Quadruple Operational Amplifiers

1 Features

- 2-kV ESD Protection for:
  - LM224K, LM224KA
  - LM324K, LM324KA
  - LM2902K, LM2902KV, LM2902KAV
- Wide Supply Ranges
  - Single Supply: 3 V to 32 V (26 V for LM2902)
  - Dual Supplies: ±1.5 V to ±16 V (±13 V for LM2902)
- Low Supply-Current Drain Independent of Supply Voltage: 0.8 mA Typical
- Common-Mode Input Voltage Range Includes Ground, Allowing Direct Sensing Near Ground
- Low Input Bias and Offset Parameters
  - Input Offset Voltage: 3 mV Typical
    A Versions: 2 mV Typical
  - Input Offset Current: 2 nA Typical
  - Input Bias Current: 20 nA Typical
    A Versions: 15 nA Typical
- Differential Input Voltage Range Equal to Maximum-Rated Supply Voltage: 32 V (26 V for LM2902)
- Open-Loop Differential Voltage Amplification: 100 V/mV Typical
- Internal Frequency Compensation
- On Products Compliant to MIL-PRF-38535, All Parameters are Tested Unless Otherwise Noted. On All Other Products, Production Processing Does Not Necessarily Include Testing of All Parameters.

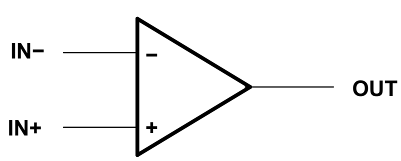
2 Applications

- Blu-ray Players and Home Theaters
- Chemical and Gas Sensors
- DVD Recorders and Players
- Digital Multimeter: Bench and Systems
- Digital Multimeter: Handhelds
- Field Transmitter: Temperature Sensors
- Motor Control: AC Induction, Brushed DC, Brushless DC, High-Voltage, Low-Voltage, Permanent Magnet, and Stepper Motor
- Oscilloscopes
- TV: LCD and Digital
- Temperature Sensors or Controllers Using Modbus
- Weigh Scales

3 Description

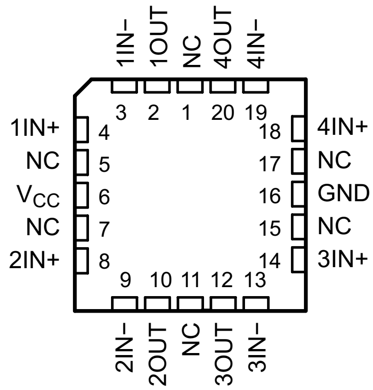
These devices consist of four independent high-gain frequency-compensated operational amplifiers that are designed specifically to operate from a single supply or split supply over a wide range of voltages.

Symbol (Each Amplifier)

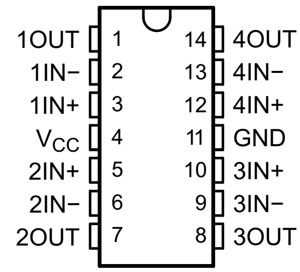


4 Pin Configuration and Functions

FK Package
20-Pin LCCC
(Top View)



D, DB, J, N, NS, PW, W
14-Pin SOIC, SSOP, CDIP, PDIP, SO, TSSOP, CFP
(Top View)



Pin Functions

PIN			I/O	DESCRIPTION
NAME	LCCC NO.	SOIC, SSOP, CDIP, PDIP, SO, TSSOP, CFP NO.		
1IN–	3	2	I	Negative input
1IN+	4	3	I	Positive input
1OUT	2	1	O	Output
2IN–	9	6	I	Negative input
2IN+	8	5	I	Positive input
2OUT	10	7	O	Output
3IN–	13	9	I	Negative input
3IN+	14	10	I	Positive input
3OUT	12	8	O	Output
4IN–	19	13	I	Negative input
4IN+	18	12	I	Positive input
4OUT	20	14	O	Output
GND	16	11	—	Ground
NC	1	—	—	Do not connect
	5			
	7			
	11			
	15			
	17			
V_{CC}	6	4	—	Power supply

5 Specifications

5.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)(1)

