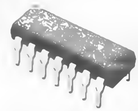
SGS-THOMSON MICROELECTRONICS

LM124,A-LM224,A LM324,A-LM2902

LOW POWER QUAD OPERATIONAL AMPLIFIERS

- LARGE VOLTAGE GAIN : 100 dB
- VERY LOW SUPPLY CURRENT/AMPLI : 375 µA
- 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 : ± 1.5 V TO ± 15 V



N
DIP14
(Plastic Package)
J
CERDIP14
(Cerdip Package)

D
SO14
(Plastic Micropackage)

GC
LCC20
(Tricecop (LCC))

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.

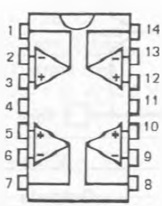
ORDER CODES

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

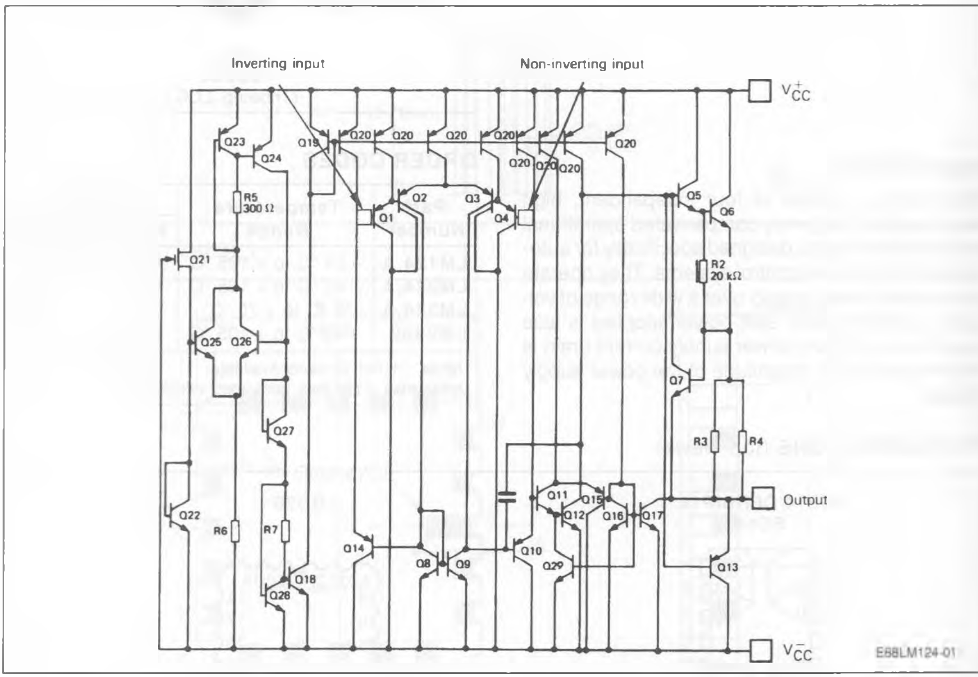
LCC20

1 - NC
2 - Output 1
3 - Inverting input 1
4 - Non-inverting input 1
5 - NC
6 - V^+_{CC}
7 - NC
8 - Non-inverting input 2
9 - Inverting input 2
10 - Output 2
11 - NC
12 - Output 3
13 - Inverting input 3
14 - Non-inverting input 3
15 - NC
16 - V^-_{CC}
17 - NC
18 - Non-inverting input 4
19 - Inverting input 4
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	500 665	500 400	500 400	mW
	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	°C
T_{stg}	Storage Temperature Range		– 65 to 150	– 65 to 150	– 65 to 150	°C

SCHEMATIC DIAGRAM (1/4 LM124)



Case	Inverting Inputs	Non-inverting Inputs	V_{CC}^-	V_{CC}^+	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 V, V^-_{CC} = Ground. V_O = 1.4 V
LM324, A : 0 ≤ T_{amb} ≤ + 70 °C
LM224, A LM2902 : – 40 ≤ T_{amb} ≤ + 105 °C
LM124, A : – 55 ≤ T_{amb} ≤ + 125 °C
(unless otherwise specified)

