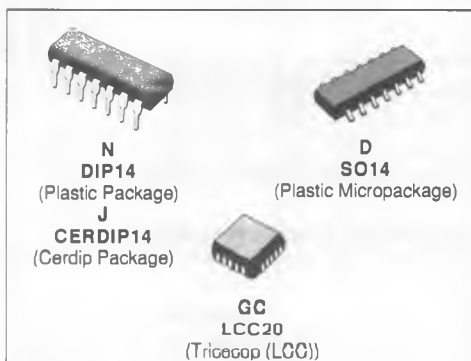


LOW POWER QUAD OPERATIONAL AMPLIFIERS

- LARGE VOLTAGE GAIN : 100 dB
- VERY LOW SUPPLY CURRENT/AMPLI : 375 μ A
- LOW INPUT BIAS CURRENT : 20 nA
- LOW INPUT OFFSET VOLTAGE : 2 mV
- LOW INPUT OFFSET CURRENT : 2 nA
- WIDE POWER SUPPLY RANGE :
 - SINGLE SUPPLY : + 3 V TO + 30 V
 - DUAL SUPPLIES : $\pm$ 1.5 V TO $\pm$ 15 V



DESCRIPTION

These circuits consist of four independent, high gain, internally frequency compensated operational amplifiers which were designed specifically for automotive and industrial control systems. 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

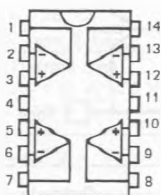
Part Number	Temperature Range	Package			
		N	J	GC	D
LM124,A	- 55 °C to + 125 °C	▲	▲	▲	▲
LM224,A	- 40 °C to + 105 °C	■	■	■	■
LM324,A	0 °C to + 70 °C	■	■	■	■
LM2902	- 40 °C to + 105 °C	■	■	■	■

Note : Hi-Rel Versions Available

Examples : LM124J, LM124GC, LM224N

PIN CONNECTIONS (top views)

DIP14/CERDIP14
SO14



- | | |
|---------------------------|----------------------------|
| 1 - Output 1 | 8 - Output 3 |
| 2 - Inverting input 1 | 9 - Inverting input 3 |
| 3 - Non-inverting input 1 | 10 - Non-inverting input 3 |
| 4 - V _{cc} | 11 - V _{cc} |
| 5 - Non-inverting input 2 | 12 - Non-inverting input 4 |
| 6 - Inverting input 2 | 13 - Inverting input 4 |
| 7 - Output 2 | 14 - Output 4 |

LCC20

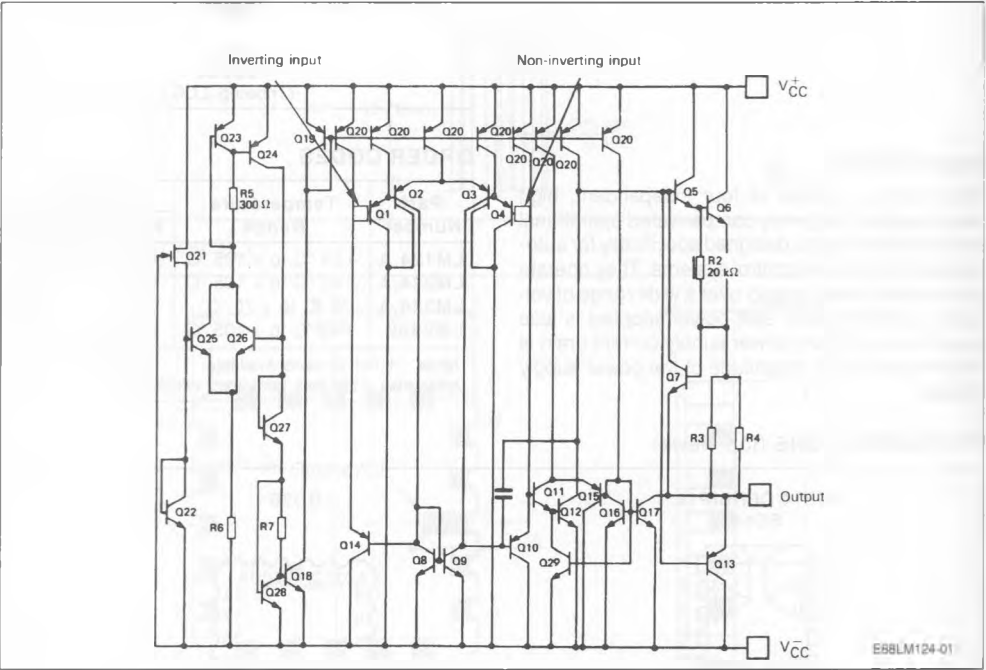


- | | |
|---------------------------|----------------------------|
| 1 - NC | 11 - NC |
| 2 - Output 1 | 12 - Output 3 |
| 3 - Inverting input 1 | 13 - Inverting input 3 |
| 4 - Non-inverting input 1 | 14 - Non-inverting input 3 |
| 5 - NC | 15 - NC |
| 6 - V _{cc} | 16 - V _{cc} |
| 7 - NC | 17 - NC |
| 8 - Non-inverting input 2 | 18 - Non-inverting input 4 |
| 9 - Inverting input 2 | 19 - Inverting input 4 |
| 10 - Output 2 | 20 - Output 4 |

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	LM124,A	LM224,A 2902	LM324,A	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 N, J Suffix GC Suffix D Suffix	500	500	500	mW
		665			
			400	400	
	Output Short-circuit Duration	Indefinite			
I_{id}	Input Current – (note 6)	50	50	50	mA
T_{oper}	Operating Free Air Temperature Range	$- 55$ to $+ 125$	$- 40$ to $+ 105$	0 to $+ 70$	$^{\circ}C$
T_{stg}	Storage Temperature Range	$- 65$ to 150	$- 65$ to 150	$- 65$ to 150	$^{\circ}C$

SCHEMATIC DIAGRAM (1/4 LM124)



Case	Inverting Inputs	Non-inverting Inputs	V_{CC}	V_{EE}	Outputs	N.C.
DIP14 CERDIP14 SO14	2, 6, 9, 13	3, 5, 10, 12	11	4	1, 7, 8, 14	
LCC20	3, 9, 13, 19	4, 8, 14, 18	16	6	1, 2, 12, 20	*

* LCC20 : Other pins are not connected.

