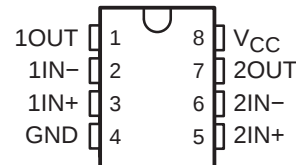


- **Controlled Baseline**
 - One Assembly/Test Site, One Fabrication Site
- **Extended Temperature Performance of -40°C to 125°C**
- **Enhanced Diminishing Manufacturing Sources (DMS) Support**
- **Enhanced Product-Change Notification**
- **Qualification Pedigree[†]**
- **ESD Protection Exceeds 500 V Per MIL-STD-883, Method 3015; Exceeds 200 V Using Machine Model ($C = 200\text{ pF}$, $R = 0$)**
- **Low Supply-Current Drain Independent of Supply Voltage . . . 0.7 mA Typ**
- **Common-Mode Input Voltage Range Includes Ground, Allowing Direct Sensing Near Ground**
- **Differential Input Voltage Range Equal to Maximum-Rated Supply Voltage:**
 - Non-V Devices . . . $\pm 26\text{ V}$
 - V-Suffix Devices . . . $\pm 32\text{ V}$
- **Low Input Bias and Offset Parameters:**
 - Input Offset Voltage . . . 3 mV Typ
 - Input Offset Current . . . 2 nA Typ
 - Input Bias Current . . . 20 nA Typ
- **Open-Loop Differential Voltage Amplification . . . 100 V/mV Typ**
- **Internal Frequency Compensation**

[†] Component qualification in accordance with JEDEC and industry standards to ensure reliable operation over an extended temperature range. This includes, but is not limited to, Highly Accelerated Stress Test (HAST) or biased 85/85, temperature cycle, autoclave or unbiased HAST, electromigration, bond intermetallic life, and mold compound life. Such qualification testing should not be viewed as justifying use of this component beyond specified performance and environmental limits.

**D OR PW PACKAGE
(TOP VIEW)**



description/ordering information

This device consists of two independent, high-gain, frequency-compensated operational amplifiers designed to operate from a single supply over a wide range of voltages. Operation from split supplies is possible as long as the difference between the two supplies is 3 V to 26 V (3 V to 32 V for V-suffix devices), and V_{CC} is at least 1.5 V more positive than the input common-mode voltage. The low supply-current drain is independent of the magnitude of the supply voltage.

Applications include transducer amplifiers, dc amplification blocks, and all the conventional operational amplifier circuits that now can be implemented more easily in single-supply-voltage systems. For example, these devices can be operated directly from the standard 5-V supply used in digital systems and easily provide the required interface electronics without additional $\pm 5\text{-V}$ supplies.

ORDERING INFORMATION

T_A	V_{IOmax} AT 25°C	MAX V_{CC}	PACKAGE [‡]		ORDERABLE PART NUMBER	TOP-SIDE MARKING
-40°C to 125°C	7 mV	26 V	SOIC (D)	Tape and reel	LM2904QDREP	2904EP
	7 mV	26 V	TSSOP (PW)	Tape and reel	LM2904QPWREP	2904EP
	7 mV	32 V	SOIC (D)	Tape and reel	LM2904VQDREP	2904VEP
	7 mV	32 V	TSSOP (PW)	Tape and reel	LM2904VQPWREP	2904VEP
	2 mV	32 V	SOIC (D)	Tape and reel	LM2904AVQDREP	2904AVE
	2 mV	32 V	TSSOP (PW)	Tape and reel	LM2904AVQPWREP	2904AVE

[‡] Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at www.ti.com/sc/package.



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.

PRODUCTION DATA information is current as of publication date. Products conform to specifications per the terms of Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.

