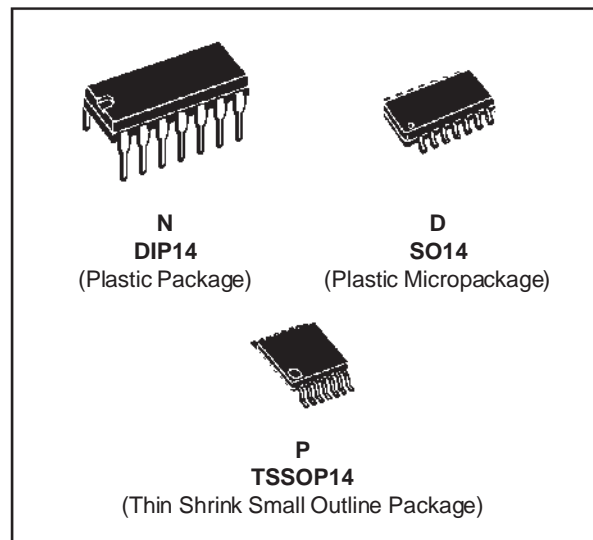




LM124 LM224 - LM324

LOW POWER QUAD OPERATIONAL AMPLIFIERS

- WIDE GAIN BANDWIDTH : 1.3MHz
- INPUT COMMON-MODE VOLTAGE RANGE INCLUDES GROUND
- LARGE VOLTAGE GAIN : 100dB
- VERY LOW SUPPLY CURRENT/AMPLI : 375 μ A
- LOW INPUT BIAS CURRENT : 20nA
- LOW INPUT OFFSET VOLTAGE : 5mV max.
(for more accurate applications, use the equivalent parts LM124A-LM224A-LM324A which feature 3mV max)
- LOW INPUT OFFSET CURRENT : 2nA
- WIDE POWER SUPPLY RANGE :
SINGLE SUPPLY : +3V TO +30V
DUAL SUPPLIES : \pm 1.5V TO \pm 15V



DESCRIPTION

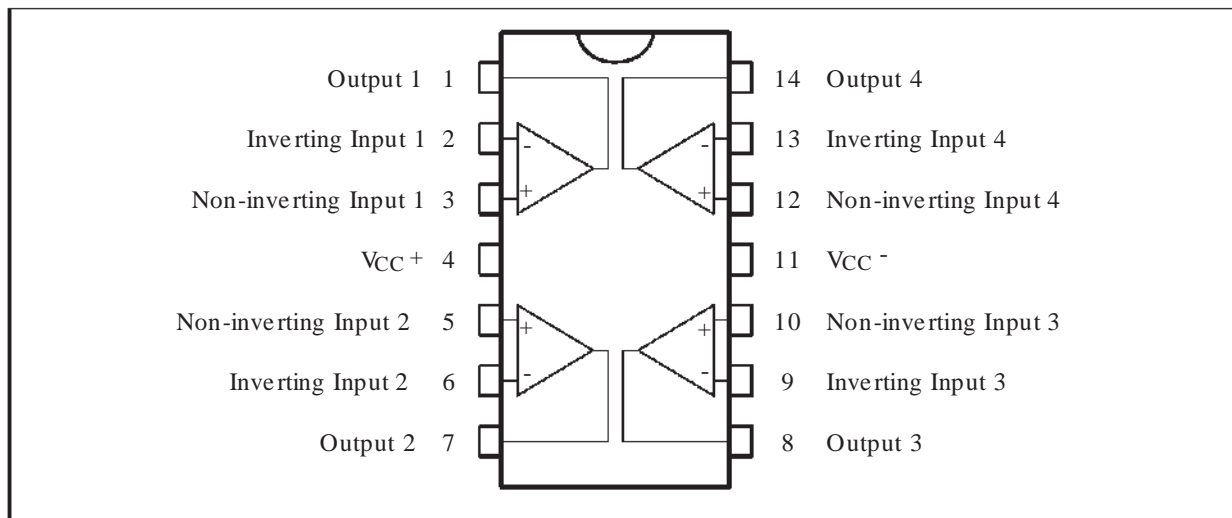
These circuits consist of four independent, high gain, internally frequency compensated operational amplifiers. They operate from a single power supply over a wide range of voltages. Operation from split power supplies is also possible and the low power supply current drain is independent of the magnitude of the power supply voltage.

ORDER CODES

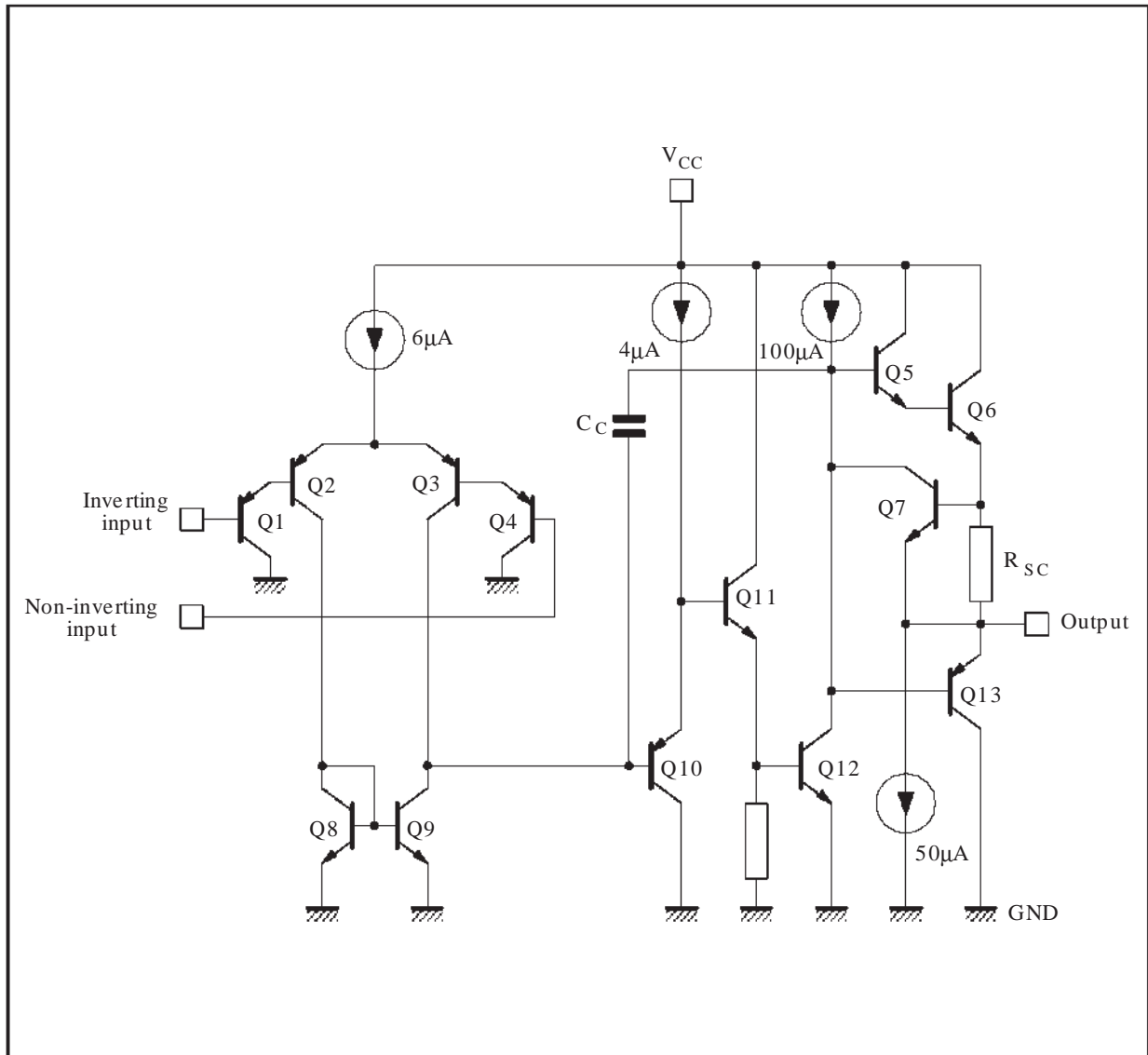
Part Number	Temperature Range	Package		
		N	D	P
LM124	-55°C, +125°C	•	•	•
LM224	-40°C, +105°C	•	•	•
LM324	0°C, +70°C	•	•	•

Example : LM224N

PIN CONNECTIONS (top view)



SCHEMATIC DIAGRAM (1/4 LM124)



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	LM124	LM224	LM324	Unit
V_{cc}	Supply Voltage	±16 or 32			V
V_i	Input Voltage	-0.3 to +32			V
V_{id}	Differential Input Voltage - (*)	+32	+32	+32	V
P_{tot}	Power Dissipation	500	500	500	mW
		N Suffix	400	400	mW
-	Output Short-circuit Duration - (note 1)	Infinite			
I_{in}	Input Current - (note 6)	50	50	50	mA
T_{oper}	Operating Free Air Temperature Range	-55 to +125	-40 to +105	0 to +70	°C
T_{stg}	Storage Temperature Range	-65 to +150	-65 to +150	-65 to +150	°C

ELECTRICAL CHARACTERISTICS

$V_{CC}^+ = +5V$, $V_{CC}^- = \text{Ground}$, $V_O = 1.4V$, $T_{amb} = +25^\circ C$ (unless otherwise specified)

Symbol	Parameter	LM124 - LM224 - LM324			Unit
		Min.	Typ.	Max.	
V_{io}	Input Offset Voltage (note 3) $T_{amb} = +25^\circ C$ LM324 $T_{min.} \leq T_{amb} \leq T_{max.}$ LM324		2	5 7 7 9	mV
I_{io}	Input Offset Current $T_{amb} = +25^\circ C$ $T_{min.} \leq T_{amb} \leq T_{max.}$		2	30 100	nA
I_{ib}	Input Bias Current (note 2) $T_{amb} = +25^\circ C$ $T_{min.} \leq T_{amb} \leq T_{max.}$		20	150 300	nA
A_{vd}	Large Signal Voltage Gain ($V_{CC}^+ = +15V$, $R_L = 2k\Omega$, $V_O = 1.4V$ to $11.4V$) $T_{amb} = +25^\circ C$ $T_{min.} \leq T_{amb} \leq T_{max.}$	50 25	100		V/mV
SVR	Supply Voltage Rejection Ratio ($R_S \leq 10k\Omega$) ($V_{CC}^+ = 5V$ to $30V$) $T_{amb} = +25^\circ C$ $T_{min.} \leq T_{amb} \leq T_{max.}$	65 65	110		dB
I_{CC}	Supply Current, all Amp, no load $T_{amb} = +25^\circ C$ $T_{min.} \leq T_{amb} \leq T_{max.}$		$V_{CC} = +5V$ 0.7 $V_{CC} = +30V$ 1.5 $V_{CC} = +5V$ 0.8 $V_{CC} = +30V$ 1.5	1.2 3 1.2 3	mA
V_{icm}	Input Common Mode Voltage Range ($V_{CC} = +30V$) - (note 4) $T_{amb} = +25^\circ C$ $T_{min.} \leq T_{amb} \leq T_{max.}$	0 0		$V_{CC} - 1.5$ $V_{CC} - 2$	V
CMR	Common-mode Rejection Ratio ($R_S \leq 10k\Omega$) $T_{amb} = +25^\circ C$ $T_{min.} \leq T_{amb} \leq T_{max.}$	70 60	80		dB
I_{source}	Output Current Source ($V_{id} = +1V$) $V_{CC} = +15V$, $V_o = +2V$	20	40	70	mA
I_{sink}	Output Sink Current ($V_{id} = -1V$) $V_{CC} = +15V$, $V_o = +2V$ $V_{CC} = +15V$, $V_o = +0.2V$	10 12	20 50		mA μA

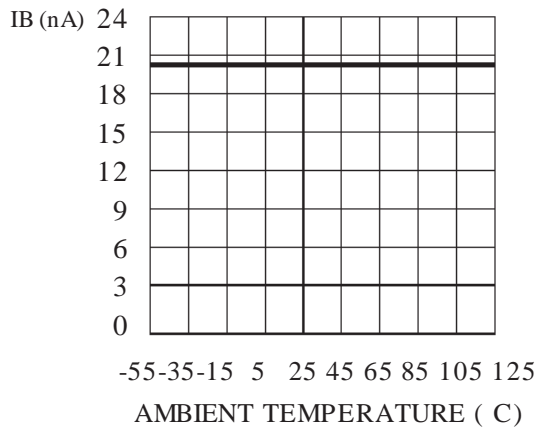
ELECTRICAL CHARACTERISTICS (continued)