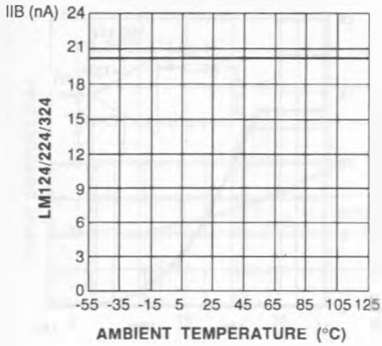
Symbol	Parameter	LM124A, 224A 324A			LM124, 224 324, 2902			Unit
		Min.	Typ.	Max.	Min.	Typ.	Max.	
V_{IO}	Input Offset Voltage (note 3) T_{amb} = + 25 °C T_{min} ≤ T_{amb} ≤ T_{max}		 2	 3 5		 2	 5 7	mV
I_{IO}	Input Offset Current T_{amb} = + 25 °C T_{min} ≤ T_{amb} ≤ T_{max}		 2	 20 40		 2	 20 40	nA
I_{IB}	Input Bias Current (note 2) T_{amb} = + 25 °C T_{min} ≤ T_{amb} ≤ T_{max}		 20	 100 200		 20	 100 200	nA
A_{VD}	Large Signal Voltage Gain (V^+_{CC} = + 15 V, R_L = 2 kΩ) (V_O = 1.4 V to 11.4 V) T_{amb} = + 25 °C T_{min} ≤ T_{amb} ≤ T_{max}	 50 25	 100		 50 25	 100		V/mV
S_{VR}	Supply Voltage Rejection Ratio (R_S ≤ 10 kΩ) T_{amb} = + 25 °C T_{min} ≤ T_{amb} ≤ T_{max}	 65 65	 110		 65 65	 110		dB
I_{CC}	Supply Current, all Amp, no Load T_{amb} = + 25 °C V_{CC} = + 5 V V_{CC} = + 30 V T_{min} ≤ T_{amb} ≤ T_{max} V_{CC} = + 5 V V_{CC} = + 30 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 °C V_{CC} = + 30 V T_{min} ≤ T_{amb} ≤ T_{max}	 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 ≤ 10 kΩ) T_{amb} = + 25 °C T_{min} ≤ T_{amb} ≤ T_{max}	 70 60	 80		 70 60	 80		dB
I_O	Output Short-circuit Current (V_I^+ = + 1 V, V_I^- = 0 V, V_{CC} = + 15 V) T_{amb} = + 25 °C T_{min} ≤ T_{amb} ≤ T_{max}	 20 10	 40	 60	 20 10	 40	 60	mA
I_{sink}	Output Current Sink (V_I^+ = – 1 V, V_I^- = 0 V) V_{CC} = + 15 V T_{amb} = + 25 °C T_{min} ≤ T_{amb} ≤ T_{max} V_O = + 0.2 V T_{amb} = + 25 °C T_{min} ≤ T_{amb} ≤ T_{max}	 10 10 12 12	 20 50		 10 10 12 12	 20 50		 mA µA
V_{OPP}	Output Voltage Swing T_{amb} = + 25 °C R_L ≥ 2 kΩ T_{min} ≤ T_{amb} ≤ T_{max} R_L ≥ 2 kΩ	 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 V) T_{amb} = + 25 °C R_L = 2 kΩ $T_{min} \le T_{amb} \le T_{max}$ T_{amb} = + 25 °C R_L = 10 kΩ $T_{min} \le T_{amb} \le T_{max}$	 26 26 27 27	 27 28 		 26 26 27 27	 27 28 		V
V_{OL}	Low Level Output Voltage ($R_L \le$ 10 kΩ) T_{amb} = + 25 °C $T_{min} \le T_{amb} \le T_{max}$	 5 	 20 20			 5 	 20 20	V
S_{VO}	Slew-rate (V_I = 0.5 to 3 V, R_L = 2 kΩ CL < 100 pF, T_{amb} = + 25 °C, unity gain V_{CC} = 15 V)	0.2	0.4		0.2	0.4		V/µs
GBP	Gain Bandwidth Product, V_{CC} = 30 V (f = 100 kHz, T_{amb} = + 25 °C, V_{IN} = 10 mV R_L = 2 kΩ, CL = 100 pF)	0.7	1.3	1.8	0.7	1.3	1.8	MHz
THD	Total Harmonic Distortion (f = 1 kHz, A_V = 20 dB, R_L = 2 kΩ, V_O = 2 V_{pp} CL < 100 pF, T_{amb} = + 25 °C, V_{CC} = 30 V)		0.015			0.015		%
V_n	Equivalent Input Noise Voltage (f = 1 kHz, R_g = 100 Ω, V_{CC} = 30 V)		40			40		$nV/\sqrt{Hz}$
DV_{io}	Average Temperature Coefficient of Input Offset Voltage $T_{min} \le T_{amb} \le T_{max}$		7	30		7	30	µV/°C
DI_{IO}	Average Temperature Coeff. of Input Offset Current $T_{min} \le T_{amb} \le T_{max}$		10	300		10	300	pA/°C
V_O1/V_O2	Channel Separation (note 5) 1 kHz ≤ f ≤ 20 kHz		120			120		dB