ELECTRICAL CHARACTERISTICS

 $V_{CC} = +5\text{ V}$, $V_{CC} = \text{Ground}$, $V_O = 1.4\text{ V}$ LM324, A : $0 \leq T_{amb} \leq +70\text{ }^{\circ}\text{C}$ LM224, A LM2902 : $-40 \leq T_{amb} \leq +105\text{ }^{\circ}\text{C}$ LM124, A : $-55 \leq T_{amb} \leq +125\text{ }^{\circ}\text{C}$

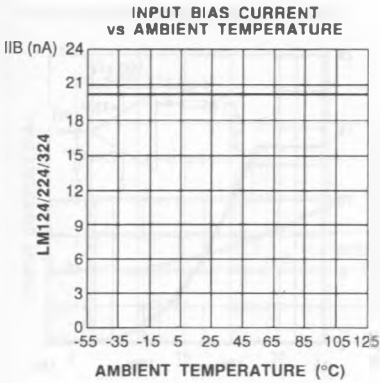
(unless otherwise specified)

Symbol	Parameter	LM124A, 224A 324A			LM124, 224 324, 2902			Unit
		Min.	Typ.	Max.	Min.	Typ.	Max.	
V_{IO}	Input Offset Voltage (note 3) $T_{amb} = +25\text{ }^{\circ}\text{C}$ $T_{min} \leq T_{amb} \leq T_{max}$		2	3 5		2	5 7	mV
I_{IO}	Input Offset Current $T_{amb} = +25\text{ }^{\circ}\text{C}$ $T_{min} \leq T_{amb} \leq T_{max}$		2	20 40		2	20 40	nA
I_{IB}	Input Bias Current (note 2) $T_{amb} = +25\text{ }^{\circ}\text{C}$ $T_{min} \leq T_{amb} \leq T_{max}$		20	100 200		20	100 200	nA
A_{VD}	Large Signal Voltage Gain ($V_{CC} = +15\text{ V}$, $R_L = 2\text{ k}\Omega$) ($V_O = 1.4\text{ V}$ to 11.4 V) $T_{amb} = +25\text{ }^{\circ}\text{C}$ $T_{min} \leq T_{amb} \leq T_{max}$	50 25	100		50 25	100		V/mV
SVR	Supply Voltage Rejection Ratio ($R_S \leq 10\text{ k}\Omega$) $T_{amb} = +25\text{ }^{\circ}\text{C}$ $T_{min} \leq T_{amb} \leq T_{max}$	65 65	110		65 65	110		dB
I_{CC}	Supply Current, all Amp, no Load $T_{amb} = +25\text{ }^{\circ}\text{C}$ $T_{min} \leq T_{amb} \leq T_{max}$ $V_{CC} = +5\text{ V}$ $V_{CC} = +30\text{ V}$ $V_{CC} = +5\text{ V}$ $V_{CC} = +30\text{ V}$		0.7 1.5 0.8 1.5	1.2 3 1.2 3		0.7 1.5 0.8 1.5	1.2 3 1.2 3	mA
V_I	Input Voltage Range (note 4) $T_{amb} = +25\text{ }^{\circ}\text{C}$ $T_{min} \leq T_{amb} \leq T_{max}$ $V_{CC} = +30\text{ V}$	0 0		$V_{CC} - 1.5$ $V_{CC} - 2$	0 0		$V_{CC} - 1.5$ $V_{CC} - 2$	V
CMR	Common-mode Rejection Ratio ($R_S \leq 10\text{ k}\Omega$) $T_{amb} = +25\text{ }^{\circ}\text{C}$ $T_{min} \leq T_{amb} \leq T_{max}$	70 60	80		70 60	80		dB
I_O	Output Short-circuit Current ($V_I^+ = +1\text{ V}$, $V_I^- = 0\text{ V}$, $V_{CC} = +15\text{ V}$) $T_{amb} = +25\text{ }^{\circ}\text{C}$ $T_{min} \leq T_{amb} \leq T_{max}$	20 10	40	60	20 10	40	60	mA
I_{sink}	Output Current Sink ($V_I^+ = -1\text{ V}$, $V_I^- = 0\text{ V}$) $V_{CC} = +15\text{ V}$ $V_O = +0.2\text{ V}$ $T_{amb} = +25\text{ }^{\circ}\text{C}$ $T_{min} \leq T_{amb} \leq T_{max}$ $T_{amb} = +25\text{ }^{\circ}\text{C}$ $T_{min} \leq T_{amb} \leq T_{max}$	10 10 12 12	20 50		10 10 12 12	20 50		mA μA
V_{OPP}	Output Voltage Swing $T_{amb} = +25\text{ }^{\circ}\text{C}$ $T_{min} \leq T_{amb} \leq T_{max}$ $R_L \geq 2\text{ k}\Omega$ $R_L \geq 2\text{ k}\Omega$	0 0		$V_{CC} - 1.5$ $V_{CC} - 2$	0 0		$V_{CC} - 1.5$ $V_{CC} - 2$	V