Symbol	Parameter	LM124 - LM224 - LM324			Unit
		Min.	Typ.	Max.	
V _{OH}	High Level Output Voltage (V _{CC} = +30V) T _{amb} = +25°C T _{min.} ≤ T _{amb} ≤ T _{max.} R _L = 2kΩ	26	27		V
		26			
		27	28		
		27			
V _{OL}	Low Level Output Voltage (R _L = 10kΩ) T _{amb} = +25°C T _{min.} ≤ T _{amb} ≤ T _{max.}		5	20	mV
				20	
SR	Slew Rate V _{CC} = 15V, V _I = 0.5 to 3V, R _L = 2kΩ, C _L = 100pF, unity gain)		0.4		V/μs
GBP	Gain Bandwidth Product V _{CC} = 30V, f = 100kHz, V _{in} = 10mV R _L = 2kΩ, C _L = 100pF		1.3		MHz
THD	Total Harmonic Distortion f = 1kHz, A _V = 20dB, R _L = 2kΩ, V _O = 2V _{pp} C _L = 100pF, V _{CC} = 30V		0.015		%
e _n	Equivalent Input Noise Voltage f = 1kHz, R _s = 100Ω, V _{CC} = 30V		40		$\frac{nV}{\sqrt{Hz}}$
DV _{io}	Input Offset Voltage Drift		7	30	μV/°C
DI _{IO}	Input Offset Current Drift		10	200	pA/°C
V _{O1} /V _{O2}	Channel Separation (note 5) 1kHz ≤ f ≤ 20kHz		120		dB

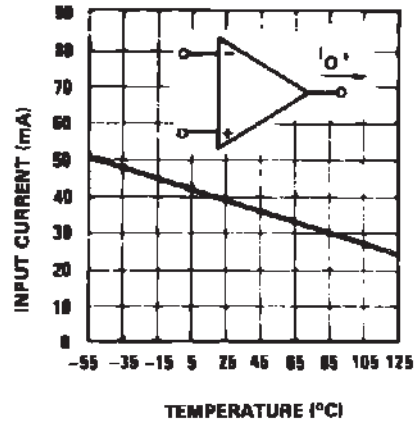
- Notes :**
- Short-circuits from the output to V_{CC} can cause excessive heating if V_{CC} > 15V. The maximum output current is approximately 40mA independent of the magnitude of V_{CC}. Destructive dissipation can result from simultaneous short-circuit on all amplifiers.
 - The direction of the input current is out of the IC. This current is essentially constant, independent of the state of the output so no loading change exists on the input lines.
 - V_o = 1.4V, R_s = 0Ω, 5V < V_{CC} < 30V, 0 < V_{ic} < V_{CC} - 1.5V
 - The input common-mode voltage of either input signal voltage should not be allowed to go negative by more than 0.3V. The upper end of the common-mode voltage range is V_{CC} - 1.5V, but either or both inputs can go to +32V without damage.
 - Due to the proximity of external components insure that coupling is not originating via stray capacitance between these external parts. This typically can be detected as this type of capacitance increases at higher frequencies.
 - This input current only exists when the voltage at any of the input leads is driven negative. It is due to the collector-base junction of the input PNP transistor becoming forward biased and thereby acting as input diodes clamps. In addition to this diode action, there is also NPN parasitic action on the IC chip. this transistor action can cause the output voltages of the Op-amps to go to the V_{CC} voltage level (or to ground for a large overdrive) for the time duration than an input is driven negative.
This is not destructive and normal output will set up again for input voltage higher than -0.3V.



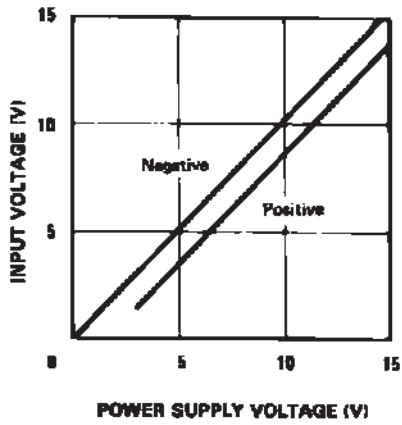
INPUT BIAS CURRENT
versus AMBIENT TEMPERATURE



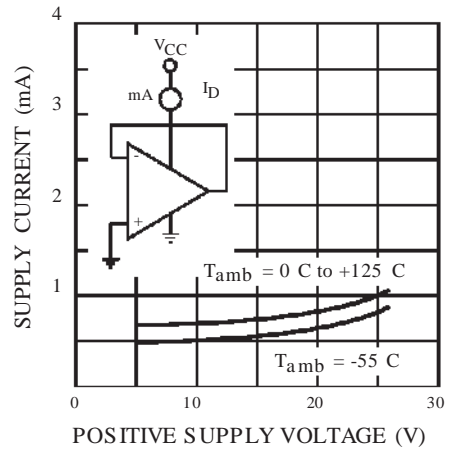
CURRENT LIMITING (Note 6)



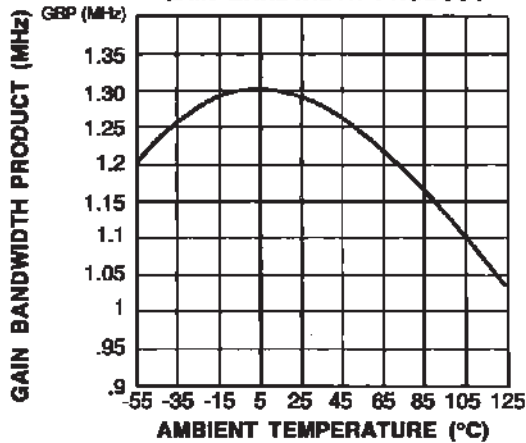
INPUT VOLTAGE RANGE



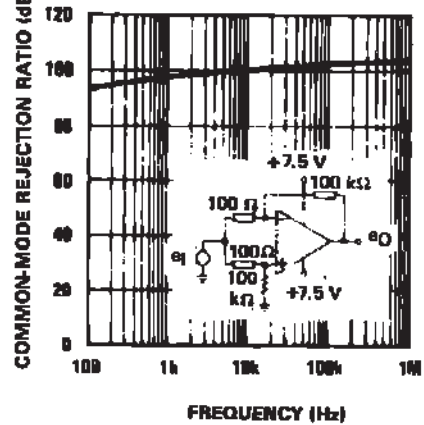
SUPPLY CURRENT



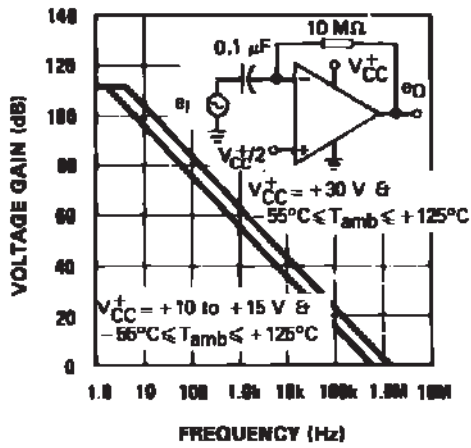
GAIN BANDWIDTH PRODUCT



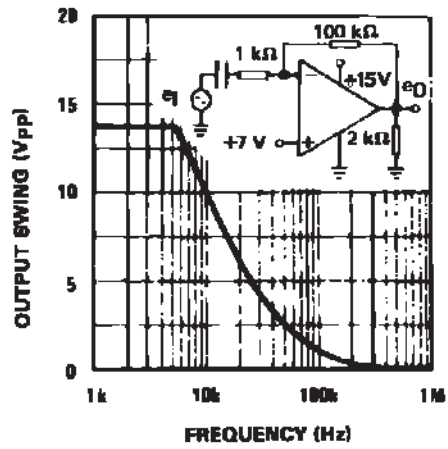
COMMON-MODE REJECTION RATIO



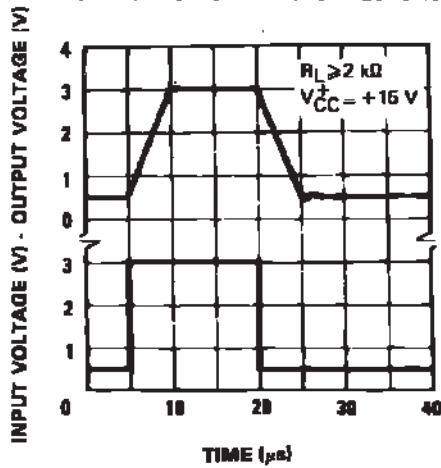
OPEN LOOP FREQUENCY RESPONSE



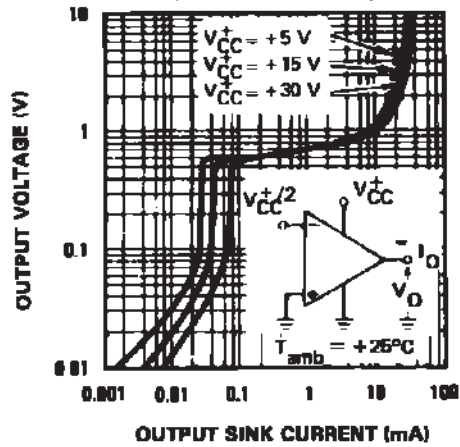
LARGE SIGNAL FREQUENCY RESPONSE



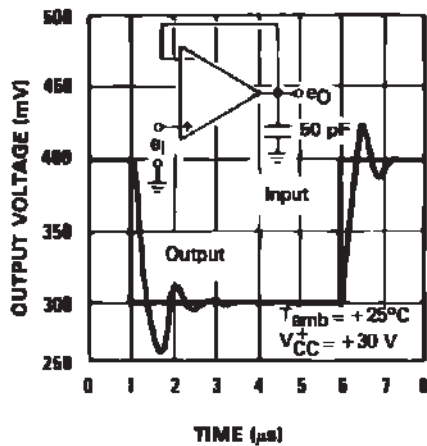
VOLTAGE FOLLOWER PULSE RESPONSE



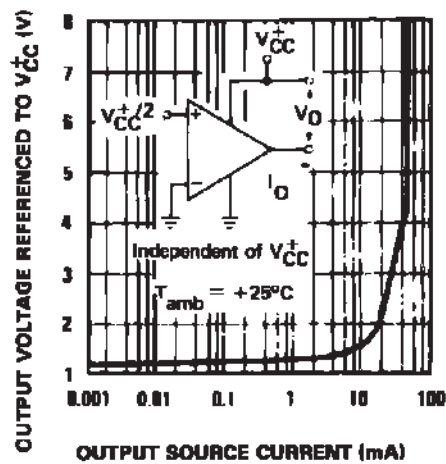
OUTPUT CHARACTERISTICS (CURRENT SINKING)