		LM2902		LMx24, LMx24x, LMx24xx, LM2902x, LM2902xx, LM2902xxx		UNIT
		MIN	MAX	MIN	MAX	
Supply voltage, V_{CC} (2)		±13	26	±16	32	V
Differential input voltage, V_{ID} (3)			±26		±32	V
Input voltage, V_I (either input)		–0.3	26	–0.3	to 32	V
Duration of output short circuit (one amplifier) to ground at (or below) T_A = 25°C, V_{CC} ≤ 15 V (4)		Unlimited		Unlimited		
Operating virtual junction temperature, T_J			150		150	°C
Case temperature for 60 seconds	FK package				260	°C
Lead temperature 1.6 mm (1/16 inch) from case for 60 seconds	J or W package		300		300	°C
Storage temperature, T_{stg}		–65	150	–65	150	°C

(1) 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.
(2) All voltage values (except differential voltages and V_{CC} specified for the measurement of I_{OS}) are with respect to the network GND.
(3) Differential voltages are at IN+, with respect to IN−.
(4) Short circuits from outputs to VCC can cause excessive heating and eventual destruction.

5.2 ESD Ratings

			VALUE	UNIT
LM224K, LM224KA, LM324K, LM324KA, LM2902K, LM2902KV, LM2902KAV				
$V_{(ESD)}$	Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 (1)	±2000	V
		Charged-device model (CDM), per JEDEC specification JESD22-C101	±1000	
LM124, LM124A, LM224, LM224A, LM324, LM324A, LM2902, LM2902V				
$V_{(ESD)}$	Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 (1)	±500	V
		Charged-device model (CDM), per JEDEC specification JESD22-C101	±1000	

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.

5.3 Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)

		LM2902		LMx24, LMx24x, LMx24xx, LM2902x, LM2902xx, LM2902xxx		UNIT
		MIN	MAX	MIN	MAX	
V_{CC} Supply voltage		3	26	3	30	V
V_{CM} Common-mode voltage		0	V_{CC} – 2	0	V_{CC} – 2	V
T_A Operating free air temperature	LM124			–55	125	°C
	LM2904	–40	125			
	LM324			0	70	
	LM224			–25	85	

5.4 Thermal Information

THERMAL METRIC(1)		LMx24, LM2902					LMx24			UNIT
		D (SOIC)	DB (SSOP)	N (PDIP)	NS (SO)	PW (TSSOP)	FK (LCCC)	J (CDIP)	W (CFP)	
		14 PINS	14 PINS	14 PINS	14 PINS	14 PINS	20 PINS	14 PINS	14 PINS	
$R_{θJA}$ (2)(3)	Junction-to-ambient thermal resistance	86	86	80	76	113	—	—	—	°C/W
$R_{θJC}$ (4)	Junction-to-case (top) thermal resistance	—	—	—	—	—	5.61	15.05	14.65	°C/W

(1) For more information about traditional and new thermal metrics, see the *IC Package Thermal Metrics* application report, SPRA953.
(2) Short circuits from outputs to VCC can cause excessive heating and eventual destruction.
(3) Maximum power dissipation is a function of $T_{J(max)}$, $R_{θJA}$, and T_A. The maximum allowable power dissipation at any allowable ambient temperature is $P_D = (T_{J(max)} – T_A)/R_{θJA}$. Operating at the absolute maximum T_J of 150°C can affect reliability.
(4) Maximum power dissipation is a function of $T_{J(max)}$, $R_{θJA}$, and T_C. The maximum allowable power dissipation at any allowable case temperature is $P_D = (T_{J(max)} – T_C)/R_{θJC}$. Operating at the absolute maximum T_J of 150°C can affect reliability.