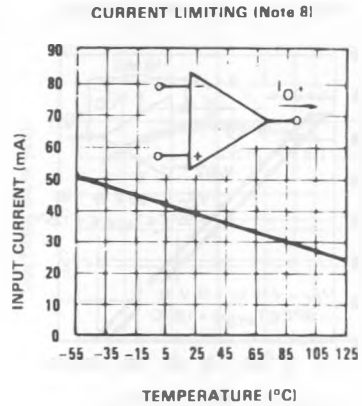
ELECTRICAL CHARACTERISTICS (continued)

Symbol	Parameter	LM124A, 224A 324A			LM124, 224 324, 2902			Unit
		Min.	Typ.	Max.	Min.	Typ.	Max.	
V_{OH}	High Level Output Voltage ($V_{CC} = +30\text{ V}$) $T_{amb} = +25\text{ }^{\circ}\text{C}$ $R_L = 2\text{ k}\Omega$ $T_{min} \leq T_{amb} \leq T_{max}$ $T_{amb} = +25\text{ }^{\circ}\text{C}$ $R_L = 10\text{ k}\Omega$ $T_{min} \leq T_{amb} \leq T_{max}$	26 26 27 27	27 28 		26 26 27 27	27 28 		V
V_{OL}	Low Level Output Voltage ($R_L \leq 10\text{ k}\Omega$) $T_{amb} = +25\text{ }^{\circ}\text{C}$ $T_{min} \leq T_{amb} \leq T_{max}$	5	20 20			5 20 20		V
S_{VO}	Slew-rate ($V_I = 0.5\text{ to }3\text{ V}$, $R_L = 2\text{ k}\Omega$ $CL < 100\text{ pF}$, $T_{amb} = +25\text{ }^{\circ}\text{C}$, unity gain $V_{CC} = 15\text{ V}$)	0.2	0.4		0.2	0.4		V/ μs
GBP	Gain Bandwidth Product, $V_{CC} = 30\text{ V}$ ($f = 100\text{ kHz}$, $T_{amb} = +25\text{ }^{\circ}\text{C}$, $V_{IN} = 10\text{ mV}$ $R_L = 2\text{ k}\Omega$, $CL = 100\text{ pF}$)	0.7	1.3	1.8	0.7	1.3	1.8	MHz
THD	Total Harmonic Distortion ($f = 1\text{ kHz}$, $A_V = 20\text{ dB}$, $R_L = 2\text{ k}\Omega$, $V_O = 2\text{ V}_{pp}$ $CL < 100\text{ pF}$, $T_{amb} = +25\text{ }^{\circ}\text{C}$, $V_{CC} = 30\text{ V}$)		0.015			0.015		%
V_n	Equivalent Input Noise Voltage ($f = 1\text{ kHz}$, $R_g = 100\text{ }\Omega$, $V_{CC} = 30\text{ V}$)		40			40		nV/ $\sqrt{\text{Hz}}$
DV_{io}	Average Temperature Coefficient of Input Offset Voltage $T_{min} \leq T_{amb} \leq T_{max}$		7	30		7	30	$\mu\text{V}/^{\circ}\text{C}$
DI_{IO}	Average Temperature Coeff. of Input Offset Current $T_{min} \leq T_{amb} \leq T_{max}$		10	300		10	300	pA/ $^{\circ}\text{C}$
V_{O1}/V_{O2}	Channel Separation (note 5) $1\text{ kHz} \leq f \leq 20\text{ kHz}$		120			120		dB

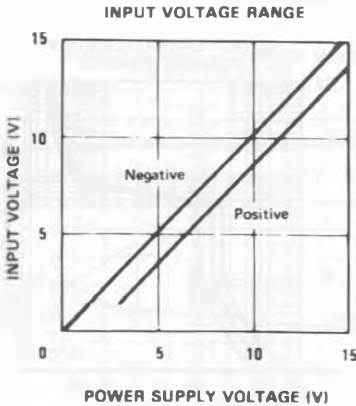
- Notes :**
1. Short-circuits from the output to V_{CC} can cause excessive heating if $V_{CC} > 15\text{ V}$. The maximum output current is approximately 40 mA independent of the magnitude of V_{CC} . Destructive dissipation can result from simultaneous short-circuits on all amplifiers.
 2. The direction 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.
 3. $V_O = 1.4\text{ V}$, $R_S = 0$, $5\text{ V} < V_{CC} < 30\text{ V}$, $0 < V_I < V_{CC} - 1.5\text{ V}$.
 4. The input common-mode voltage of either input signal voltage should not be allowed to go negative by more than 0.3 V. The upper end of the common-mode voltage range is $V_{CC} - 1.5\text{ V}$, but either or both inputs can go to +32 V without damage.
 5. 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.
 6. This input only exist 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 diode 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 -0.3 V .