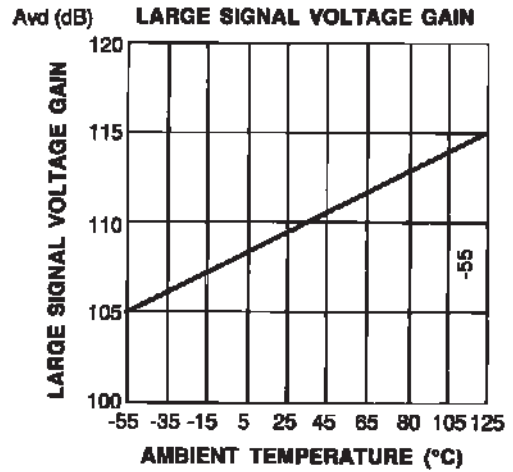
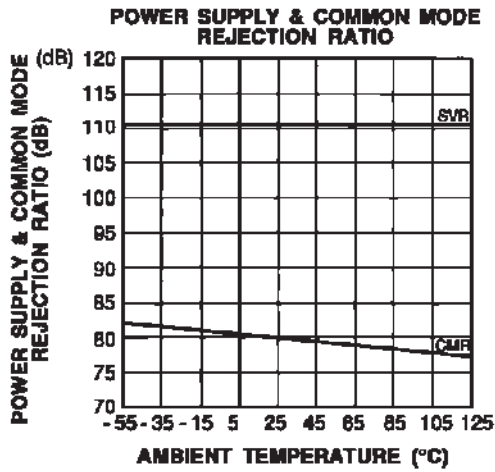
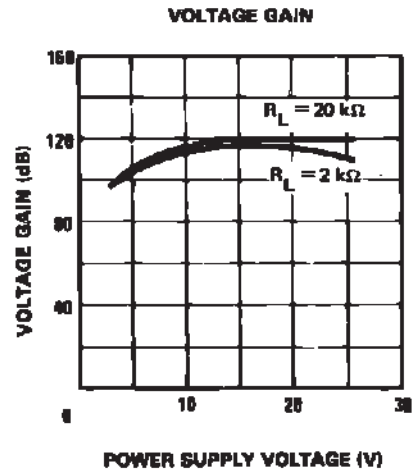
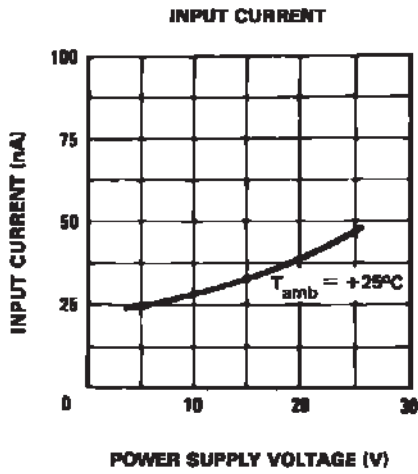


VOLTAGE FOLLOWER PULSE RESPONSE (SMALL SIGNAL)



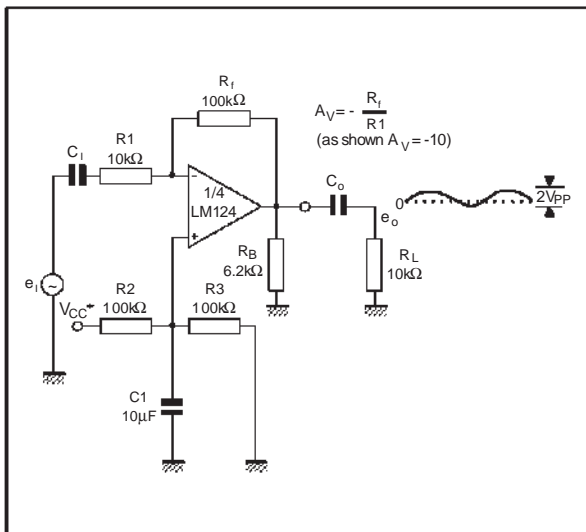
OUTPUT CHARACTERISTICS (CURRENT SOURCING)



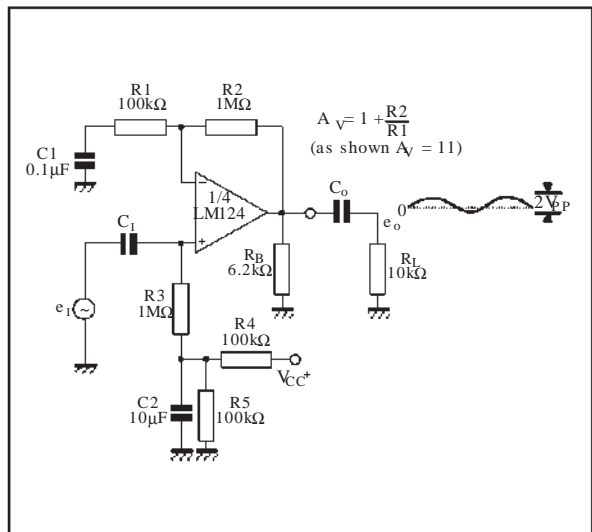


TYPICAL SINGLE - SUPPLY APPLICATIONS

AC COUPLED INVERTING AMPLIFIER

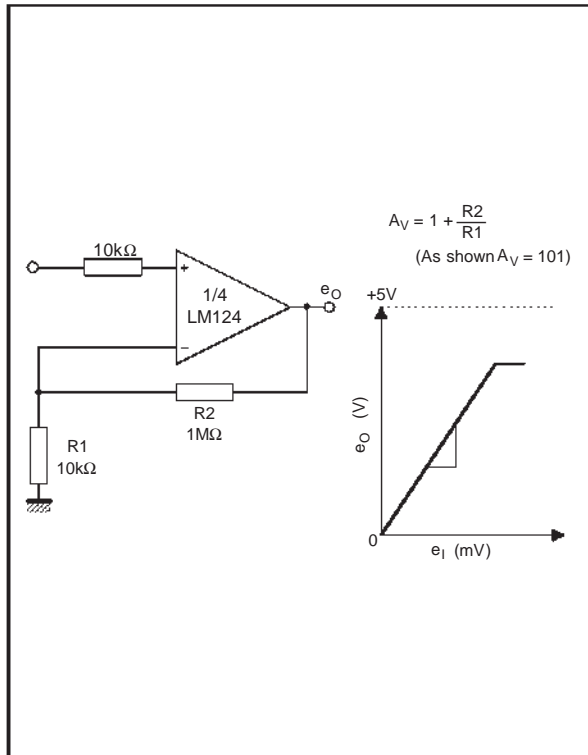


AC COUPLED NON-INVERTING AMPLIFIER

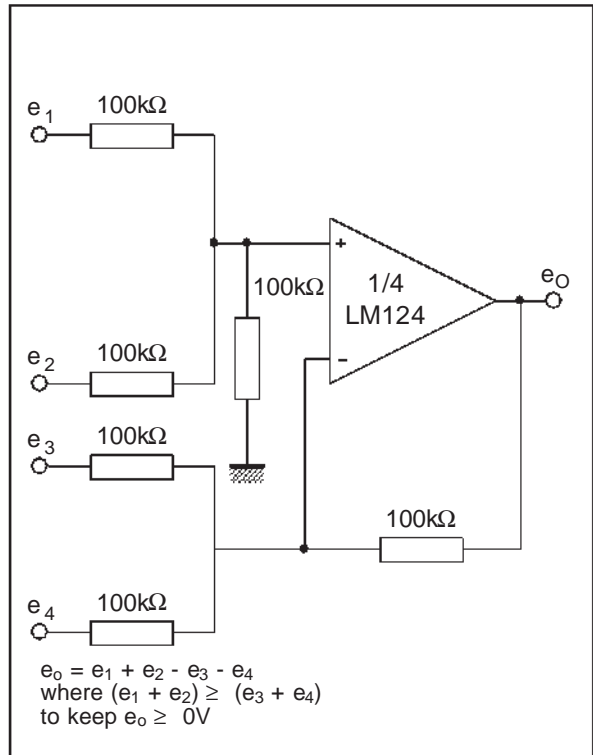


TYPICAL SINGLE - SUPPLY APPLICATIONS

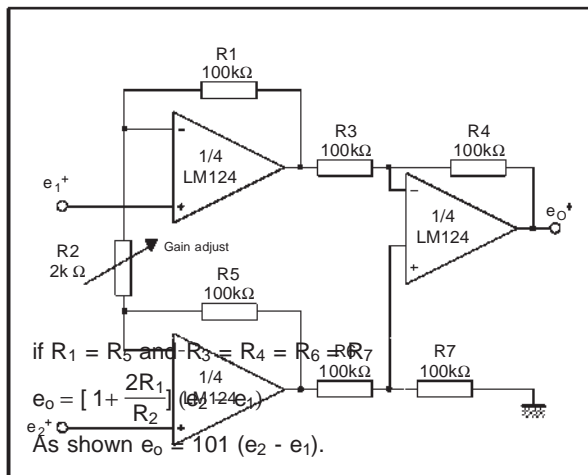
NON-INVERTING DC GAIN



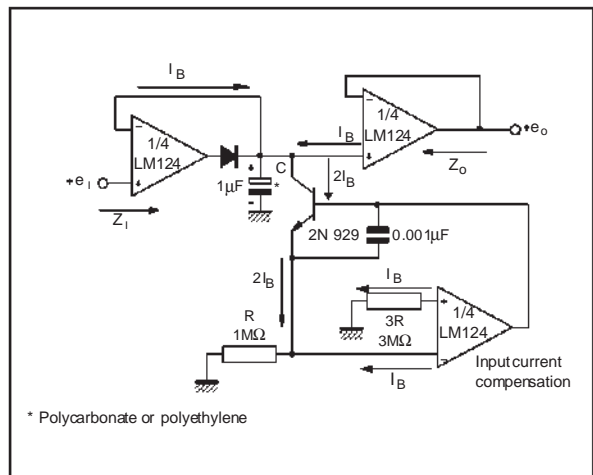
DC SUMMING AMPLIFIER



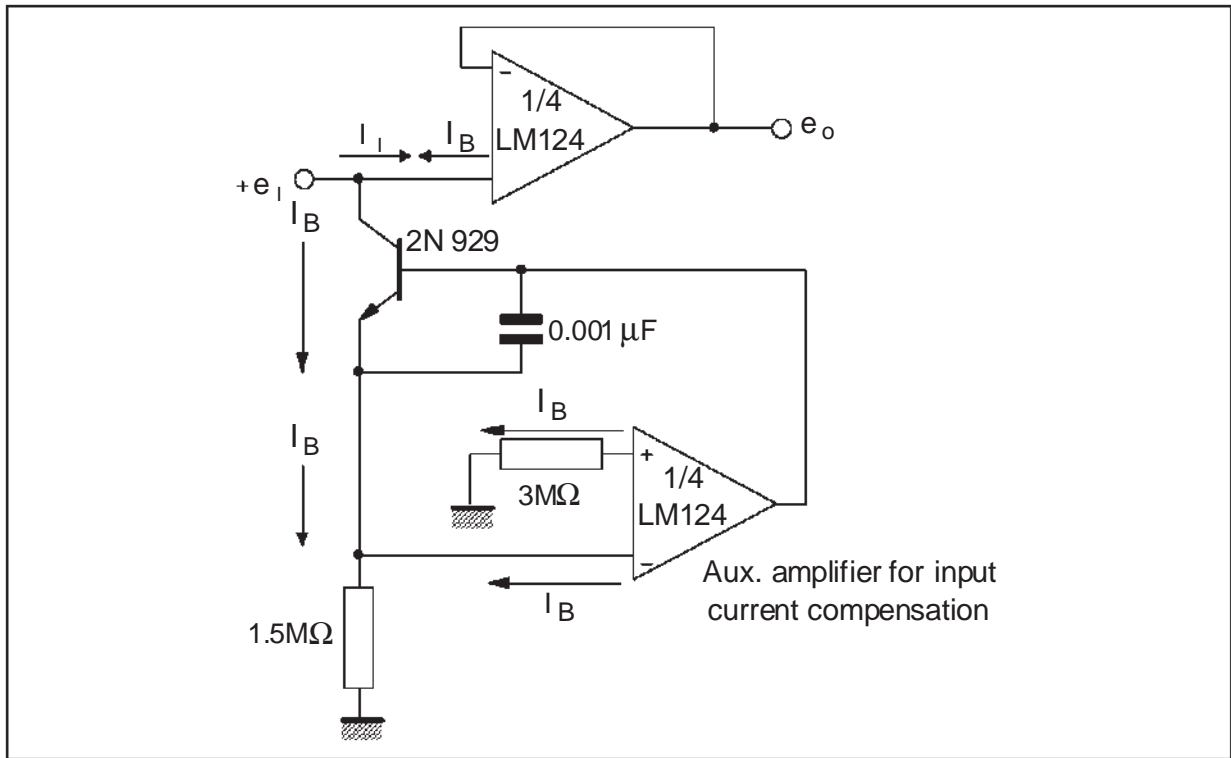
HIGH INPUT Z ADJUSTABLE GAIN DC INSTRUMENTATION AMPLIFIER



LOW DRIFT PEAK DETECTOR

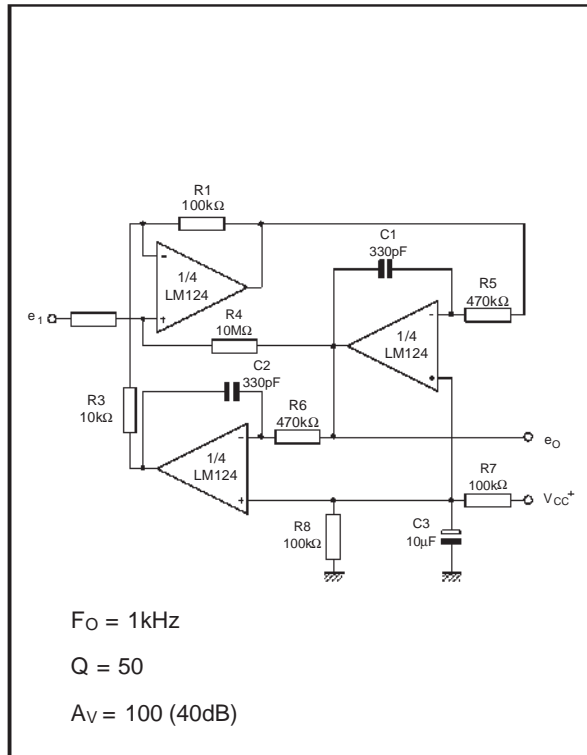


USING SYMMETRICAL AMPLIFIERS TO REDUCE INPUT CURRENT (GENERAL CONCEPT)