**TEXAS
INSTRUMENTS**

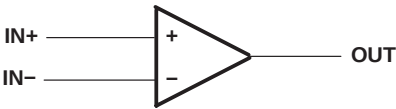
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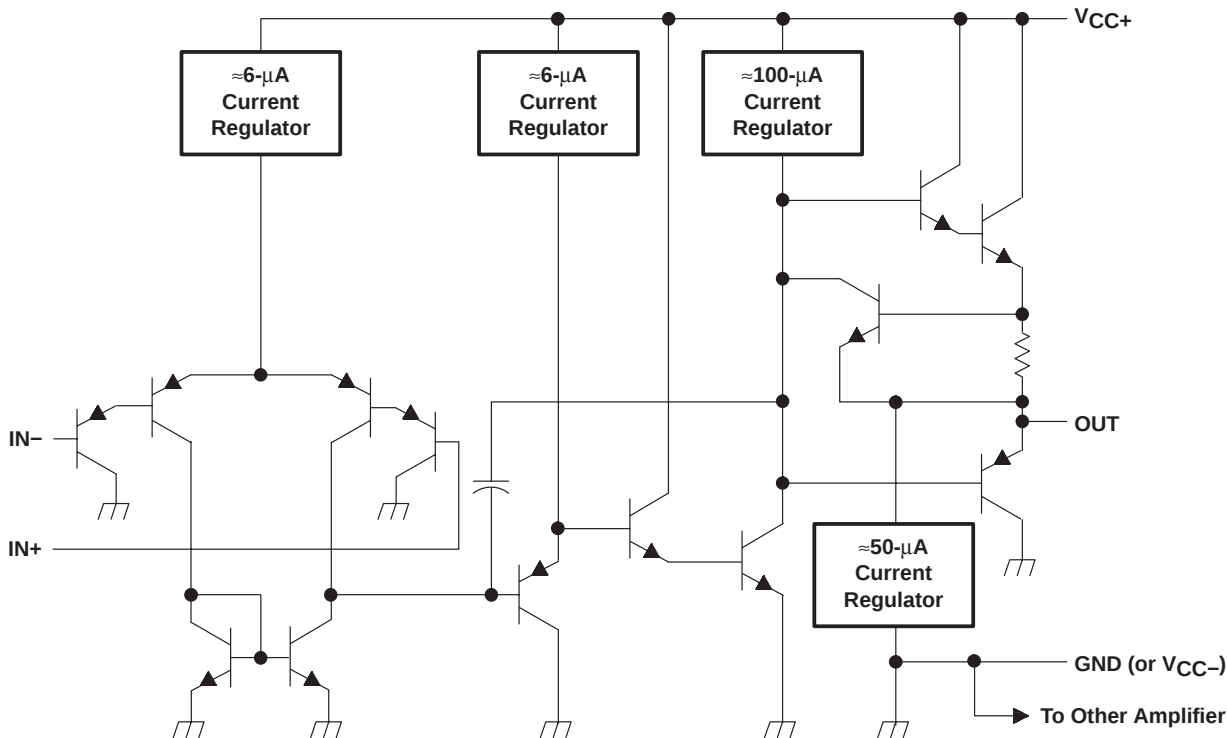
LM2904-EP
DUAL OPERATIONAL AMPLIFIER

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symbol (each amplifier)



schematic (each amplifier)



COMPONENT COUNT	
Epi-FET	1
Diodes	2
Resistors	7
Transistors	51
Capacitors	2

absolute maximum ratings over operating free-air temperature (unless otherwise noted)[†]

Supply voltage, V_{CC} (see Note 1): Non-V devices	26 V
V-suffix devices	32 V
Differential input voltage, V_{ID} (see Note 2): Non-V devices	± 26 V
V-suffix devices	± 32 V
Input voltage range, V_I (either input): Non-V devices	-0.3 V to 26 V
V-suffix devices	-0.3 V to 32 V
Duration of output short circuit (one amplifier) to ground at (or below) 25°C	
free-air temperature ($V_{CC} \leq 15$ V) (see Note 3)	Unlimited
Operating virtual junction temperature, T_J	150°C
Package thermal impedance, θ_{JA} (see Notes 4 and 5): D package	97°C/W
PW package	149°C/W
Operating free-air temperature range, T_A (see Figure 1)	-40°C to 125°C
Storage temperature range, T_{Stg}	-65°C to 150°C

[†] Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

- NOTES:
1. All voltage values, except differential voltages and V_{CC} specified for measurement of I_{OS} , are with respect to the network ground terminal.
 2. Differential voltages are at $IN+$ with respect to $IN-$.
 3. Short circuits from outputs to V_{CC} can cause excessive heating and eventual destruction.
 4. Maximum power dissipation is a function of $T_J(\max)$, θ_{JA} , and T_A . The maximum allowable power dissipation at any allowable ambient temperature is $P_D = (T_J(\max) - T_A)/\theta_{JA}$. Operating at the absolute maximum T_J of 150°C can affect reliability.
 5. The package thermal impedance is calculated in accordance with JESD 51-7.