5.5 Electrical Characteristics for LMx24 and LM324K

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

PARAMETER		TEST CONDITIONS(1)		T_A(2)	LM124, LM224			LM324, LM324K			UNIT
					MIN	TYP(3)	MAX	MIN	TYP(3)	MAX	
V_{IO}	Input offset voltage	V_{CC} = 5 V to MAX, $V_{IC} = V_{ICR}$min, V_O = 1.4 V		25°C		3	5		3	7	mV
				Full range			7			9	
I_{IO}	Input offset current	V_O = 1.4 V		25°C		2	30		2	50	nA
				Full range			100			150	
I_{IB}	Input bias current	V_O = 1.4 V		25°C		–20	–150		–20	–250	nA
				Full range			–300			–500	
V_{ICR}	Common-mode input voltage range	V_{CC} = 5 V to MAX		25°C	0 to V_{CC} – 1.5			0 to V_{CC} – 1.5			V
				Full range	0 to V_{CC} – 2			0 to V_{CC} – 2			
V_{OH}	High-level output voltage	R_L = 2 kΩ		25°C	V_{CC} – 1.5			V_{CC} – 1.5			V
		R_L = 10 kΩ		25°C							
		V_{CC} = MAX	R_L = 2 kΩ	Full range	26			26			
			R_L ≥ 10 kΩ	Full range	27	28		27	28		
V_{OL}	Low-level output voltage	R_L ≤ 10 kΩ		Full range		5	20		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	50	100		25	100		V/mV
				Full range	25			15			
CMRR	Common-mode rejection ratio	$V_{IC} = V_{ICR}$min		25°C	70	80		65	80		dB
k_{SVR}	Supply-voltage rejection ratio ($ΔV_{CC}$ /ΔVIO)			25°C	65	100		65	100		dB
V_{O1}/ V_{O2}	Crosstalk attenuation	f = 1 kHz to 20 kHz		25°C		120			120		dB
I_O	Output current	V_{CC} = 15 V, V_{ID} = 1 V, V_O = 0	Source	25°C	–20	–30	–60	–20	–30	–60	mA
				Full range	–10			–10			
		V_{CC} = 15 V, V_{ID} = –1 V, V_O = 15 V	Sink	25°C	10	20		10	20		
				Full range	5			5			
		V_{ID} = –1 V, V_O = 200 mV		25°C	12	30		12	30		μA
I_{OS}	Short-circuit output current	V_{CC} at 5 V, V_O = 0, GND at –5 V		25°C		±40	±60		±40	±60	mA
I_{CC}	Supply current (four amplifiers)	V_O = 2.5 V, no load		Full range		0.7	1.2		0.7	1.2	mA
		V_{CC} = MAX, V_O = 0.5 V_{CC}, no load		Full range		1.4	3		1.4	3	

(1) 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 LM2902 and 30 V for the others.
(2) Full range is –55°C to 125°C for LM124, –25°C to 85°C for LM224, and 0°C to 70°C for LM324.
(3) All typical values are at T_A = 25°C

Electrical Characteristics for LMx24A and LM324KA (continued)

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

PARAMETER		TEST CONDITIONS[(1)]		T_A[(2)]	LM124A			LM224A			LM324A, LM324KA			UNIT
					MIN	TYP[(3)]	MAX	MIN	TYP[(3)]	MAX	MIN	TYP[(3)]	MAX	
V_{ICR}	Common-mode input voltage range	V_{CC} = 30 V		25°C	0 to V_{CC} − 1.5			0 to V_{CC} − 1.5			0 to V_{CC} − 1.5			V
				Full range	0 to V_{CC} − 2			0 to V_{CC} − 2			0 to V_{CC} − 2			
V_{OH}	High-level output voltage	R_L = 2 kΩ		25°C	V_{CC} − 1.5			V_{CC} − 1.5			V_{CC} − 1.5			V
		V_{CC} = 30 V	R_L= 2 kΩ	Full range	26			26			26			
			R_L≥ 10 kΩ	Full range	27			27	28		27	28		
V_{OL}	Low-level output voltage	R_L ≤ 10 kΩ		Full range			20		5	20		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	50	100		50	100		25	100		V/mV
				Full range	25			25			15			
CMRR	Common-mode rejection ratio	V_{IC} = V_{ICR}min		25°C	70			70	80		65	80		dB
k_{SVR}	Supply-voltage rejection ratio (ΔV_{CC} /ΔV_{IO})			25°C	65			65	100		65	100		dB
V_{O1}/ V_{O2}	Crosstalk attenuation	f = 1 kHz to 20 kHz		25°C		120			120			120		dB
I_O	Output current	V_{CC} = 15 V, V_{ID} = 1 V, V_O = 0	Source	25°C	–20			–20	–30	–60	–20	–30	–60	mA
				Full range	–10			–10			–10			
		V_{CC} = 15 V, V_{ID} = –1 V, V_O = 15 V	Sink	25°C	10			10	20		1	20		
				Full range	5			5			5			
		V_{ID} = −1 V, V_O = 200 mV		25°C	12			12	30		12	30		μA
I_{OS}	Short-circuit output current	V_{CC} at 5 V, GND at –5 V, V_O = 0		25°C		±40	±60		±40	±60		±40	±60	mA
I_{CC}	Supply current (four amplifiers)	V_O = 2.5 V, no load		Full range		0.7	1.2		0.7	1.2		0.7	1.2	mA
		V_{CC} = 30 V, V_O = 15 V, no load		Full range		1.4	3.		1.4	3		1.4	3	