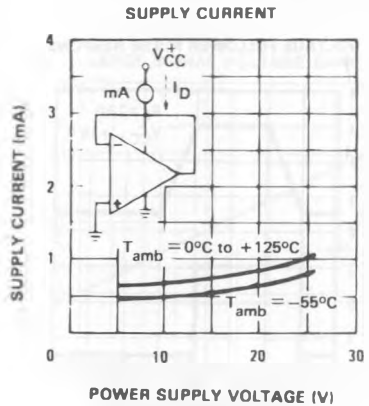
E88LM124-02



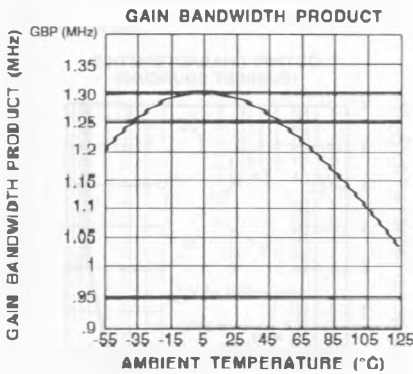
E88LM124-03



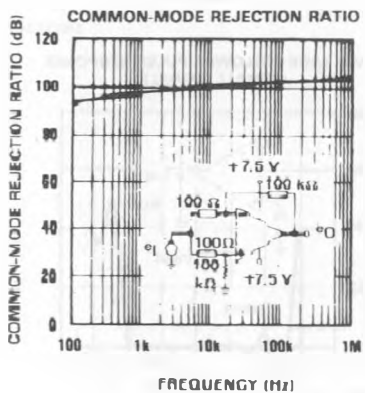
E88LM124-04



E88LM124-05

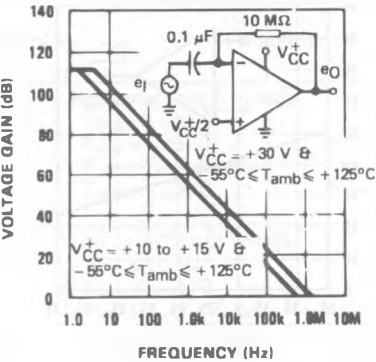


E88LM124-06



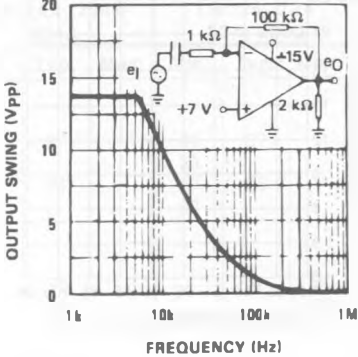
E88LM124-07

OPEN LOOP FREQUENCY RESPONSE



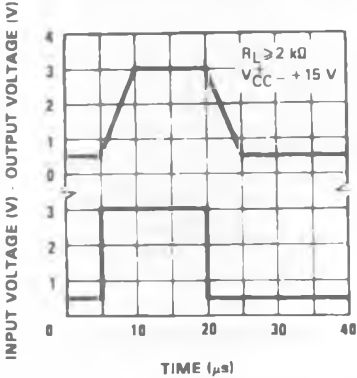
EB8LM124-08

LARGE SIGNAL FREQUENCY RESPONSE



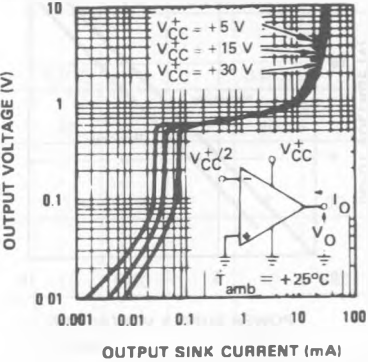
EB8LM124-09

VOLTAGE FOLLOWER PULSE RESPONSE



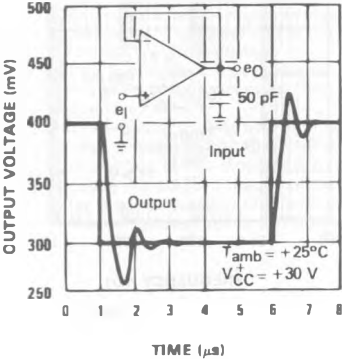
EB8LM124-10

OUTPUT CHARACTERISTICS (CURRENT SINKING)



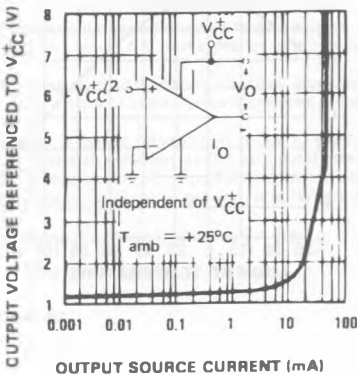
EB8LM124-11

VOLTAGE FOLLOWER PULSE RESPONSE (SMALL SIGNAL)



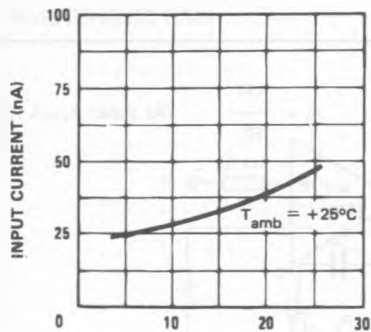
EB8LM124-12

OUTPUT CHARACTERISTICS (CURRENT SOURCING)



EB8LM124-13

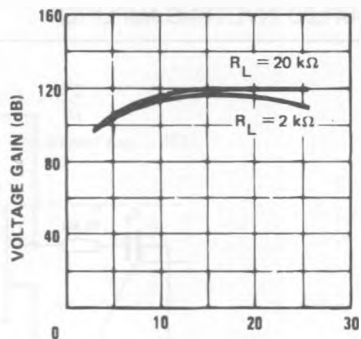
INPUT CURRENT



POWER SUPPLY VOLTAGE (V)

E88LM124-14

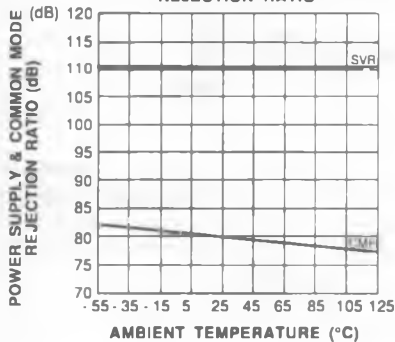
VOLTAGE GAIN



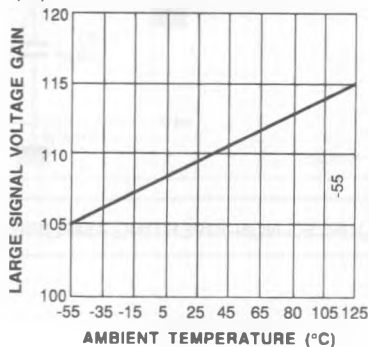
POWER SUPPLY VOLTAGE (V)