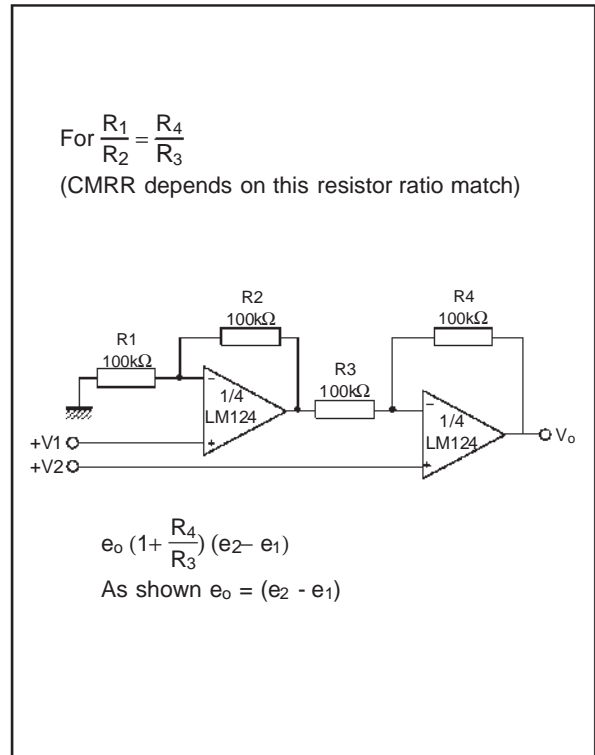


TYPICAL SINGLE - SUPPLY APPLICATIONS

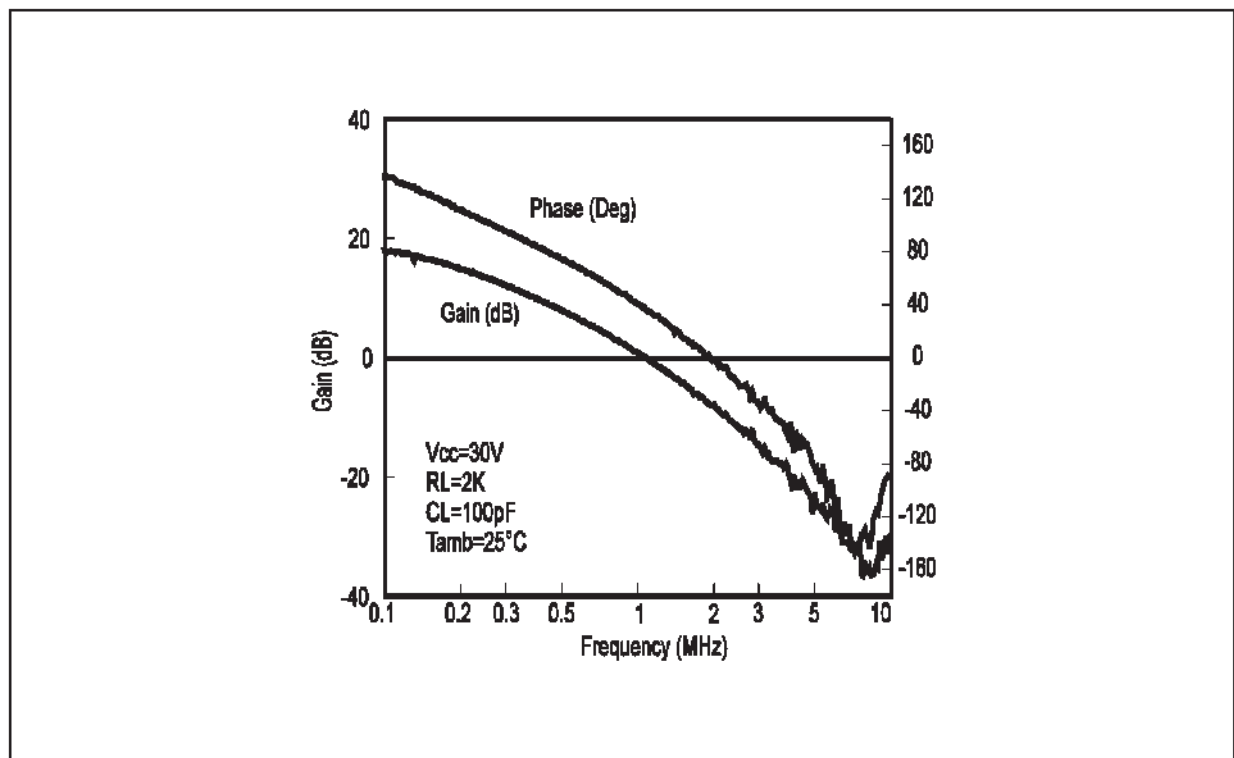
ACTIVER BANDPASS FILTER



HIGH INPUT Z, DC DIFFERENTIAL AMPLIFIER



VOLTAGE GAIN AND PHASE vs FREQUENCY



- LARGE VOLTAGE GAIN : 100dB
- VERY LOW SUPPLY CURRENT/AMPLI : 375µA
- LOW INPUT BIAS CURRENT : 20nA
- LOW INPUT OFFSET VOLTAGE : 2mV
- LOW INPUT OFFSET CURRENT : 2nA
- WIDE POWER SUPPLY RANGE :
SINGLE SUPPLY : +3V to +30V
DUAL SUPPLIES : ±1.5V to ±15V

Applies to : LM124-LM224-LM324

** Standard Linear Ics Macromodels, 1993.

** CONNECTIONS :

- * 1 INVERTING INPUT
- * 2 NON-INVERTING INPUT
- * 3 OUTPUT
- * 4 POSITIVE POWER SUPPLY
- * 5 NEGATIVE POWER SUPPLY

.SUBCKT LM124 1 3 2 4 5 (analog)

.MODEL MDTH D IS=1E-8 KF=3.104131E-15
CJO=10F

* INPUT STAGE

CIP 2 5 1.000000E-12

CIN 1 5 1.000000E-12

EIP 10 5 2 5 1

EIN 16 5 1 5 1

RIP 10 11 2.600000E+01

RIN 15 16 2.600000E+01

RIS 11 15 2.003862E+02

DIP 11 12 MDTH 400E-12

DIN 15 14 MDTH 400E-12

VOFP 12 13 DC 0

VOFN 13 14 DC 0

IPOL 13 5 1.000000E-05

CPS 11 15 3.783376E-09

DINN 17 13 MDTH 400E-12

VIN 17 5 0.000000E+00

DINR 15 18 MDTH 400E-12

VIP 4 18 2.000000E+00

FCP 4 5 VOFP 3.400000E+01

FCN 5 4 VOFN 3.400000E+01

FIBP 2 5 VOFN 2.000000E-03

FIBN 5 1 VOFP 2.000000E-03

* AMPLIFYING STAGE

FIP 5 19 VOFP 3.600000E+02

FIN 5 19 VOFN 3.600000E+02

RG1 19 5 3.652997E+06

RG2 19 4 3.652997E+06

CC 19 5 6.000000E-09

DOPM 19 22 MDTH 400E-12

DONM 21 19 MDTH 400E-12

HOPM 22 28 VOUT 7.500000E+03

VIPM 28 4 1.500000E+02

HONM 21 27 VOUT 7.500000E+03

VINM 5 27 1.500000E+02

EOUT 26 23 19 5 1

VOUT 23 5 0

ROUT 26 3 20

COUT 3 5 1.000000E-12

DOP 19 25 MDTH 400E-12

VOP 4 25 2.242230E+00

DON 24 19 MDTH 400E-12

VON 24 5 7.922301E-01

.ENDS

ELECTRICAL CHARACTERISTICS

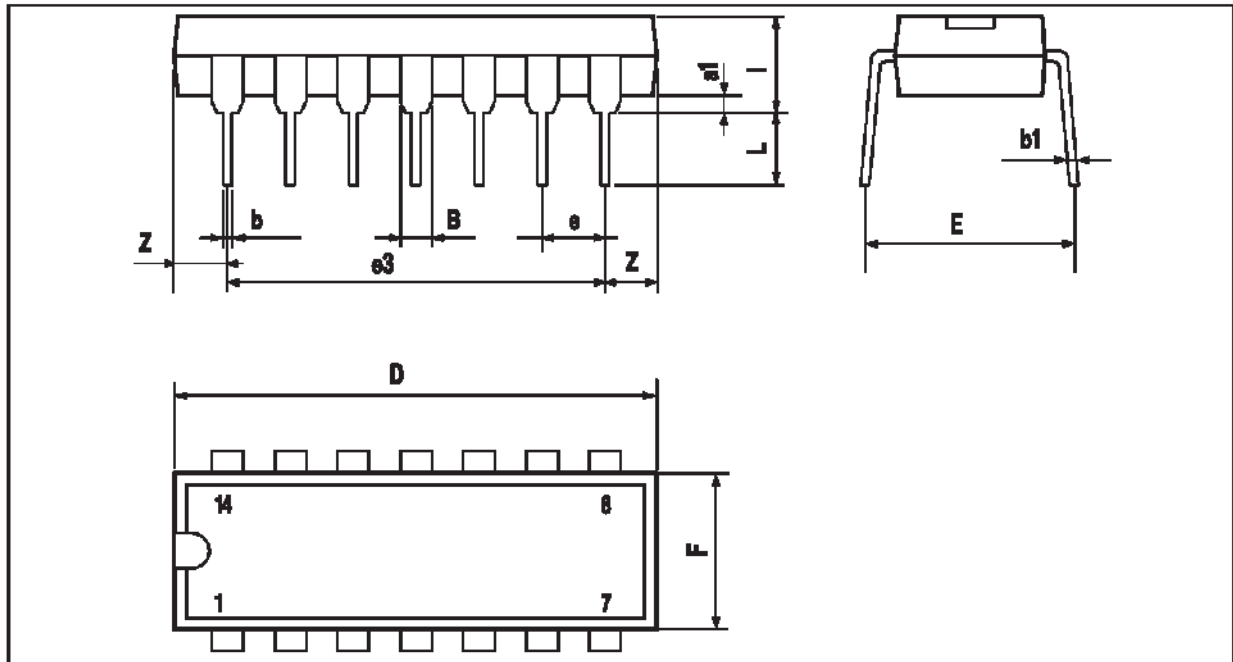
V_{CC}⁺ = +5V, V_{CC}⁻ = 0V, T_{amb} = 25°C (unless otherwise specified)

Symbol	Conditions	Value	Unit
V _{io}		0	mV
A _{vd}	R _L = 2kΩ	100	V/mV
I _{CC}	No load, per operator	350	µA
V _{icm}		-15 to +13.5	V
V _{OH}	R _L = 2kΩ (V _{CC} ⁺ = 15V)	+13.5	V
V _{OL}	R _L = 10kΩ	5	mV
I _{OS}	V _O = +2V, V _{CC} = +15V	+40	mA
GBP	R _L = 2kΩ, C _L = 100pF	1.3	MHz
SR	R _L = 2kΩ, C _L = 100pF	0.4	V/µs