5.6 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 7)	0.5	V/μs
B_1	Unity-gain bandwidth	R_L = 1 MΩ, C_L = 20 pF (see Figure 7)	1.2	MHz
V_n	Equivalent input noise voltage	R_S = 100 Ω, V_I = 0 V, f = 1 kHz (see Figure 8)	35	nV/√Hz

5.7 Typical Characteristics

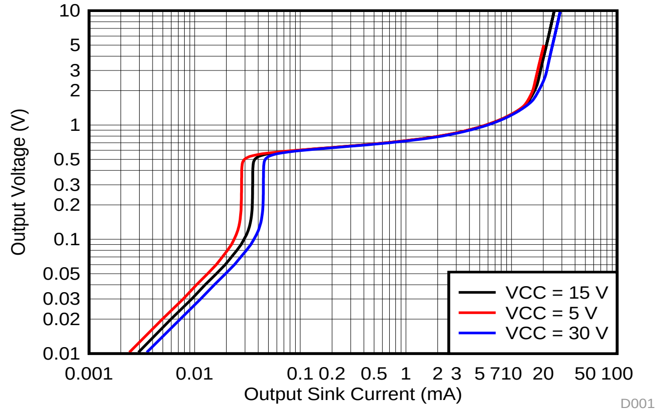


Figure 1. Output Sinking Characteristics

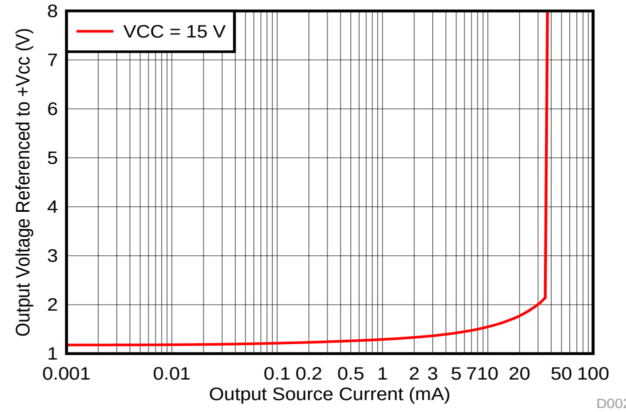