E88LM124-15

POWER SUPPLY & COMMON MODE REJECTION RATIO

AMBIENT TEMPERATURE ($^{\circ}\text{C}$)

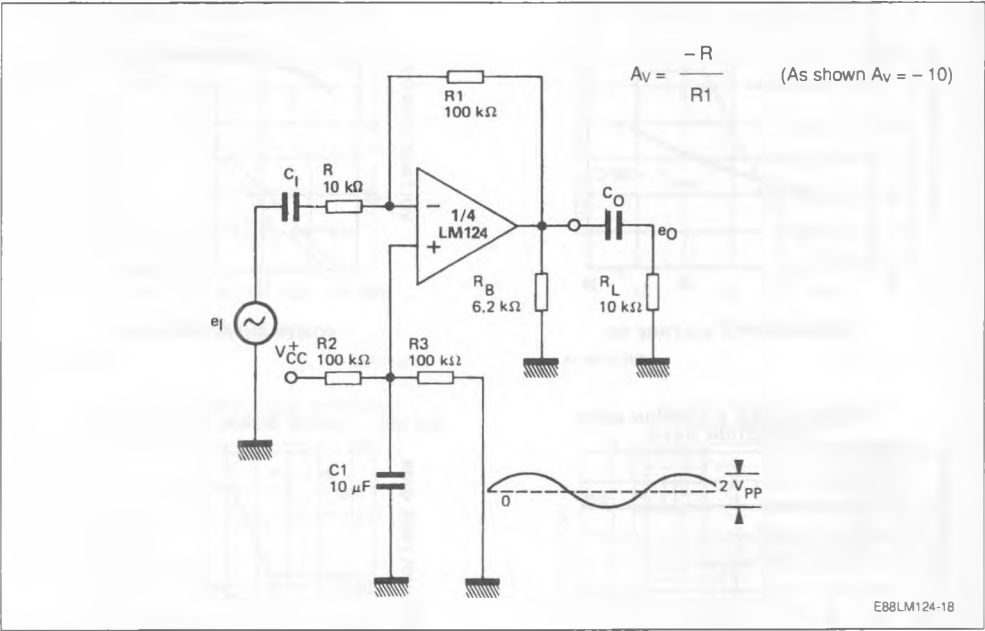
E88LM124-16

A_{vd} (dB) LARGE SIGNAL VOLTAGE GAINAMBIENT TEMPERATURE ($^{\circ}\text{C}$)