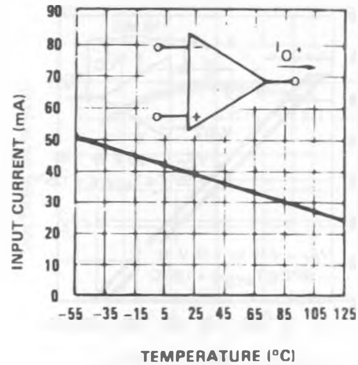
Notes :
1. Short-circuits from the output to V_{CC} can cause excessive heating if V_{CC} > 15 V. The maximum output current is approximatively 40 mA independent of the magnitude of V_{CC}. Destructive dissipation can result from simultaneous short-circuits on all amplifiers.
2. The direction of the input current is out of the IC. This current is essentialy constant, independent of the state of the output so no loading change exists on the input lines.
3. V_o = 1.4 V, R_s = 0, 5 V < V_{CC} < 30 V, 0 < V_i < V_{CC} – 1.5 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 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 frequences.
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.

INPUT BIAS CURRENT vs AMBIENT TEMPERATURE



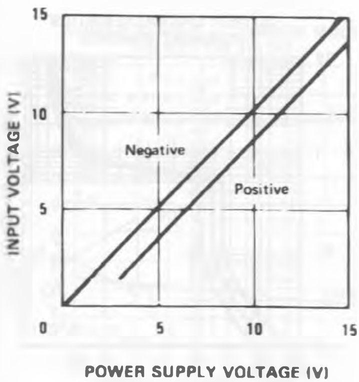
E88LM124-02

CURRENT LIMITING (Note 8)