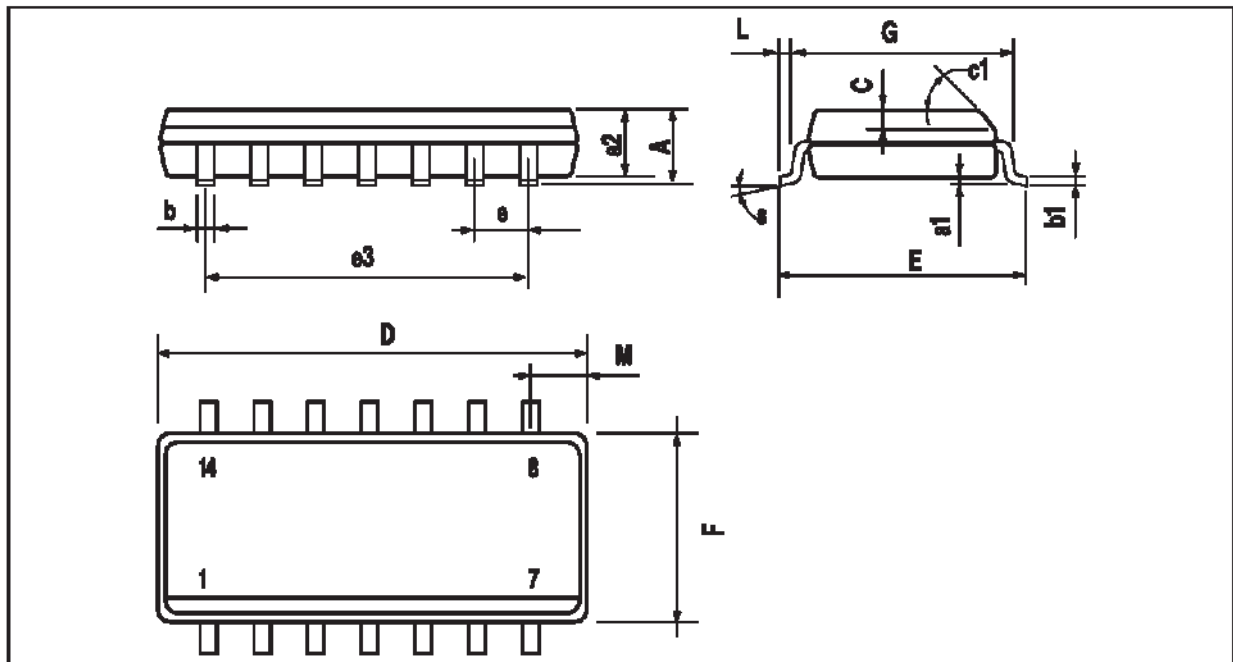
LM124 - LM224 - LM324

PACKAGE MECHANICAL DATA
14 PINS - PLASTIC DIP



Dimensions	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
a1	0.51			0.020		
B	1.39		1.65	0.055		0.065
b		0.5			0.020	
b1		0.25			0.010	
D			20			0.787
E		8.5			0.335	
e		2.54			0.100	
e3		15.24			0.600	
F			7.1			0.280
i			5.1			0.201
L		3.3			0.130	
Z	1.27		2.54	0.050		0.100

PACKAGE MECHANICAL DATA
14 PINS - PLASTIC MICROPACKAGE (SO)

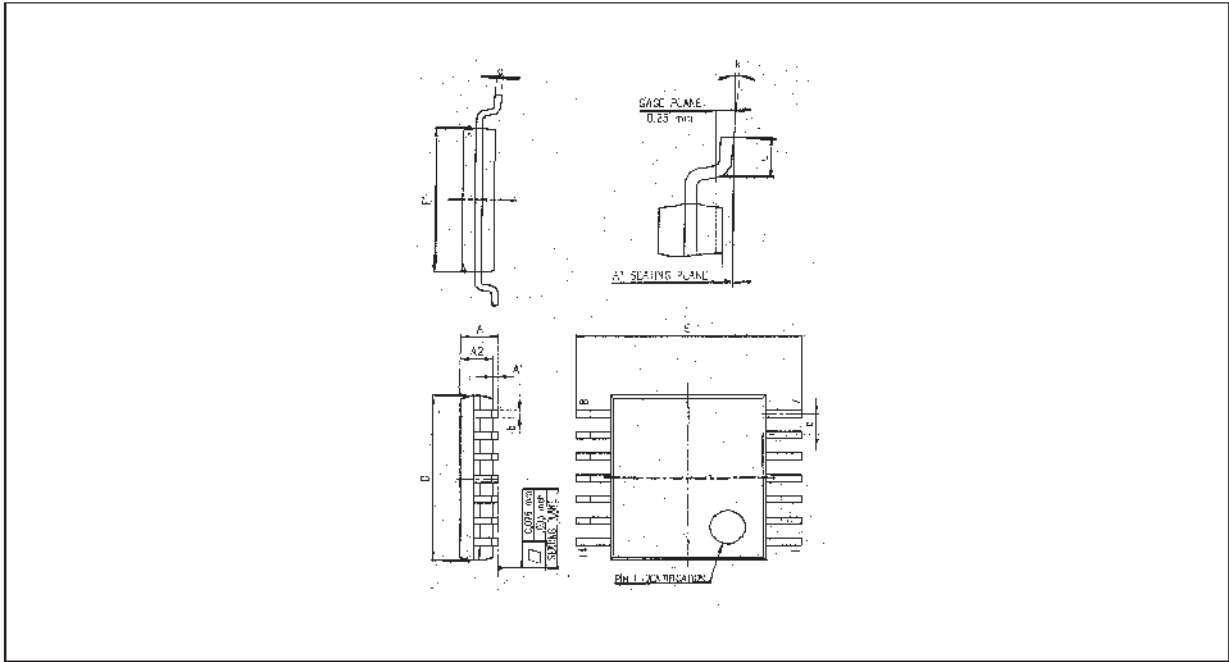


PM-S014.EPS

Dimensions	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.75			0.069
a1	0.1		0.2	0.004		0.008
a2			1.6			0.063
b	0.35		0.46	0.014		0.018
b1	0.19		0.25	0.007		0.010
C		0.5			0.020	
c1	45° (typ.)					
D	8.55		8.75	0.336		0.334
E	5.8		6.2	0.228		0.244
e		1.27			0.050	
e3		7.62			0.300	
F	3.8		4.0	0.150		0.157
G	4.6		5.3	0.181		0.208
L	0.5		1.27	0.020		0.050
M			0.68			0.027
S	8° (max.)					

SO14.TBL

PACKAGE MECHANICAL DATA
 14 PINS - THIN SHRINK SMALL OUTLINE PACKAGE



Dim.	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.20			0.05
A1	0.05		0.15	0.01		0.006
A2	0.80	1.00	1.05	0.031	0.039	0.041
b	0.19		0.30	0.007		0.15
c	0.09		0.20	0.003		0.012
D	4.90	5.00	5.10	0.192	0.196	0.20
E		6.40			0.252	
E1	4.30	4.40	4.50	0.169	0.173	0.177
e		0.65			0.025	
k	0°		8°	0°		8°
l	0.50	0.60	0.75	0.09	0.0236	0.030

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LM124, LM124A, LM224, LM224A, LM324, LM324A, LM2902, LM2902V, LM224K, LM224KA, LM324K, LM324KA, LM2902K, LM2902KV, LM2902KAV QUADRUPLE OPERATIONAL AMPLIFIERS

SLOS066R – SEPTEMBER 1975 – REVISED JANUARY 2005

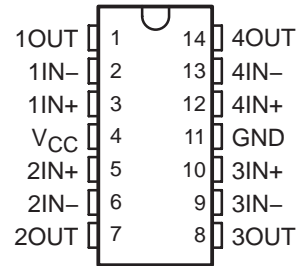
- **2-kV ESD Protection for:**
 - LM224K, LM224KA
 - LM324K, LM324KA
 - LM2902K, LM2902KV, LM2902KAV
- **Wide Supply Ranges**
 - Single Supply . . . 3 V to 32 V
(26 V for LM2902)
 - Dual Supplies . . . ± 1.5 V to ± 16 V
(± 13 V for LM2902)
- **Low Supply-Current Drain Independent of Supply Voltage . . . 0.8 mA Typ**
- **Common-Mode Input Voltage Range Includes Ground, Allowing Direct Sensing Near Ground**
- **Low Input Bias and Offset Parameters**
 - Input Offset Voltage . . . 3 mV Typ
A Versions . . . 2 mV Typ
 - Input Offset Current . . . 2 nA Typ
 - Input Bias Current . . . 20 nA Typ
A Versions . . . 15 nA Typ
- **Differential Input Voltage Range Equal to Maximum-Rated Supply Voltage . . . 32 V (26 V for LM2902)**
- **Open-Loop Differential Voltage Amplification . . . 100 V/mV Typ**
- **Internal Frequency Compensation**

description/ordering information

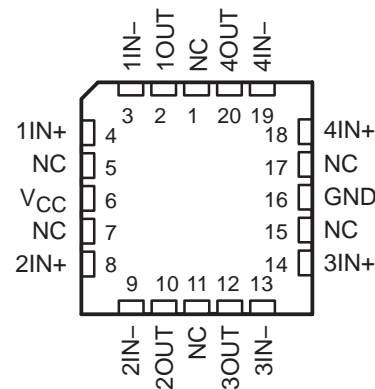
These devices consist of four independent high-gain frequency-compensated operational amplifiers that are designed specifically to operate from a single supply over a wide range of voltages. Operation from split supplies also is possible if the difference between the two supplies is 3 V to 32 V (3 V to 26 V for the LM2902), 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 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.

LM124 . . . D, J, OR W PACKAGE
LM124A . . . J PACKAGE
LM224, LM224A, LM224K, LM224KA . . . D OR N PACKAGE
LM324, LM324K . . . D, N, NS, OR PW PACKAGE
LM324A . . . D, DB, N, NS, OR PW PACKAGE
LM324KA . . . D, N, NS, OR PW PACKAGE
LM2902 . . . D, N, NS, OR PW PACKAGE
LM2902K . . . D, DB, N, NS, OR PW PACKAGE
LM2902KV, LM2902KAV . . . D OR PW PACKAGE
(TOP VIEW)



LM124, LM124A . . . FK PACKAGE
(TOP VIEW)



NC – No internal connection

**LM124, LM124A, LM224, LM224A, LM324, LM324A, LM2902, LM2902V,
LM224K, LM224KA, LM324K, LM324KA, LM2902K, LM2902KV, LM2902KAV
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description/ordering information (continued)

ORDERING INFORMATION

TA	V _{IO} max AT 25°C	MAX TESTED V _{CC}	PACKAGE†		ORDERABLE PART NUMBER	TOP-SIDE MARKING
0°C to 70°C	7 mV	30 V	PDIP (N)	Tube of 25	LM324N	LM324N
						LM324KN
			SOIC (D)	Tube of 50	LM324D	LM324
				Reel of 2500	LM324DR	
				Tube of 50	LM324KD	LM324K
				Reel of 2500	LM324KDR	
			SOP (NS)	Reel of 2000	LM324NSR	LM324
				Tube of 50	LM324KNS	LM324K
				Reel of 2000	LM324KNSR	
			TSSOP (PW)	Tube of 90	LM324PW	L324
				Reel of 2000	LM324PWR	
				Tube of 90	LM324KPW	L324K
	Reel of 2000	LM324KPWR				
	3 mV	30 V	PDIP (N)	Tube of 25	LM324AN	LM324AN
						LM324KAN
			SOIC (D)	Tube of 50	LM324AD	LM324A
				Reel of 2500	LM324ADR	
				Tube of 50	LM324KAD	LM324KA
				Reel of 2500	LM324KADR	
			SOP (NS)	Reel of 2000	LM324ANSR	LM324A
				Tube of 50	LM324KANS	LM324KA
				Reel of 2000	LM324KANSR	
			SSOP (DB)	Reel of 2000	LM324ADBR	LM324A
			TSSOP (PW)	Tube of 90	LM324APW	L324A
Reel of 2000				LM324APWR		
Tube of 90	LM324KAPW	L324KA				
Reel of 2000	LM324KAPWR					
-25°C to 85°C	5 mV	30 V	PDIP (N)	Tube of 25	LM224N	LM224N
						LM224KN
			SOIC (D)	Tube of 50	LM224D	LM224
				Reel of 2500	LM224DR	
				Tube of 50	LM224KD	LM224K
				Reel of 2500	LM224KDR	
	3 mV	30 V	PDIP (N)	Tube of 25	LM224AN	LM224AN
						LM224KAN
			SOIC (D)	Tube of 50	LM224AD	LM224A
				Reel of 2500	LM224ADR	
				Tube of 50	LM224KAD	LM224KA
				Reel of 2500	LM224KADR	