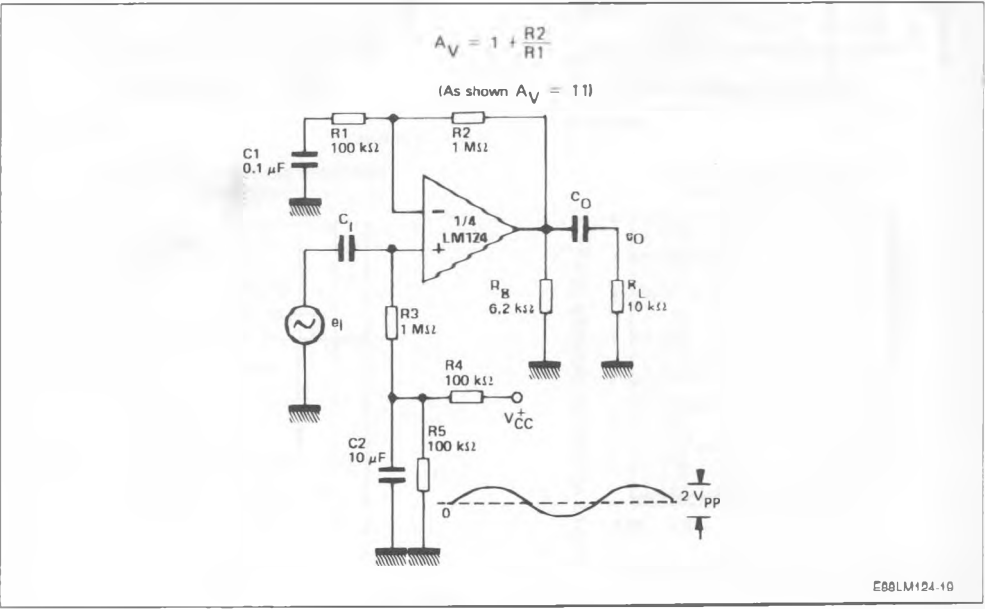
E88LM124-17

TYPICAL SINGLE - SUPPLY APPLICATIONS

AC COUPLED INVERTING AMPLIFIER

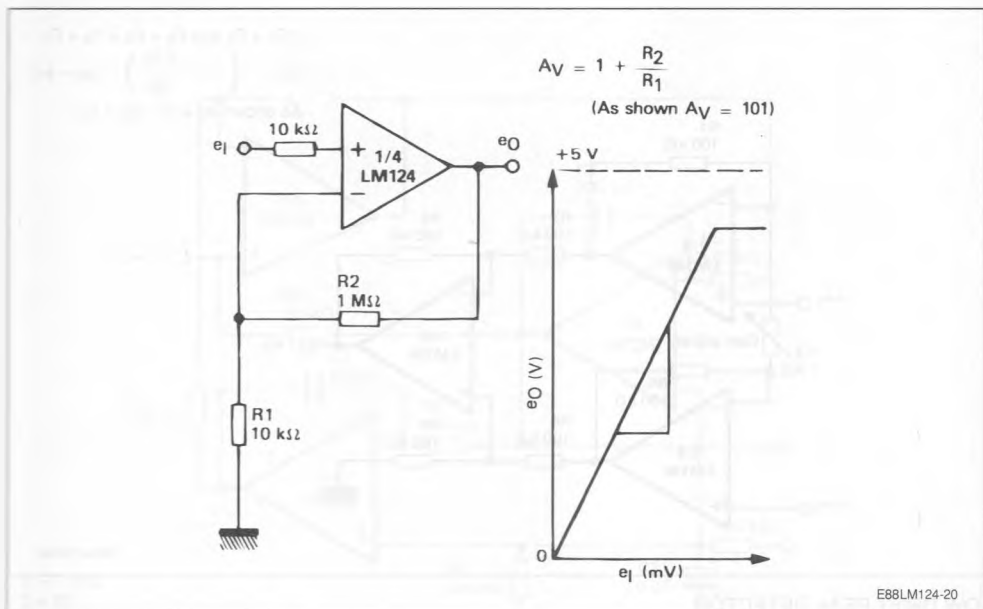


AC COUPLED NON-INVERTING AMPLIFIER

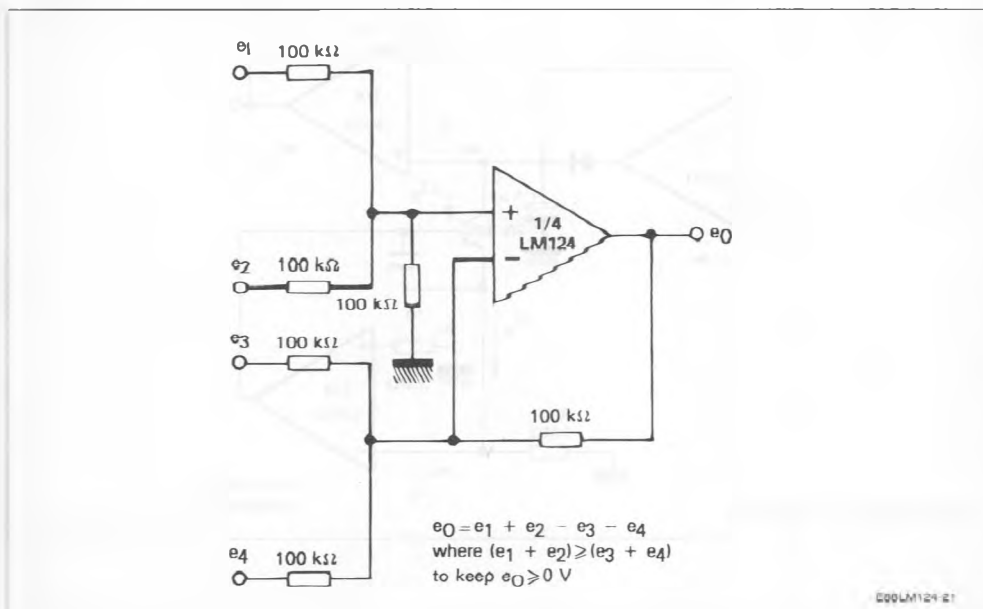


TYPICAL SINGLE - SUPPLY APPLICATIONS (continued)