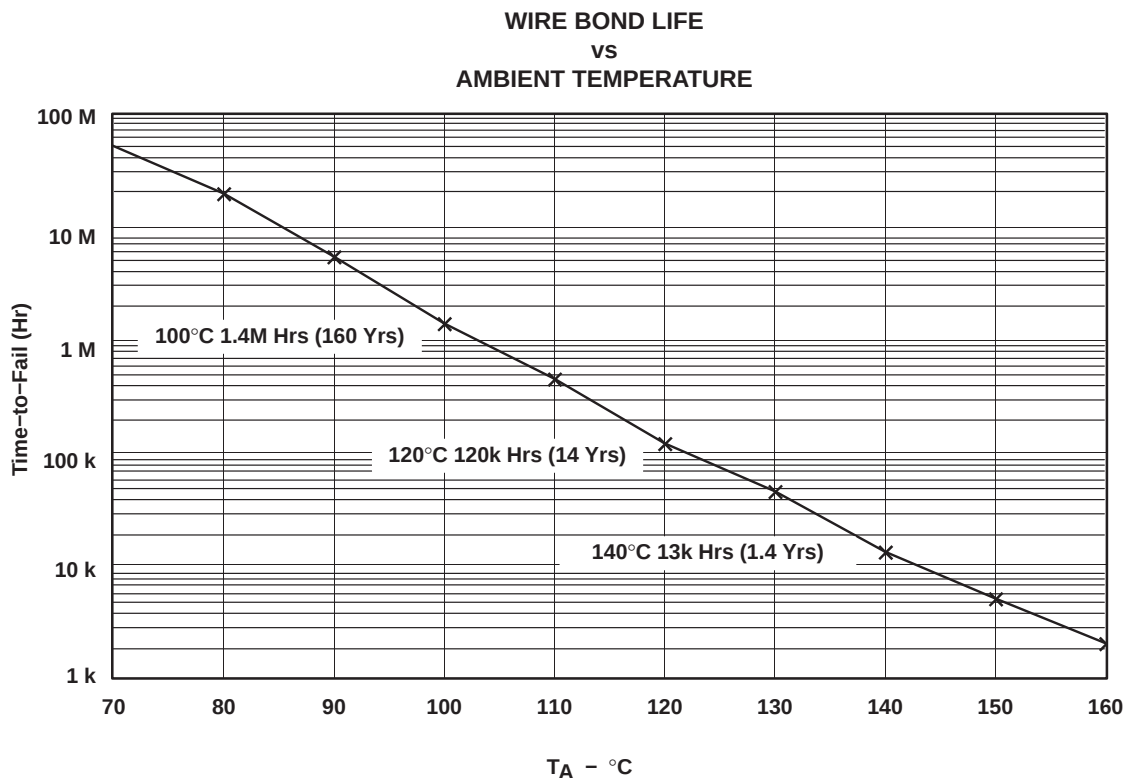


Figure 1. Estimated Wire Bond Life

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electrical characteristics at specified free-air temperature, $V_{CC} = 5\text{ V}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		T_A ‡	MIN	TYP§	MAX	UNIT
V_{IO} Input offset voltage	$V_{CC} = 5\text{ V to MAX}$, $V_{IC} = V_{ICR(min)}$, $V_O = 1.4\text{ V}$	Non-A devices	25°C	3	7		mV
			Full range		10		
		A-suffix devices	25°C	1	2		
			Full range		4		
$\alpha_{V_{IO}}$ Average temperature coefficient of input offset voltage			Full range	7			$\mu\text{V}/^\circ\text{C}$
I_{IO} Input offset current	$V_O = 1.4\text{ V}$	Non-V devices	25°C	2	50		nA
			Full range		300		
		V-suffix devices	25°C	5	50		
			Full range		150		
$\alpha_{I_{IO}}$ Average temperature coefficient of input offset current			Full range	10			$\text{pA}/^\circ\text{C}$
I_{IB} Input bias current	$V_O = 1.4\text{ V}$		25°C	-20	-250		nA
			Full range		-500		
I_B Drift			Full range	50			$\text{pA}/^\circ\text{C}$
V_{ICR} Common-mode input voltage range	$V_{CC} = 5\text{ V to MAX}$		25°C	0 to $V_{CC} - 1.5$			V
			Full range	0 to $V_{CC} - 2$			
V_{OH} High-level output voltage	$R_L \geq 10\text{ k}\Omega$		25°C	$V_{CC} - 1.5$			V
	$V_{CC} = \text{MAX}$, Non-V devices	$R_L = 2\text{ k}\Omega$	Full range	22			
		$R_L \geq 10\text{ k}\Omega$		23	24		
	$V_{CC} = \text{MAX}$, V-suffix devices	$R_L = 2\text{ k}\Omega$	Full range	26			
		$R_L \geq 10\text{ k}\Omega$		27	28		
V_{OL} Low-level output voltage	$R_L \leq 10\text{ k}\Omega$		Full range	5	20		mV
A_{VD} Large-signal differential voltage amplification	$V_{CC} = 15\text{ V}$, $V_O = 1\text{ V to } 11\text{ V}$, $R_L \geq 2\text{ k}\Omega$		25°C	25	100		V/mV
			Full range	15			
CMRR Common-mode rejection ratio	$V_{CC} = 5\text{ V to MAX}$, $V_{IC} = V_{ICR(min)}$		25°C	65	80		dB
k_{SVR} Supply-voltage rejection ratio ($\Delta V_{DD}/\Delta V_{IO}$)	$V_{CC} = 5\text{ V to MAX}$		25°C	65	100		dB
V_{O1}/V_{O2} Crosstalk attenuation	$f = 1\text{ kHz to } 20\text{ kHz}$		25°C	120			dB
I_O Output current	$V_{CC} = 15\text{ V}$, $V_{ID} = 1\text{ V}$, $V_O = 0$		25°C	-20	-30		mA
			Full range	-10			
	$V_{CC} = 15\text{ V}$, $V_{ID} = -1\text{ V}$, $V_O = 15\text{ V}$		25°C	10	20		
			Full range	5			
	$V_{ID} = -1\text{ V}$, $V_O = 200\text{ mV}$		25°C	12	40		
I_{OS} Short-circuit output current	V_{CC} at 5 V, GND at -5 V, $V_O = 0$		25°C	± 40	± 60		mA
I_{CC} Supply current (two amplifiers)	$V_O = 2.5\text{ V}$, No load		Full range	0.7	1.2		mA
	$V_{CC} = \text{MAX}$, $V_O = 0.5 V_{CC}$, No load			1	2		

