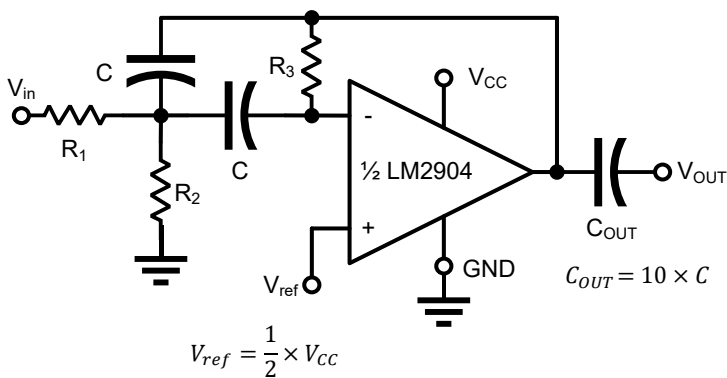


Figure 8-9. Bi-Quad Filter



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

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

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

LM2904 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+, dual power supply is V+ and V-) 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 0.1 μ F, 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 RI and RF 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.

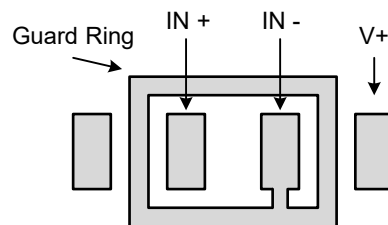


Figure 8-11. Guard Ring

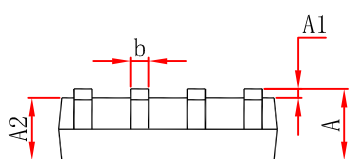
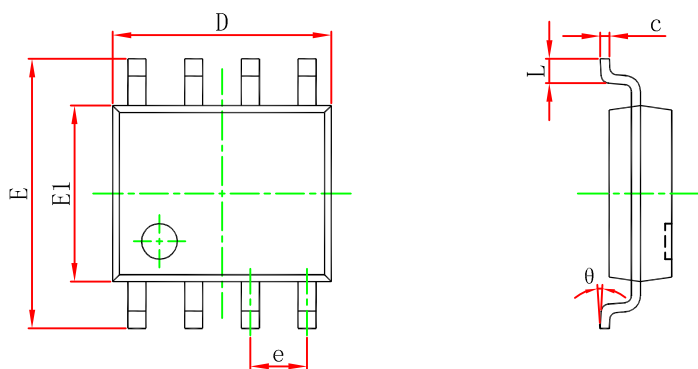
NOTE

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

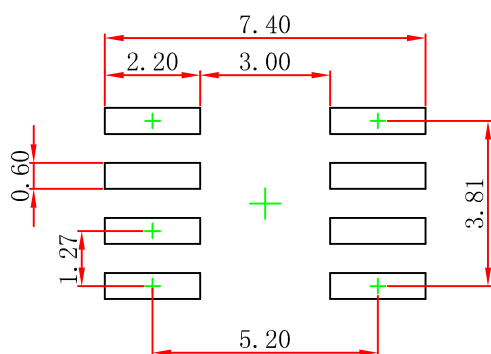
SOP8 Mechanical Information

Outline Dimensions



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.007	0.010
D	4.700	5.100	0.185	0.201
e	1.270 (BSC)		0.050 (BSC)	
E	5.800	6.300	0.228	0.244
E1	3.800	4.000	0.150	0.157
L	0.400	1.270	0.016	0.050
	0°	8°	0°	8°

SOP8 Suggest Pad Layout



NOTE:

1. Controlling dimension: in millimeters.
2. General tolerance: $\pm 0.05\text{mm}$.
3. The pad layout is for reference purposes only.

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

October, 2023: changed from rev - 1.0 to rev - 1.1:

- Page 2, Orderable Information, PACKING OPTION, changed from 4000 units per reel to 2500 units per reel;
- Deleted Packaging Information section.

June, 2023: released LM2904 rev -1.0.

DISCLAIMER

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