NON-INVERTING DC GAIN

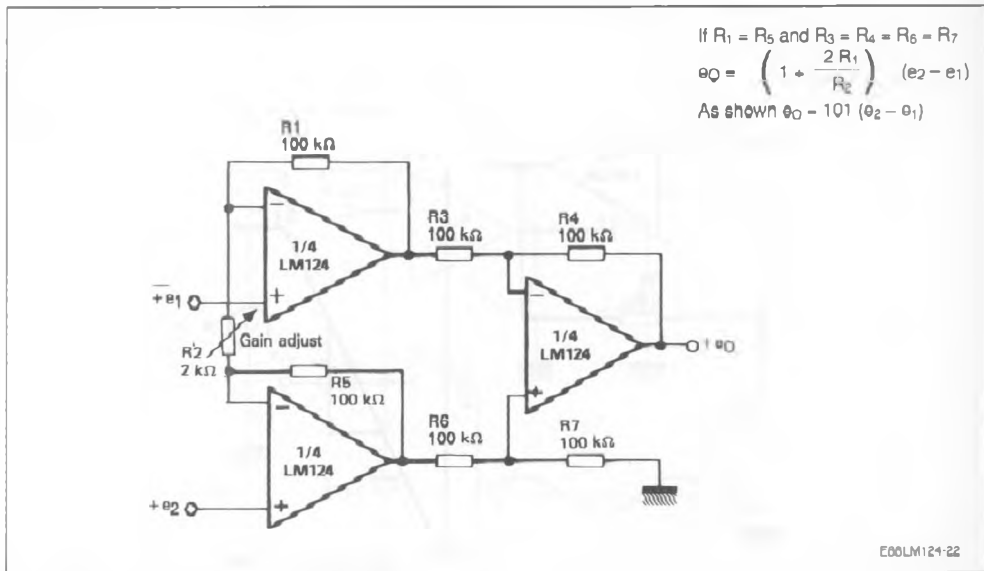


DC SUMMING AMPLIFIER

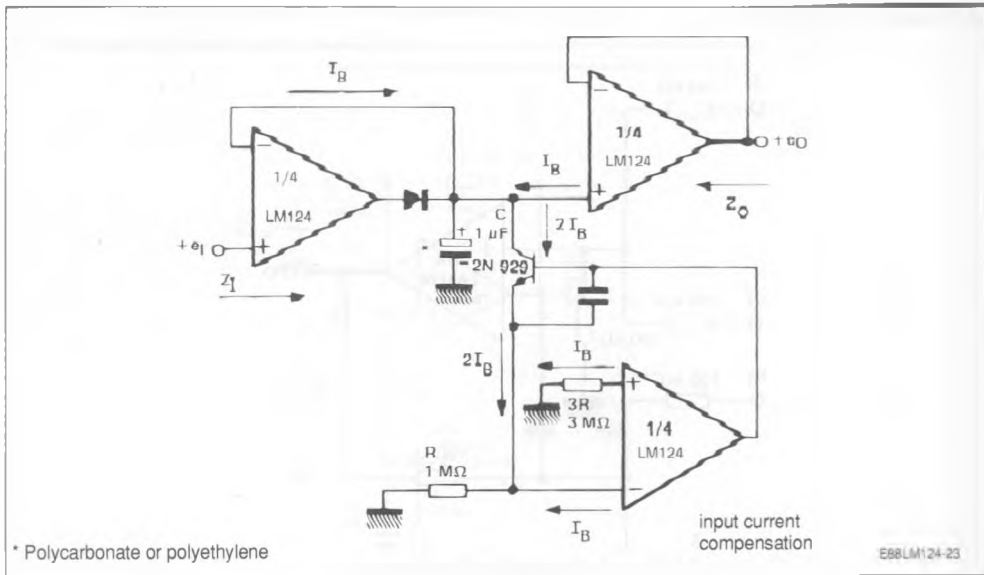


TYPICAL SINGLE SUPPLY APPLICATIONS (continued)

HIGH INPUT Z ADJUSTABLE GAIN DC INSTRUMENTATION AMPLIFIER

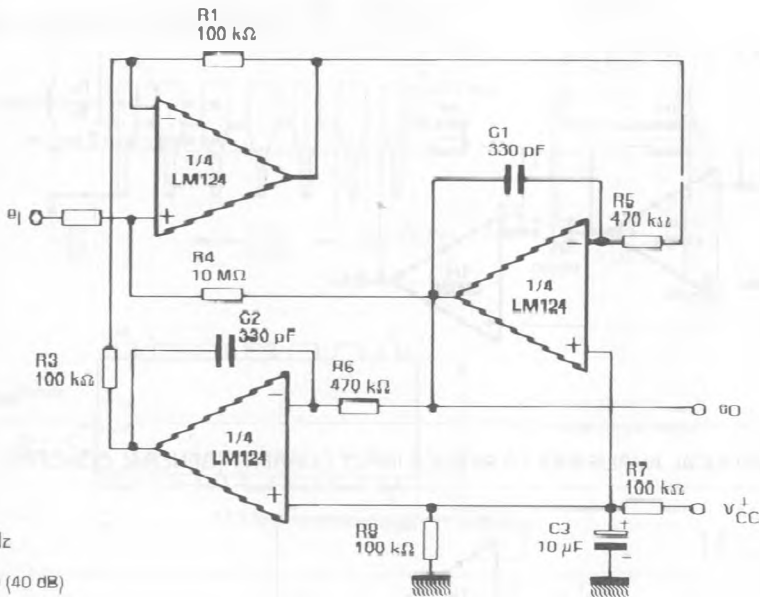


LOW DRIFT PEAK DETECTOR



TYPICAL SINGLE SUPPLY APPLICATIONS (continued)