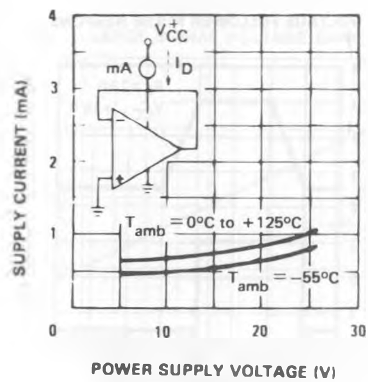
E88LM124-03

INPUT VOLTAGE RANGE



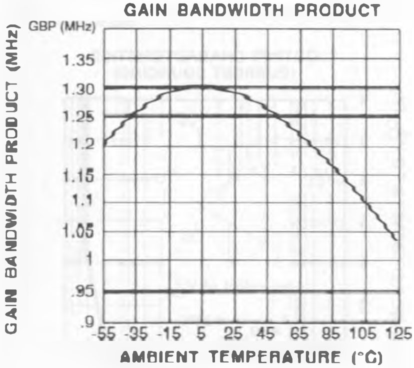
E88LM124-04

SUPPLY CURRENT



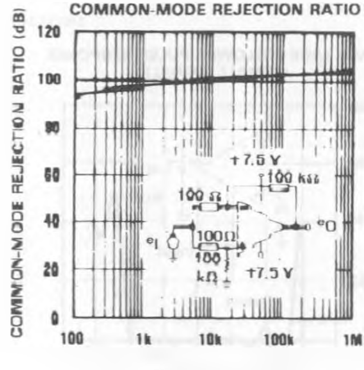
E88LM124-05

GAIN BANDWIDTH PRODUCT



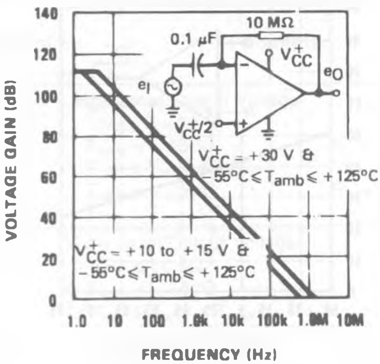
E88LM124-06

COMMON-MODE REJECTION RATIO



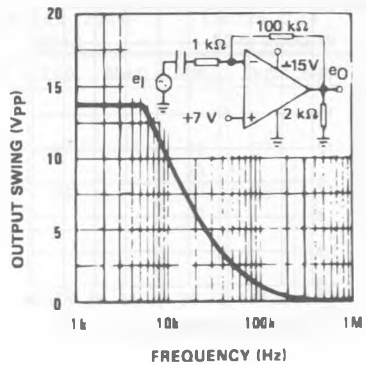
E88LM124-07

OPEN LOOP FREQUENCY RESPONSE



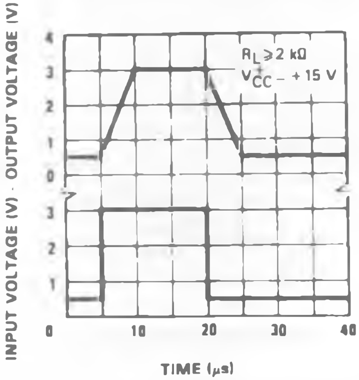
E88LM124-08

LARGE SIGNAL FREQUENCY RESPONSE



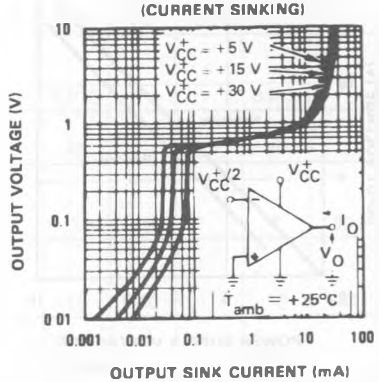
E88LM124-09

VOLTAGE FOLLOWER PULSE RESPONSE



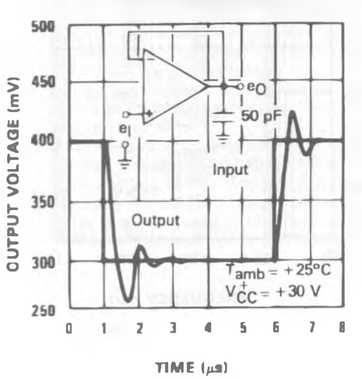
E88LM124-10

OUTPUT CHARACTERISTICS (CURRENT SINKING)



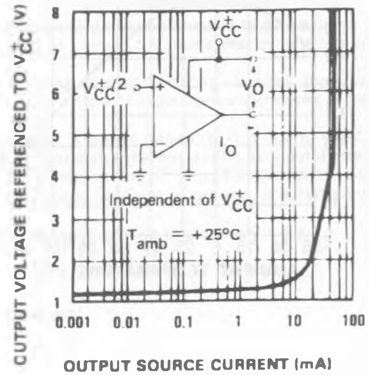
E88LM124-11

VOLTAGE FOLLOWER PULSE RESPONSE (SMALL SIGNAL)

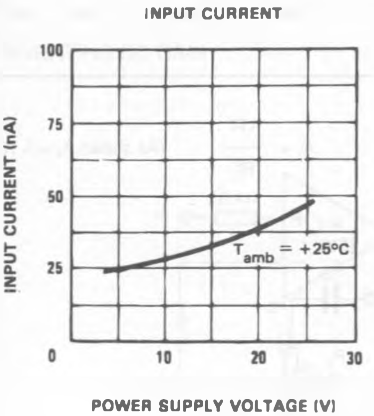


E88LM124-12

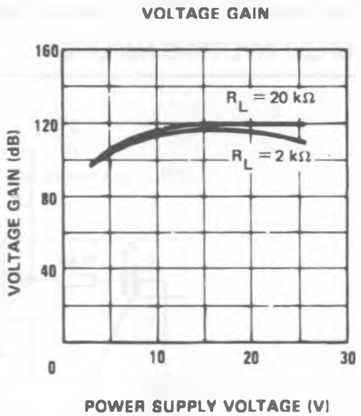
OUTPUT CHARACTERISTICS (CURRENT SOURCING)