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



**LM124, LM124A, LM224, LM224A, LM324, LM324A, LM2902, LM2902V,
LM224K, LM224KA, LM324K, LM324KA, LM2902K, LM2902KV, LM2902KAV
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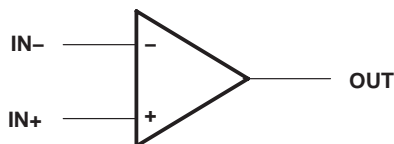
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ORDERING INFORMATION (CONTINUED)

TA	V _{IO} max AT 25°C	MAX TESTED V _{CC}	PACKAGE†		ORDERABLE PART NUMBER	TOP-SIDE MARKING
-40°C to 125°C	7 mV	26 V	PDIP (N)	Tube of 25	LM2902N	LM2902N
				Tube of 25	LM2902KN	LM2902KN
			SOIC (D)	Tube of 50	LM2902D	LM2902
				Reel of 2500	LM2902DR	
				Tube of 50	LM2902KD	LM2902K
				Reel of 2500	LM2902KDR	
			SOP (NS)	Reel of 2000	LM2902NSR	LM2902
				Tube of 50	LM2902KNS	LM2902K
				Reel of 2000	LM2902KNSR	
			SSOP (DB)	Tube of 80	LM2902KDB	L2902K
				Reel of 2000	LM2902KDBR	
			TSSOP (PW)	Tube of 90	LM2902PW	L2902
	Reel of 2000	LM2902PWR				
	Tube of 90	LM2902KPW		L2902K		
	Reel of 2000	LM2902KPWR				
	32 V	SOIC (D)	Reel of 2500	LM2902KVQDR	L2902KV	
TSSOP (PW)		Reel of 2000	LM2902KVQPWR	L2902KV		
2 mV	32 V	SOIC (D)	Reel of 2500	LM2902KAVQDR	L2902KA	
		TSSOP (PW)	Reel of 2000	LM2902KAVQPWR	L2902KA	
-55°C to 125°C	5 mV	30 V	CDIP (J)	Tube of 25	LM124J	LM124J
			CFP (W)	Tube of 25	LM124W	LM124W
			LCCC (FK)	Tube of 55	LM124FK	LM124FK
			SOIC (D)	Tube of 50	LM124D	LM124
	Reel of 2500	LM124DR				
	2 mV	30 V	CDIP (J)	Tube of 25	LM124AJ	LM124AJ
LCCC (FK)			Tube of 55	LM124AFK	LM124AFK	

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

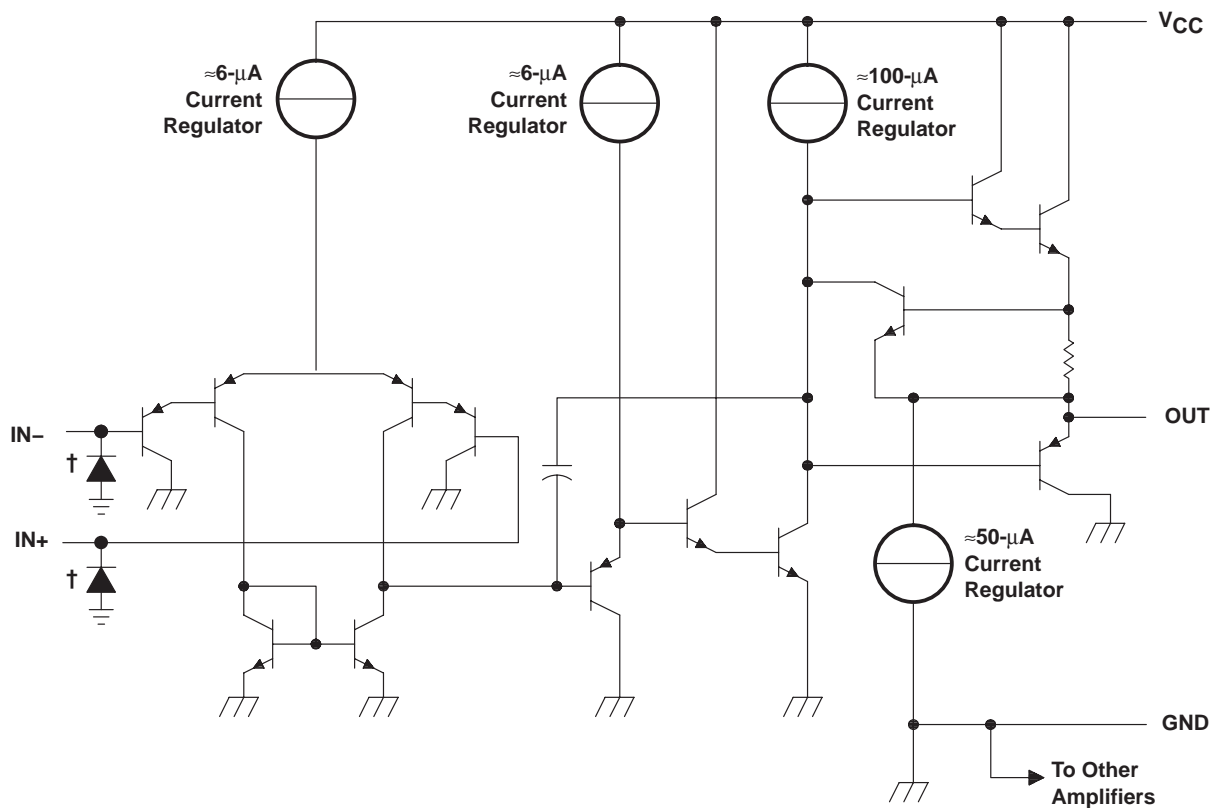
symbol (each amplifier)



**LM124, LM124A, LM224, LM224A, LM324, LM324A, LM2902, LM2902V,
LM224K, LM224KA, LM324K, LM324KA, LM2902K, LM2902KV, LM2902KAV**
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schematic (each amplifier)



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

† ESD protection cells - available on LM324K and LM324KA only

**LM124, LM124A, LM224, LM224A, LM324, LM324A, LM2902, LM2902V,
LM224K, LM224KA, LM324K, LM324KA, LM2902K, LM2902KV, LM2902KAV
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absolute maximum ratings over operating free-air temperature range (unless otherwise noted)†

		LM2902	ALL OTHER DEVICES	UNIT
Supply voltage, V_{CC} (see Note 1)		±13 or 26	±16 or 32	V
Differential input voltage, V_{ID} (see Note 2)		±26	±32	V
Input voltage, V_I (either input)		–0.3 to 26	–0.3 to 32	V
Duration of output short circuit (one amplifier) to ground at (or below) $T_A = 25^\circ\text{C}$, $V_{CC} \leq 15\text{ V}$ (see Note 3)		Unlimited	Unlimited	
Package thermal impedance, θ_{JA} (see Notes 4 and 5)	D package	86	86	°C/W
	DB package	96	96	
	N package	80	80	
	NS package	76	76	
	PW package	113	113	
Package thermal impedance, θ_{JC} (see Notes 6 and 7)	FK package		5.61	°C/W
	J package		15.05	
	W package		14.65	
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 range, T_{stg}		–65 to 150	–65 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 the measurement of I_{OS}) are with respect to the network GND.
 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 $T_J(\text{max})$, θ_{JA} , and T_A . The maximum allowable power dissipation at any allowable ambient temperature is $P_D = (T_J(\text{max}) - T_A)/\theta_{JA}$. 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.
 6. Maximum power dissipation is a function of $T_J(\text{max})$, θ_{JC} , and T_C . The maximum allowable power dissipation at any allowable case temperature is $P_D = (T_J(\text{max}) - T_C)/\theta_{JC}$. Operating at the absolute maximum T_J of 150°C can affect reliability.
 7. The package thermal impedance is calculated in accordance with MIL-STD-883.

ESD protection

TEST CONDITIONS		TYP	UNIT
Human-Body Model	LM224K, LM224KA, LM324K, LM324KA, LM2902K, LM2902KV, LM2902KAV	±2	kV



LM124, LM124A, LM224, LM224A, LM324, LM324A, LM2902, LM2902V, LM224K, LM224KA, LM324K, LM324KA, LM2902K, LM2902KV, LM2902KAV QUADRUPLE OPERATIONAL AMPLIFIERS

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

PARAMETER	TEST CONDITIONS†	T_A ‡	LM124 LM224			LM324 LM324K			UNIT	
			MIN	TYP§	MAX	MIN	TYP§	MAX		
V_{IO} Input offset voltage	$V_{CC} = 5\text{ V to MAX}$, $V_{IC} = V_{ICRmin}$, $V_O = 1.4\text{ V}$	25°C		3	5		3	7	mV	
		Full range						9		
I_{IO} Input offset current	$V_O = 1.4\text{ V}$	25°C		2	30		2	50	nA	
		Full range						150		
I_{IB} Input bias current	$V_O = 1.4\text{ V}$	25°C		-20	-150		-20	-250	nA	
		Full range						-500		
V_{ICR} Common-mode input voltage range	$V_{CC} = 5\text{ V to MAX}$	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	$R_L = 2\text{ k}\Omega$	25°C		$V_{CC} - 1.5$		$V_{CC} - 1.5$			V	
	$R_L = 10\text{ k}\Omega$	25°C								
	$V_{CC} = \text{MAX}$	$R_L = 2\text{ k}\Omega$	Full range		26		26			
		$R_L \geq 10\text{ k}\Omega$	Full range		27	28	27	28		
V_{OL} Low-level output voltage	$R_L \leq 10\text{ k}\Omega$	Full range		5	20		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		50	100		25	100	V/mV	
		Full range		25			15			
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICRmin}$	25°C		70	80		65	80	dB	
k_{SVR} Supply-voltage rejection ratio ($\Delta V_{CC}/\Delta V_{IO}$)		25°C		65	100		65	100	dB	
V_{O1}/V_{O2} Crosstalk attenuation	$f = 1\text{ kHz to }20\text{ kHz}$	25°C		120		120			dB	
I_O Output current	$V_{CC} = 15\text{ V}$, $V_{ID} = 1\text{ V}$, $V_O = 0$	Source	25°C	-20	-30	-60	-20	-30	-60	mA
			Full range		-10			-10		
	$V_{CC} = 15\text{ V}$, $V_{ID} = -1\text{ V}$, $V_O = 15\text{ V}$	Sink	25°C		10	20		10	20	
			Full range		5			5		
	$V_{ID} = -1\text{ V}$, $V_O = 200\text{ mV}$	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)	$V_O = 2.5\text{ V}$, No load	Full range		0.7	1.2		0.7	1.2	mA	
	$V_{CC} = \text{MAX}$, $V_O = 0.5 V_{CC}$, No load	Full range		1.4	3		1.4	3		

† 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.

‡ 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.