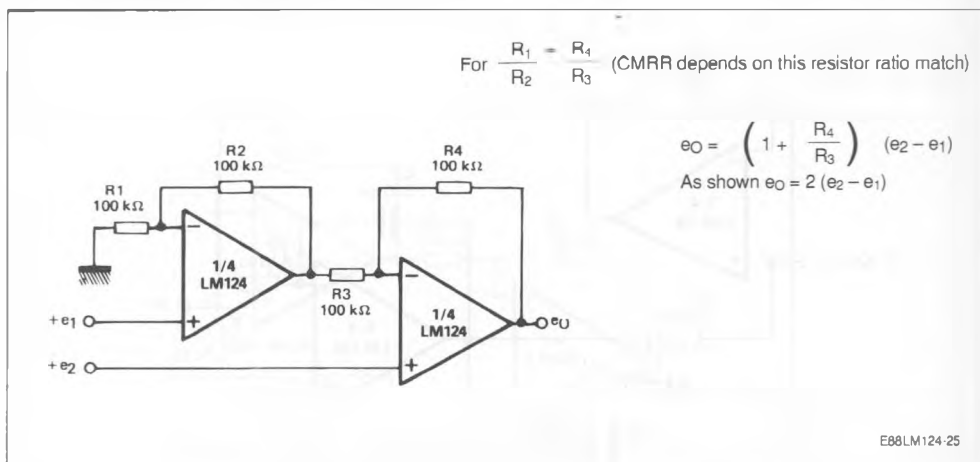
ACTIVE BANDPASS FILTER



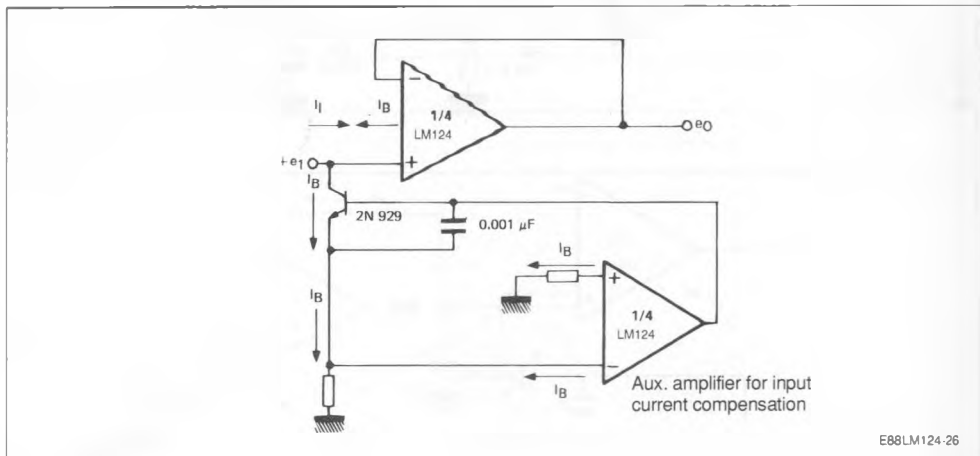
C00LM124-74

TYPICAL SINGLE SUPPLY APPLICATIONS (continued)

HIGH INPUT Z, DC DIFFERENTIAL AMPLIFIER

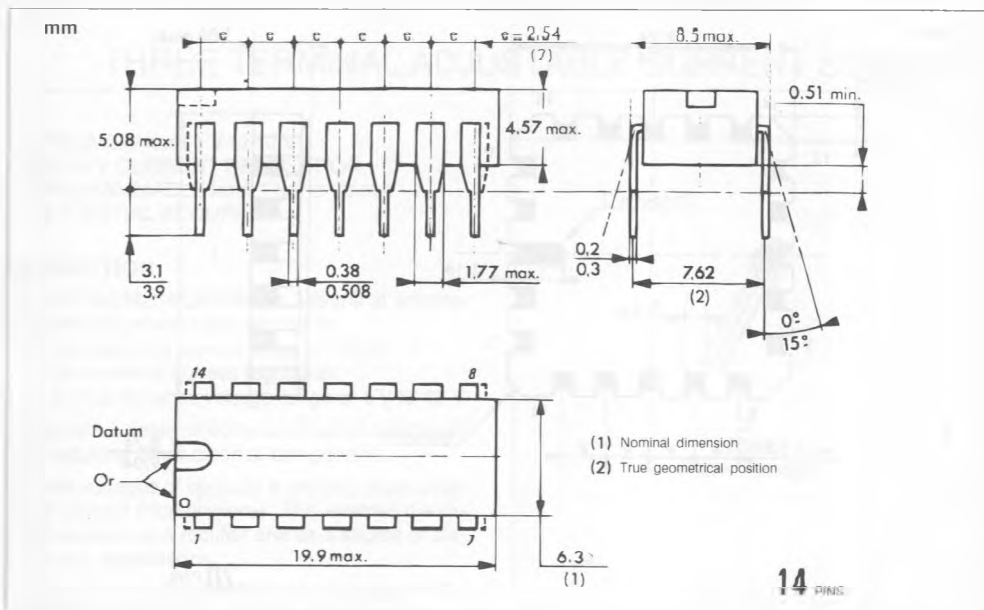


USING SYMMETRICAL AMPLIFIERS TO REDUCE INPUT CURRENT (GENERAL CONCEPT)

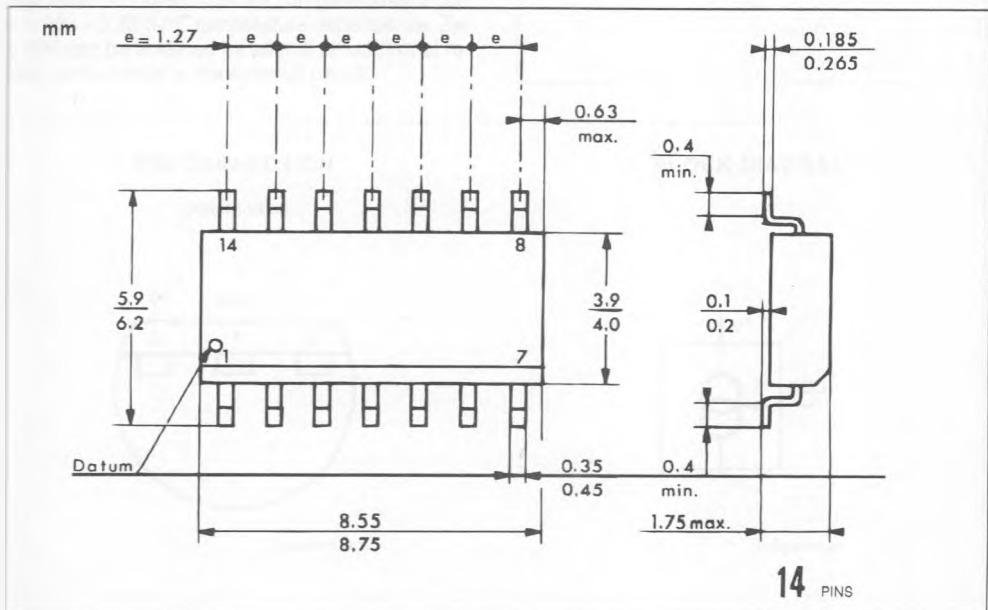


PACKAGE MECHANICAL DATA

14 PINS – N SUFFIX – PLASTIC PACKAGE – J SUFFIX – Cerdip PACKAGE



14 PINS – D SUFFIX – PLASTIC MICROPACKAGE.



PACKAGE MECHANICAL DATA (continued)

20 PINS – GC SUFFIX – TRICECOP (LCC)

