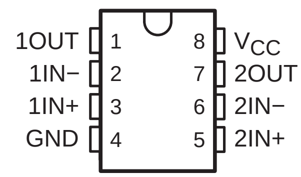
- **Controlled Baseline**
  - **One Assembly/Test Site, One Fabrication Site**
- **Extended Temperature Performance of −40°C to 125°C**
- **Enhanced Diminishing Manufacturing Sources (DMS) Support**
- **Enhanced Product-Change Notification**
- **Qualification Pedigree†**
- **ESD Protection Exceeds 500 V Per MIL-STD-883, Method 3015; Exceeds 200 V Using Machine Model (C = 200 pF, R = 0)**
- **Low Supply-Current Drain Independent of Supply Voltage . . . 0.7 mA Typ**

† 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.

- **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 . . . ±26 V**
  - **V-Suffix Devices . . . ±32 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**

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.

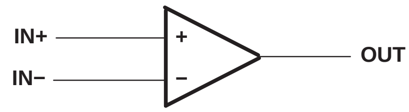
Applications include transducer amplifiers, dc amplification blocks, and all the conventional operational amplifier circuits that now can be implemented more easily in single-supply-voltage systems. For example, these devices can be operated directly from the standard 5-V supply used in digital systems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

ORDERING INFORMATION

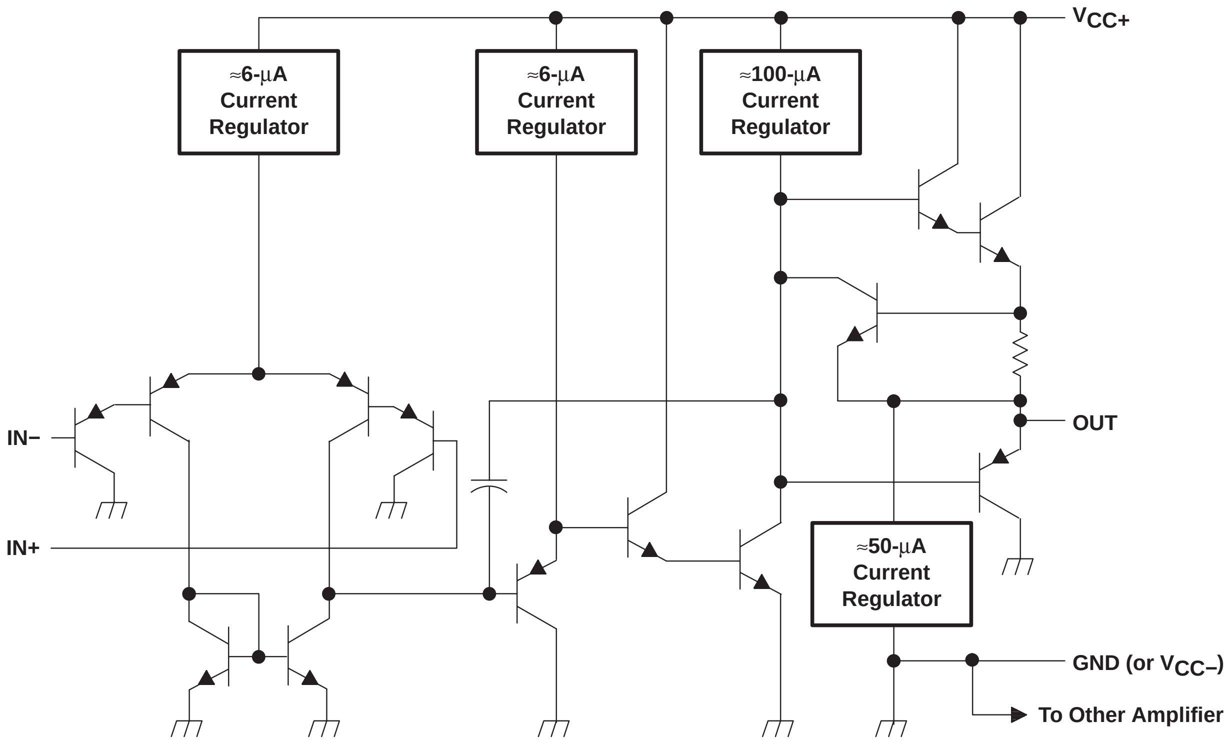
T_A	V_{IO}max AT 25°C	MAX V_{CC}	PACKAGE‡		ORDERABLE PART NUMBER	TOP-SIDE MARKING
−40°C to 125°C	7 mV	26 V	SOIC (D)	Tape and reel	LM2904QDREP	2904EP
	7 mV	26 V	TSSOP (PW)	Tape and reel	LM2904QPWREP	2904EP
	7 mV	32 V	SOIC (D)	Tape and reel	LM2904VQDREP	2904VEP
	7 mV	32 V	TSSOP (PW)	Tape and reel	LM2904VQPWREP	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.

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} ≤ 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.