Figure 2. Output Sourcing Characteristics

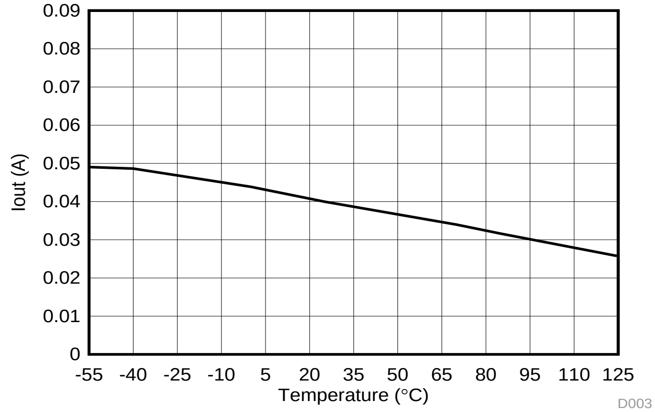


Figure 3. Source Current Limiting

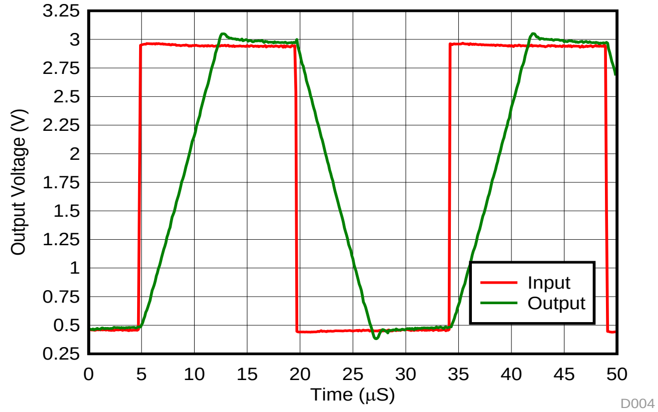


Figure 4. Voltage Follower Large Signal Response (50 pF)

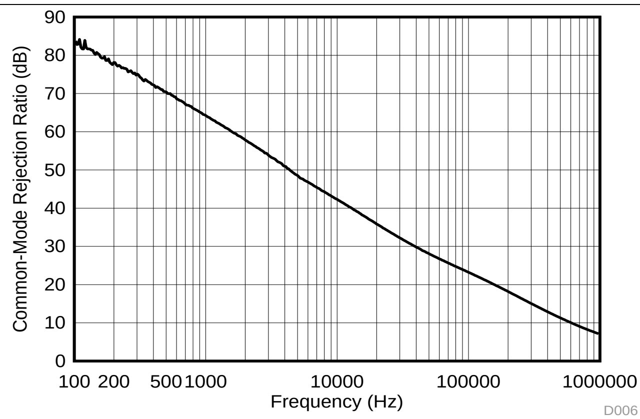


Figure 5. Common-Mode Rejection Ratio

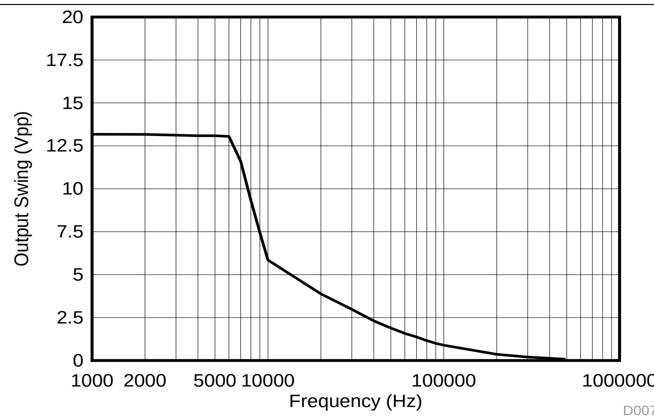


Figure 6. Maximum Output Swing vs. Frequency (VCC = 15 V)