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



**LM124, LM124A, LM224, LM224A, LM324, LM324A, LM2902, LM2902V,
LM224K, LM224KA, LM324K, LM324KA, LM2902K, LM2902KV, LM2902KAV**
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electrical characteristics at specified free-air temperature, $V_{CC} = 5\text{ V}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		T_A ‡	LM2902			LM2902V			UNIT
				MIN	TYP§	MAX	MIN	TYP§	MAX	
V_{IO} Input offset voltage	$V_{CC} = 5\text{ V}$ to MAX, $V_{IC} = V_{ICRmin}$, $V_O = 1.4\text{ V}$	Non-A-suffix devices	25°C	3 7		3 7		mV		
			Full range	10		10				
		A-suffix devices	25°C			1 2				
			Full range			4				
$\Delta V_{IO}/\Delta T$ Input offset voltage temperature drift	$R_S = 0\ \Omega$	Full range			7		$\mu\text{V}/^\circ\text{C}$			
I_{IO} Input offset current	$V_O = 1.4\text{ V}$	25°C	2 50		2 50		nA			
		Full range	300		150					
$\Delta I_{IO}/\Delta T$ Input offset current temperature drift		Full range			10		$\text{pA}/^\circ\text{C}$			
I_{IB} Input bias current	$V_O = 1.4\text{ V}$	25°C	-20 -250		-20 -250		nA			
		Full range	-500		-500					
V_{ICR} Common-mode input voltage range	$V_{CC} = 5\text{ V}$ 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	$R_L = 2\text{ k}\Omega$	25°C					V			
		25°C	$V_{CC} - 1.5$		$V_{CC} - 1.5$					
	$V_{CC} = \text{MAX}$	$R_L = 2\text{ k}\Omega$	Full range	22		26				
		$R_L \geq 10\text{ k}\Omega$	Full range	23 24		27				
V_{OL} Low-level output voltage	$R_L \leq 10\text{ k}\Omega$	Full range	5 20		5 20		mV			
A_{VD} Large-signal differential voltage amplification	$V_{CC} = 15\text{ V}$, $V_O = 1\text{ V}$ to 11 V , $R_L \geq 2\text{ k}\Omega$	25°C	25 100		25 100		V/mV			
		Full range	15		15					
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICRmin}$	25°C	50 80		60 80		dB			
k_{SVR} Supply-voltage rejection ratio ($\Delta V_{CC}/\Delta V_{IO}$)		25°C	50 100		60 100		dB			
V_{O1}/V_{O2} Crosstalk attenuation	$f = 1\text{ kHz}$ to 20 kHz	25°C	120		120		dB			
I_O Output current	$V_{CC} = 15\text{ V}$, $V_{ID} = 1\text{ V}$, $V_O = 0$	Source	25°C	-20 -30 -60		-20 -30 -60		mA		
			Full range	-10		-10				
	$V_{CC} = 15\text{ V}$, $V_{ID} = -1\text{ V}$, $V_O = 15\text{ V}$	Sink	25°C	10 20		10 20				
			Full range	5		5				
	$V_{ID} = -1\text{ V}$, $V_O = 200\text{ mV}$	25°C	30		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		± 40 ± 60		mA		
I_{CC} Supply current (four amplifiers)	$V_O = 2.5\text{ V}$, No load	Full range	0.7 1.2		0.7 1.2		mA			
	$V_{CC} = \text{MAX}$, $V_O = 0.5 V_{CC}$, No load	Full range	1.4 3		1.4 3					

† 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 32 V for LM2902V.

‡ Full range is -40°C to 125°C for LM2902.

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



**LM124, LM124A, LM224, LM224A, LM324, LM324A, LM2902, LM2902V,
LM224K, LM224KA, LM324K, LM324KA, LM2902K, LM2902KV, LM2902KAV**
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electrical characteristics at specified free-air temperature, $V_{CC} = 5\text{ V}$ (unless otherwise noted)

PARAMETER	TEST CONDITIONS†	T_A ‡	LM124A			LM224A			LM324A, LM324KA			UNIT
			MIN	TYP§	MAX	MIN	TYP§	MAX	MIN	TYP§	MAX	
V_{IO} Input offset voltage	$V_{CC} = 5\text{ V to }30\text{ V},$ $V_{IC} = V_{ICRmin}, V_O = 1.4\text{ V}$	25°C		2	2	3		2	2	3	mV	
		Full range		4	4	4		4	4	5		
I_{IO} Input offset current	$V_O = 1.4\text{ V}$	25°C		10	2	15		2	2	30	nA	
		Full range		30	30	30		30	30	75		
I_{IB} Input bias current	$V_O = 1.4\text{ V}$	25°C		-50	-15	-80		-15	-15	-100	nA	
		Full range		-100	-100	-100		-100	-100	-200		
V_{ICR} Common-mode input voltage range	$V_{CC} = 30\text{ V}$	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	$R_L = 2\text{ k}\Omega$ $V_{CC} = 30\text{ V}$	25°C		26			0 to $V_{CC} - 1.5$				V	
		Full range		27	26	27	0 to $V_{CC} - 1.5$					
V_{OL} Low-level output voltage	$R_L \leq 10\text{ k}\Omega$	25°C		20			0 to $V_{CC} - 1.5$				V	
		Full range		20	20	20	0 to $V_{CC} - 1.5$					
A/D 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		100			0 to $V_{CC} - 2$				V/mV	
		Full range		25	25	25	0 to $V_{CC} - 2$					
CMRR Common-mode rejection ratio	$V_{IC} = V_{ICRmin}$	25°C		70	80	80					dB	
kSVR Supply-voltage rejection ratio ($\Delta V_{CC}/\Delta V_{IO}$)		25°C		65	100	100					dB	
V_{O1}/V_{O2} Crosstalk attenuation	$f = 1\text{ kHz to }20\text{ kHz}$	25°C		120							dB	
		25°C		-20	-30	-60						
I_O Output current	$V_{CC} = 15\text{ V},$ $V_{ID} = 1\text{ V},$ $V_O = 0$	25°C		-10							mA	
		Full range		10	20	20						
I_{OS} Short-circuit output current	$V_{CC} = 15\text{ V},$ $V_{ID} = -1\text{ V},$ $V_O = 15\text{ V}$	25°C		5							mA	
		Full range		12	30	30						
I_{CC} Supply current (four amplifiers)	$V_{CC} = 5\text{ V},$ $V_O = 0$	25°C		± 40	± 60	± 60					μA	
		Full range		0.7	1.2	1.2						
I_{CC} Supply current (four amplifiers)	$V_{CC} = 30\text{ V},$ No load	25°C		1.4	1.4	3					mA	
		Full range		1.4	1.4	3						

† All characteristics are measured under open-loop conditions, with zero common-mode input voltage, unless otherwise specified.

‡ Full range is -55°C to 125°C for LM124A, -25°C to 85°C for LM224A, and 0°C to 70°C for LM324A.

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



**LM124, LM124A, LM224, LM224A, LM324, LM324A, LM2902, LM2902V,
LM224K, LM224KA, LM324K, LM324KA, LM2902K, LM2902KV, LM2902KAV**
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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 1)	0.5	$\text{V}/\mu\text{s}$
B_1	Unity-gain bandwidth	$R_L = 1\text{ M}\Omega$, $C_L = 20\text{ pF}$ (see Figure 1)	1.2	MHz
V_n	Equivalent input noise voltage	$R_S = 100\ \Omega$, $V_I = 0\text{ V}$, $f = 1\text{ kHz}$ (see Figure 2)	35	$\text{nV}/\sqrt{\text{Hz}}$

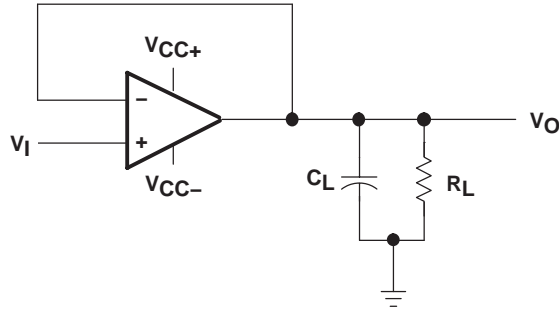


Figure 1. Unity-Gain Amplifier

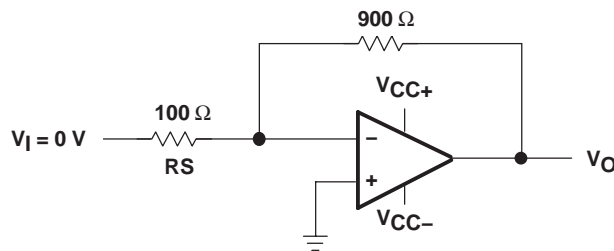


Figure 2. Noise-Test Circuit

PACKAGING INFORMATION

Orderable Device	Status ⁽¹⁾	Package Type	Package Drawing	Pins	Package Qty	Eco Plan ⁽²⁾	Lead/Ball Finish	MSL Peak Temp ⁽³⁾
5962-7704301VCA	ACTIVE	CDIP	J	14	1	TBD	A42 SNPB	N / A for Pkg Type
77043012A	ACTIVE	LCCC	FK	20	1	TBD	POST-PLATE	N / A for Pkg Type
7704301CA	ACTIVE	CDIP	J	14	1	TBD	A42 SNPB	N / A for Pkg Type
7704301DA	ACTIVE	CFP	W	14	1	TBD	A42 SNPB	N / A for Pkg Type
77043022A	ACTIVE	LCCC	FK	20	1	TBD	POST-PLATE	N / A for Pkg Type
7704302CA	ACTIVE	CDIP	J	14	1	TBD	A42 SNPB	N / A for Pkg Type
JM38510/11005BCA	ACTIVE	CDIP	J	14	1	TBD	A42 SNPB	N / A for Pkg Type
LM124AFKB	ACTIVE	LCCC	FK	20	1	TBD	POST-PLATE	N / A for Pkg Type
LM124AJ	ACTIVE	CDIP	J	14	1	TBD	A42 SNPB	N / A for Pkg Type
LM124AJB	ACTIVE	CDIP	J	14	1	TBD	A42 SNPB	N / A for Pkg Type
LM124D	ACTIVE	SOIC	D	14	50	TBD	CU NIPDAU	Level-3-245C-168 HR
LM124DR	ACTIVE	SOIC	D	14	2500	TBD	CU NIPDAU	Level-3-245C-168 HR
LM124FKB	ACTIVE	LCCC	FK	20	1	TBD	POST-PLATE	N / A for Pkg Type
LM124J	ACTIVE	CDIP	J	14	1	TBD	A42 SNPB	N / A for Pkg Type
LM124JB	ACTIVE	CDIP	J	14	1	TBD	A42 SNPB	N / A for Pkg Type
LM124N	OBSOLETE	PDIP	N	14		TBD	Call TI	Call TI
LM124W	ACTIVE	CFP	W	14	1	TBD	A42 SNPB	N / A for Pkg Type
LM124WB	ACTIVE	CFP	W	14	1	TBD	A42 SNPB	N / A for Pkg Type
LM224AD	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM224ADE4	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM224ADR	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM224ADRE4	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM224AN	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
LM224ANE4	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
LM224D	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM224DE4	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM224DG4	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM224DR	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM224DRE4	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM224DRG4	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM224KAD	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM224KADE4	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM

Orderable Device	Status ⁽¹⁾	Package Type	Package Drawing	Pins	Package Qty	Eco Plan ⁽²⁾	Lead/Ball Finish	MSL Peak Temp ⁽³⁾
LM224KADR	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM224KADRE4	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM224KAN	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
LM224KANE4	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
LM224KD	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM224KDE4	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM224KDR	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM224KDRE4	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM224KN	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
LM224KNE4	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
LM224N	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
LM224NE4	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
LM2902D	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM2902DE4	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM2902DG4	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM2902DR	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM2902DRE4	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM2902DRG4	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM2902KAVQDR	ACTIVE	SOIC	D	14	2500	Pb-Free (RoHS)	CU NIPDAU	Level-2-250C-1 YEAR/ Level-1-235C-UNLIM
LM2902KAVQPWR	ACTIVE	TSSOP	PW	14	2000	TBD	CU NIPDAU	Level-1-250C-UNLIM
LM2902KD	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM2902KDB	ACTIVE	SSOP	DB	14	80	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM2902KDBE4	ACTIVE	SSOP	DB	14	80	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM2902KDBR	ACTIVE	SSOP	DB	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM2902KDBRE4	ACTIVE	SSOP	DB	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM2902KDE4	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM

Orderable Device	Status ⁽¹⁾	Package Type	Package Drawing	Pins	Package Qty	Eco Plan ⁽²⁾	Lead/Ball Finish	MSL Peak Temp ⁽³⁾
LM2902KDR	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM2902KDRE4	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM2902KN	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
LM2902KNE4	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
LM2902KNSR	ACTIVE	SO	NS	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM2902KNSRE4	ACTIVE	SO	NS	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM2902KPW	ACTIVE	TSSOP	PW	14	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM2902KPWE4	ACTIVE	TSSOP	PW	14	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM2902KPWR	ACTIVE	TSSOP	PW	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM2902KPWRE4	ACTIVE	TSSOP	PW	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM2902KVQDR	ACTIVE	SOIC	D	14	2500	Pb-Free (RoHS)	CU NIPDAU	Level-2-250C-1 YEAR/ Level-1-235C-UNLIM
LM2902KVQPWR	ACTIVE	TSSOP	PW	14	2000	TBD	CU NIPDAU	Level-1-250C-UNLIM
LM2902N	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
LM2902NE4	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
LM2902NSR	ACTIVE	SO	NS	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM2902NSRG4	ACTIVE	SO	NS	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM2902PW	ACTIVE	TSSOP	PW	14	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM2902PWE4	ACTIVE	TSSOP	PW	14	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM2902PWG4	ACTIVE	TSSOP	PW	14	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM2902PWLE	OBSOLETE	TSSOP	PW	14		TBD	Call TI	Call TI
LM2902PWR	ACTIVE	TSSOP	PW	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM2902PWRE4	ACTIVE	TSSOP	PW	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM2902PWRG4	ACTIVE	TSSOP	PW	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM2902QN	OBSOLETE	PDIP	N	14		TBD	Call TI	Call TI
LM324AD	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM324ADBLE	OBSOLETE	SSOP	DB	14		TBD	Call TI	Call TI
LM324ADBR	ACTIVE	SSOP	DB	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM324ADBRE4	ACTIVE	SSOP	DB	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM

Orderable Device	Status ⁽¹⁾	Package Type	Package Drawing	Pins	Package Qty	Eco Plan ⁽²⁾	Lead/Ball Finish	MSL Peak Temp ⁽³⁾
						no Sb/Br)		
LM324ADE4	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM324ADR	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM324ADRE4	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM324AN	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
LM324ANE4	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
LM324ANSR	ACTIVE	SO	NS	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM324ANSRE4	ACTIVE	SO	NS	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM324APW	ACTIVE	TSSOP	PW	14	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM324APWE4	ACTIVE	TSSOP	PW	14	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM324APWG4	ACTIVE	TSSOP	PW	14	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM324APWLE	OBSOLETE	TSSOP	PW	14		TBD	Call TI	Call TI
LM324APWR	ACTIVE	TSSOP	PW	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM324APWRE4	ACTIVE	TSSOP	PW	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM324APWRG4	ACTIVE	TSSOP	PW	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM324D	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM324DE4	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM324DG4	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM324DR	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM324DRE4	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM324DRG4	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM324KAD	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM324KADE4	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM324KADG4	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM324KADR	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM324KADRE4	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM324KADRG4	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM

Orderable Device	Status ⁽¹⁾	Package Type	Package Drawing	Pins	Package Qty	Eco Plan ⁽²⁾	Lead/Ball Finish	MSL Peak Temp ⁽³⁾
						no Sb/Br)		
LM324KAN	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
LM324KANE4	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
LM324KANS	PREVIEW	SO	NS	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM324KANSR	ACTIVE	SO	NS	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM324KANSRE4	ACTIVE	SO	NS	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM324KAPW	ACTIVE	TSSOP	PW	14	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM324KAPWE4	ACTIVE	TSSOP	PW	14	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM324KAPWG4	ACTIVE	TSSOP	PW	14	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM324KAPWR	ACTIVE	TSSOP	PW	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM324KAPWRE4	ACTIVE	TSSOP	PW	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM324KAPWRG4	ACTIVE	TSSOP	PW	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM324KD	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM324KDE4	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM324KDR	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM324KDRE4	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM324KN	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
LM324KNE4	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
LM324KNS	PREVIEW	SO	NS	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM324KNSR	ACTIVE	SO	NS	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM324KNSRE4	ACTIVE	SO	NS	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM324KPW	ACTIVE	TSSOP	PW	14	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM324KPWE4	ACTIVE	TSSOP	PW	14	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM324KPWR	ACTIVE	TSSOP	PW	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM324KPWRE4	ACTIVE	TSSOP	PW	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM324N	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type

Orderable Device	Status ⁽¹⁾	Package Type	Package Drawing	Pins	Package Qty	Eco Plan ⁽²⁾	Lead/Ball Finish	MSL Peak Temp ⁽³⁾
LM324NE4	ACTIVE	PDIP	N	14	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type
LM324NSR	ACTIVE	SO	NS	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM324NSRE4	ACTIVE	SO	NS	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM324NSRG4	ACTIVE	SO	NS	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM324PW	ACTIVE	TSSOP	PW	14	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM324PWE4	ACTIVE	TSSOP	PW	14	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM324PWG4	ACTIVE	TSSOP	PW	14	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM324PWLE	OBSOLETE	TSSOP	PW	14		TBD	Call TI	Call TI
LM324PWR	ACTIVE	TSSOP	PW	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM324PWRE4	ACTIVE	TSSOP	PW	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM324PWRG4	ACTIVE	TSSOP	PW	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
LM324Y	OBSOLETE	XCEPT	Y	0		TBD	Call TI	Call TI

⁽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⁾ Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

TBD: The Pb-Free/Green conversion plan has not been defined.

Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

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

Important Information and Disclaimer: The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

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J (R-GDIP-T**)

14 LEADS SHOWN

CERAMIC DUAL IN-LINE PACKAGE



DIM \ PINS **	14	16	18	20
A	0.300 (7,62) BSC	0.300 (7,62) BSC	0.300 (7,62) BSC	0.300 (7,62) BSC
B MAX	0.785 (19,94)	.840 (21,34)	0.960 (24,38)	1.060 (26,92)
B MIN	—	—	—	—
C MAX	0.300 (7,62)	0.300 (7,62)	0.310 (7,87)	0.300 (7,62)
C MIN	0.245 (6,22)	0.245 (6,22)	0.220 (5,59)	0.245 (6,22)



4040083/F 03/03

- NOTES:
- All linear dimensions are in inches (millimeters).
 - This drawing is subject to change without notice.
 - This package is hermetically sealed with a ceramic lid using glass frit.
 - Index point is provided on cap for terminal identification only on press ceramic glass frit seal only.
 - Falls within MIL STD 1835 GDIP1-T14, GDIP1-T16, GDIP1-T18 and GDIP1-T20.

W (R-GDFP-F14)

CERAMIC DUAL FLATPACK



- NOTES:
- A. All linear dimensions are in inches (millimeters).
 - B. This drawing is subject to change without notice.
 - C. This package can be hermetically sealed with a ceramic lid using glass frit.
 - D. Index point is provided on cap for terminal identification only.
 - E. Falls within MIL STD 1835 GDFP1-F14 and JEDEC MO-092AB

FK (S-CQCC-N**)

LEADLESS CERAMIC CHIP CARRIER

28 TERMINAL SHOWN



- NOTES:
- A. All linear dimensions are in inches (millimeters).
 - B. This drawing is subject to change without notice.
 - C. This package can be hermetically sealed with a metal lid.
 - D. The terminals are gold plated.
 - E. Falls within JEDEC MS-004

N (R-PDIP-T**)

PLASTIC DUAL-IN-LINE PACKAGE

16 PINS SHOWN



- NOTES:
- A. All linear dimensions are in inches (millimeters).
 - B. This drawing is subject to change without notice.
 - Falls within JEDEC MS-001, except 18 and 20 pin minimum body length (Dim A).
 - The 20 pin end lead shoulder width is a vendor option, either half or full width.

D (R-PDSO-G14)

PLASTIC SMALL-OUTLINE PACKAGE



- NOTES:
- A. All linear dimensions are in inches (millimeters).
 - B. This drawing is subject to change without notice.
 - C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed .006 (0,15) per end.
 - D. Body width does not include interlead flash. Interlead flash shall not exceed .017 (0,43) per side.
 - E. Reference JEDEC MS-012 variation AB.

MECHANICAL DATA

NS (R-PDSO-G**)

PLASTIC SMALL-OUTLINE PACKAGE

14-PINS SHOWN

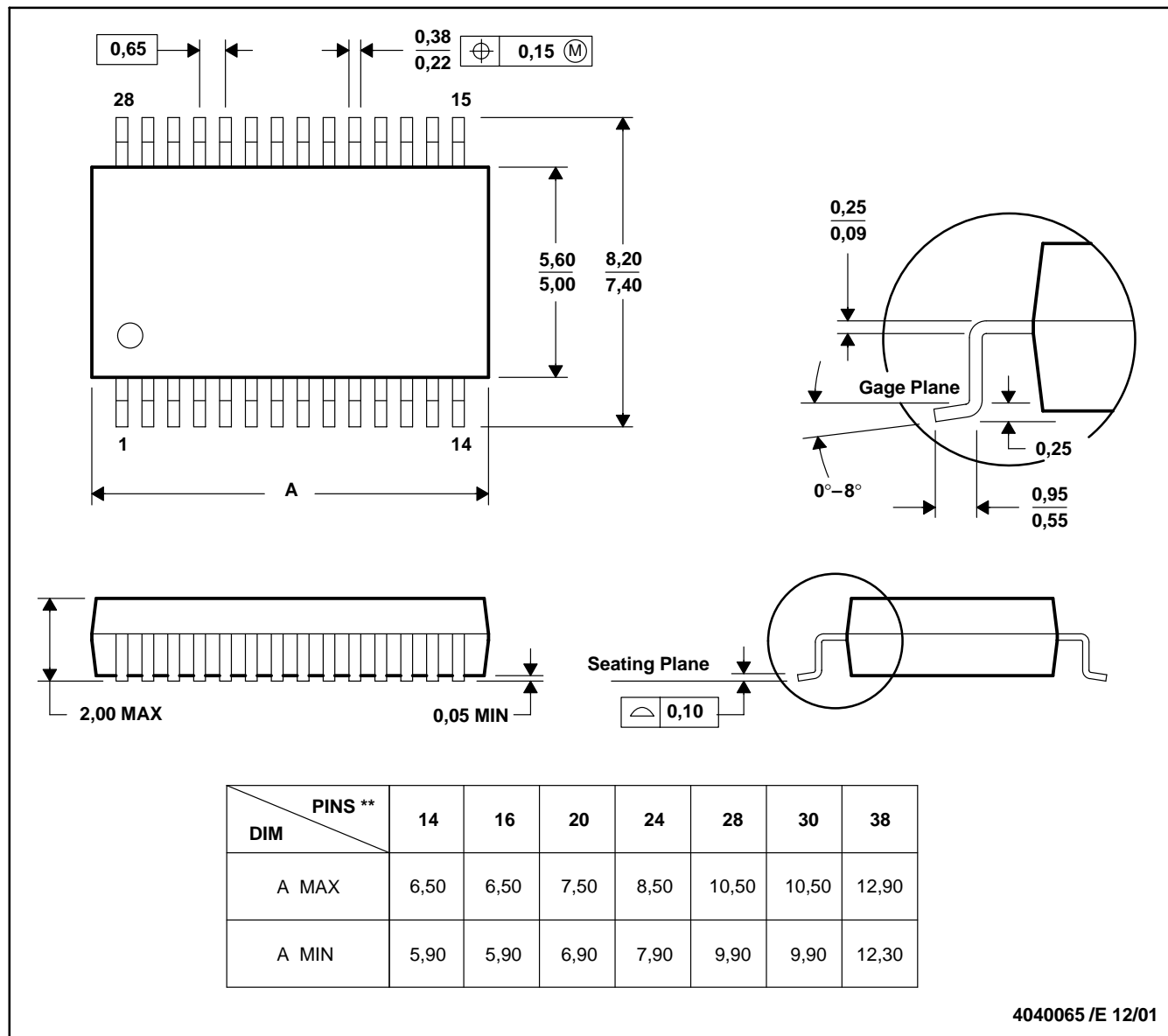


- NOTES:
- A. All linear dimensions are in millimeters.
 - B. This drawing is subject to change without notice.
 - C. Body dimensions do not include mold flash or protrusion, not to exceed 0,15.

DB (R-PDSO-G**)

PLASTIC SMALL-OUTLINE

28 PINS SHOWN



- NOTES: A. All linear dimensions are in millimeters.
 B. This drawing is subject to change without notice.
 C. Body dimensions do not include mold flash or protrusion not to exceed 0,15.
 D. Falls within JEDEC MO-150

PW (R-PDSO-G**)

PLASTIC SMALL-OUTLINE PACKAGE

14 PINS SHOWN



4040064/F 01/97

- NOTES: A. All linear dimensions are in millimeters.
 B. This drawing is subject to change without notice.
 C. Body dimensions do not include mold flash or protrusion not to exceed 0,15.
 D. Falls within JEDEC MO-153

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