WIRE BOND LIFE
vs
AMBIENT TEMPERATURE

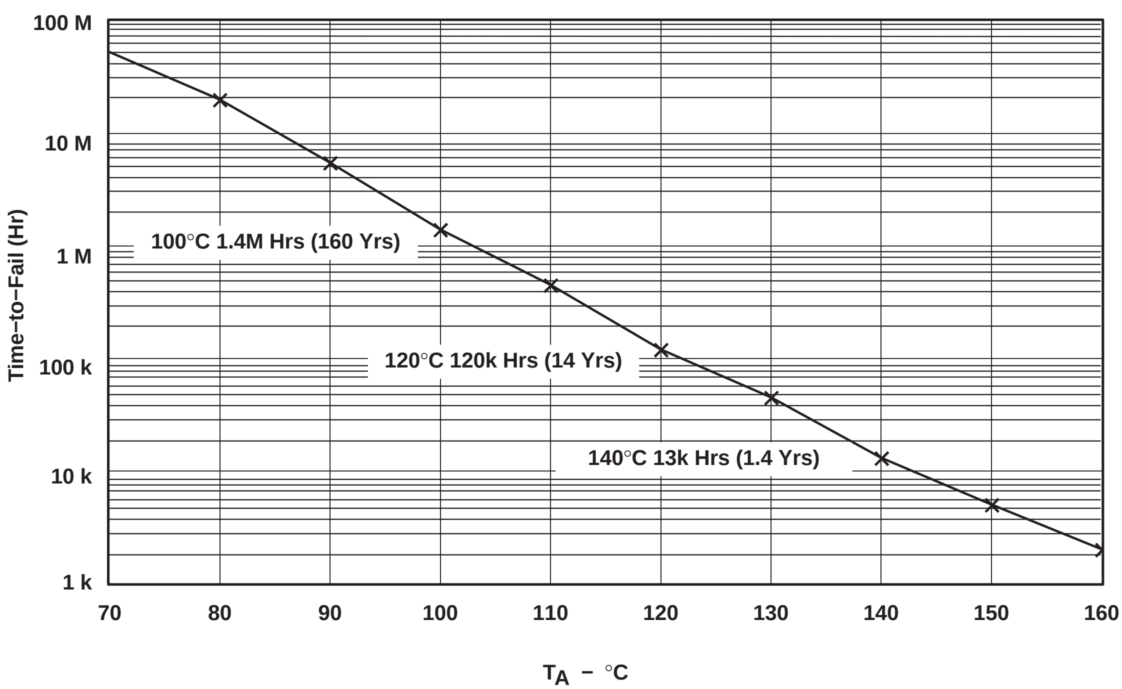


Figure 1. Estimated Wire Bond Life

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

PARAMETER		TEST CONDITIONS†		T_A‡	MIN	TYP§	MAX	UNIT
V_{IO}	Input offset voltage	V_{CC} = 5 V to MAX, $V_{IC}=V_{ICR(min)}$, V_O = 1.4 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		µV/°C
I_{IO}	Input offset current	V_O = 1.4 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		pA/°C
I_{IB}	Input bias current	V_O = 1.4 V		25°C		−20	−250	nA
				Full range			−500	
I_B	Drift			Full range		50		pA/°C
V_{ICR}	Common-mode input voltage range	V_{CC} = 5 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 ≥ 10 kΩ		25°C	V_{CC} − 1.5			V
		V_{CC} = MAX, Non-V devices	R_L = 2 kΩ	Full range	22			
			R_L ≥ 10 kΩ		23	24		
		V_{CC} = MAX, V-suffix devices	R_L = 2 kΩ	Full range	26			
			R_L ≥ 10 kΩ		27	28		
V_{OL}	Low-level output voltage	R_L ≤ 10 kΩ		Full range		5	20	mV
A_{VD}	Large-signal differential voltage amplification	V_{CC} = 15 V, V_O = 1 V to 11 V, R_L = ≥ 2 kΩ		25°C	25	100		V/mV
				Full range	15			
CMRR	Common-mode rejection ratio	V_{CC} = 5 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 V to MAX		25°C	65	100		dB
V_{O1}/V_{O2}	Crosstalk attenuation	f = 1 kHz to 20 kHz		25°C		120		dB
I_O	Output current	V_{CC} = 15 V, V_{ID} = 1 V, V_O = 0		25°C	−20	−30		mA
				Full range	−10			
		V_{CC} = 15 V, V_{ID} = −1 V, V_O = 15 V		25°C	10	20		
				Full range	5			
		V_{ID} = −1 V,	V_O = 200 mV	25°C	12	40		µA
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 V,	No load	Full range		0.7	1.2	mA
		V_{CC} = 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°C.

operating conditions, V_{CC} = ±15 V, T_A = 25°C

PARAMETER		TEST CONDITIONS	TYP	UNIT
SR	Slew rate at unity gain	R_L = 1 MΩ, C_L = 30 pF, V_I = ±10 V (see Figure 2)	0.3	V/μs
B_1	Unity-gain bandwidth	R_L = 1 MΩ, C_L = 20 pF (see Figure 2)	0.7	MHz
V_n	Equivalent input noise voltage	R_S = 100 Ω, V_I = 0 V, f = 1 kHz (see Figure 3)	40	nV/√Hz

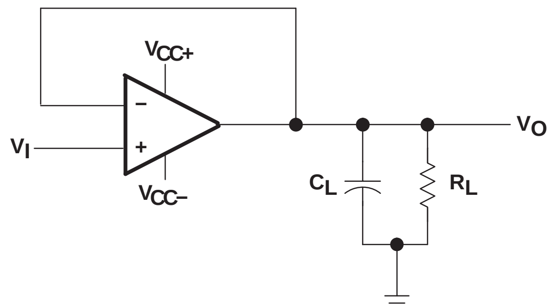


Figure 2. Unity-Gain Amplifier

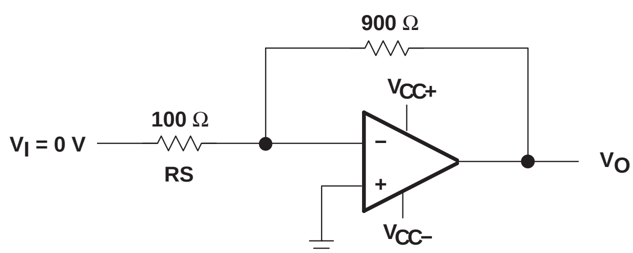


Figure 3. Noise-Test Circuit

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