6 Parameter Measurement Information

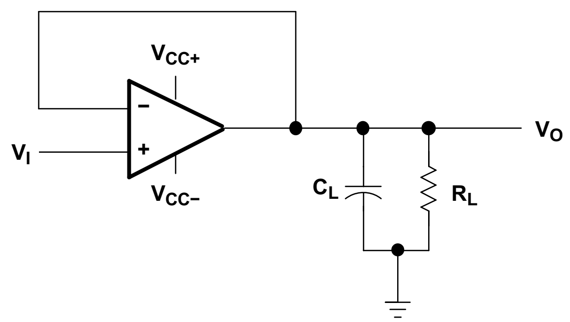


Figure 7. Unity-Gain Amplifier

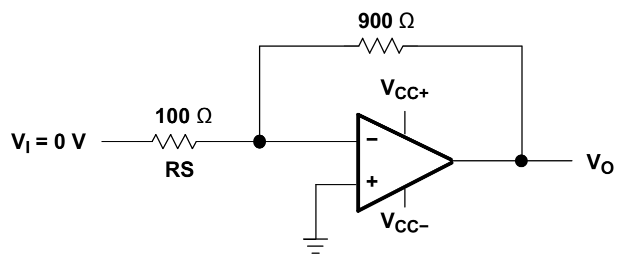


Figure 8. Noise-Test Circuit

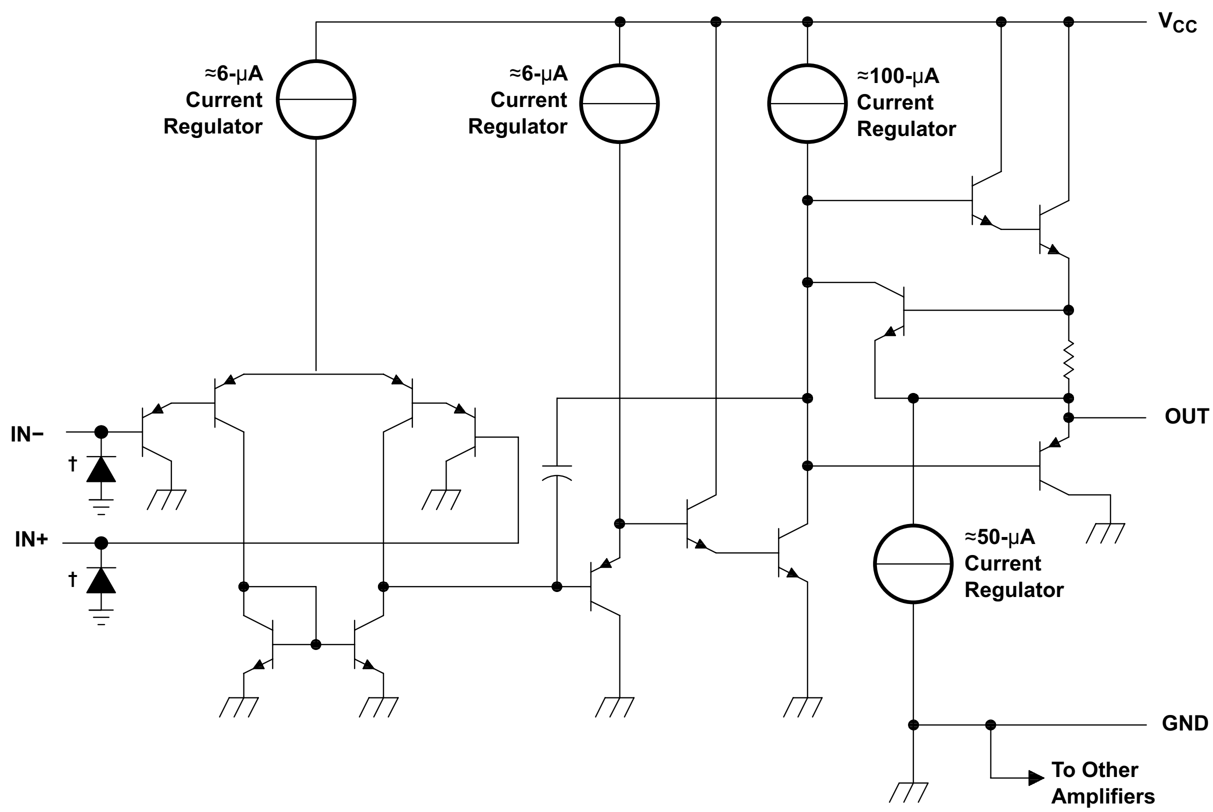
7 Detailed Description

7.1 Overview

These devices consist of four independent high-gain frequency-compensated operational amplifiers that are designed specifically to operate from a single supply over a wide range of voltages. Operation from split supplies also is possible if the difference between the two supplies is 3 V to 32 V (3 V to 26 V for the LM2902 device), 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 more easily implemented in single-supply-voltage systems. For example, the LM124 device can be operated directly from the standard 5-V supply that is used in digital systems and provides the required interface electronics, without requiring additional ±15-V supplies.

7.2 Functional Block Diagram



COMPONENT COUNT (total device)	
Epi-FET	1
Transistors	95
Diodes	4
Resistors	11
Capacitors	4

† ESD protection cells - available on LM324K and LM324KA only

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