† All characteristics are measured under open-loop conditions, with zero common-mode input voltage, unless otherwise specified. MAX V_{CC} for testing purposes is 26 V for non-V devices and 32 V for V-suffix devices.

‡ Full range is -40°C to 125°C for LM2904Q.

§ All typical values are at $T_A = 25^\circ\text{C}$.



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operating conditions, $V_{CC} = \pm 15\text{ V}$, $T_A = 25^\circ\text{C}$

PARAMETER		TEST CONDITIONS	TYP	UNIT
SR	Slew rate at unity gain	$R_L = 1\text{ M}\Omega$, $C_L = 30\text{ pF}$, $V_I = \pm 10\text{ V}$ (see Figure 2)	0.3	$\text{V}/\mu\text{s}$
B_1	Unity-gain bandwidth	$R_L = 1\text{ M}\Omega$, $C_L = 20\text{ pF}$ (see Figure 2)	0.7	MHz
V_N	Equivalent input noise voltage	$R_S = 100\text{ }\Omega$, $V_I = 0\text{ V}$, $f = 1\text{ kHz}$ (see Figure 3)	40	$\text{nV}/\sqrt{\text{Hz}}$

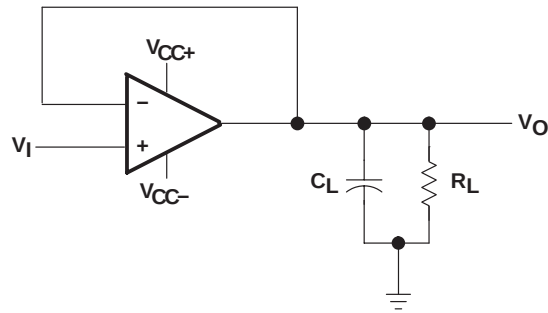


Figure 2. Unity-Gain Amplifier

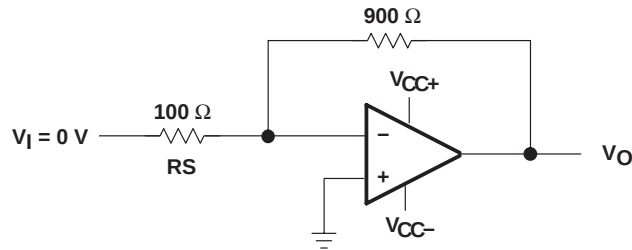


Figure 3. Noise-Test Circuit

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
LM2904 MWC	ACTIVE	WAFERSALE	YS	0	1	RoHS & Green	Call TI	Level-1-NA-UNLIM	-40 to 85		Samples

(1) The marketing status values are defined as follows:

ACTIVE: Product device recommended for new designs.

LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

PREVIEW: Device has been announced but is not in production. Samples may or may not be available.

OBSOLETE: TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "-" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead finish/Ball material - Orderable Devices 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.

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OTHER QUALIFIED VERSIONS OF LM2904-EP :

- Catalog: [LM2904](#)
- Automotive: [LM2904-Q1](#)

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product
- Automotive - Q100 devices qualified for high-reliability automotive applications targeting zero defects

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