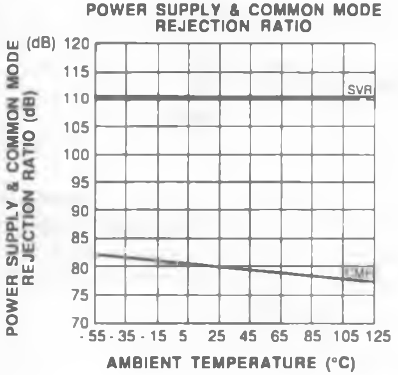
E88LM124-13



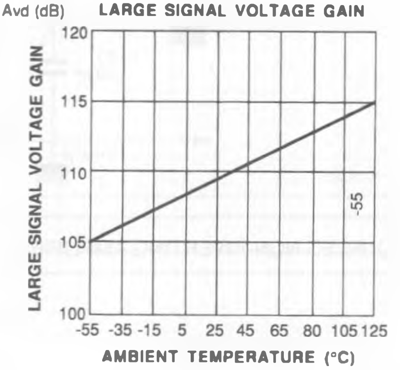
E88LM124-14



E88LM124-15



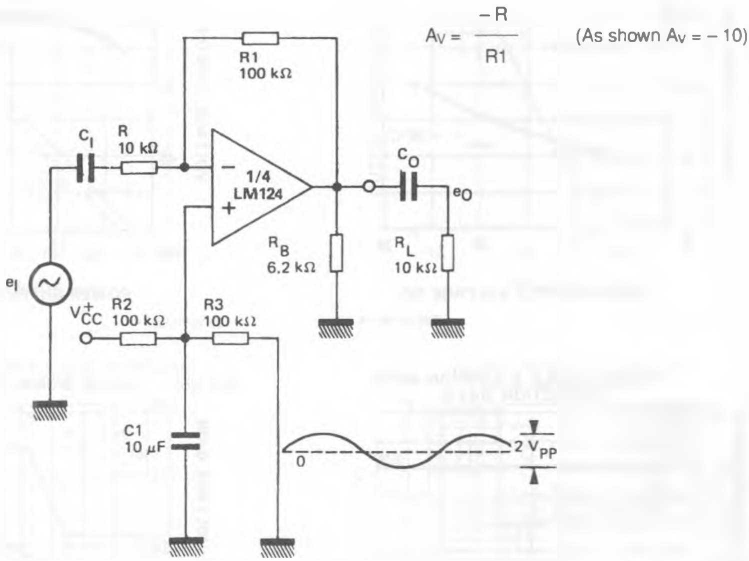
E88LM124-16



E88LM124-17

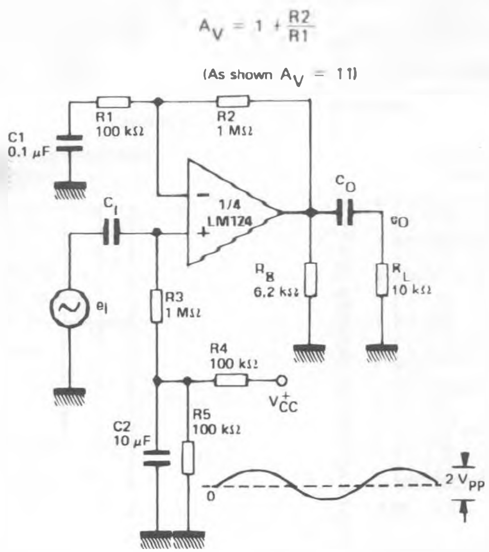
TYPICAL SINGLE - SUPPLY APPLICATIONS

AC COUPLED INVERTING AMPLIFIER



E88LM124-18

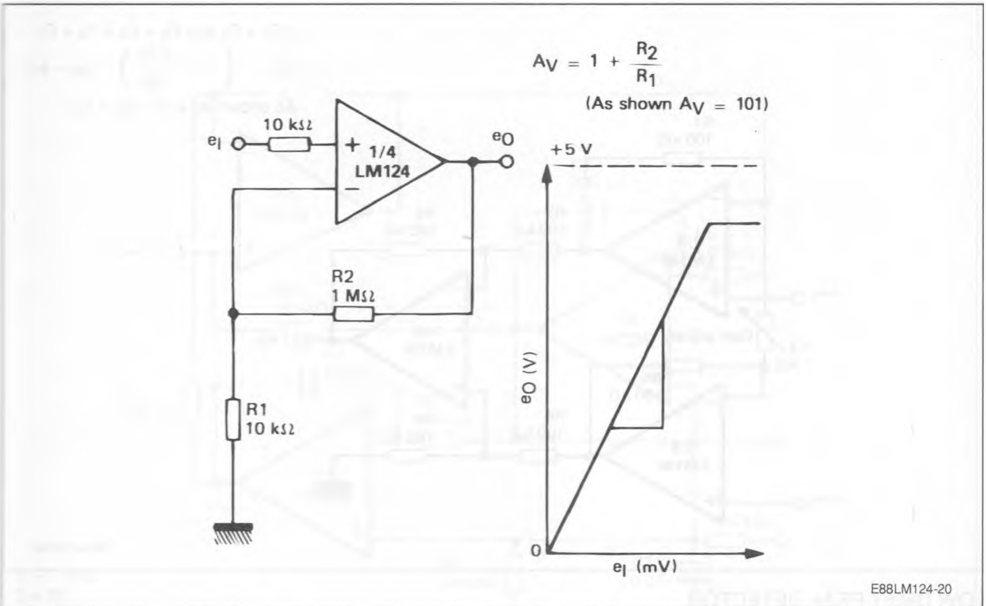
AC COUPLED NON-INVERTING AMPLIFIER



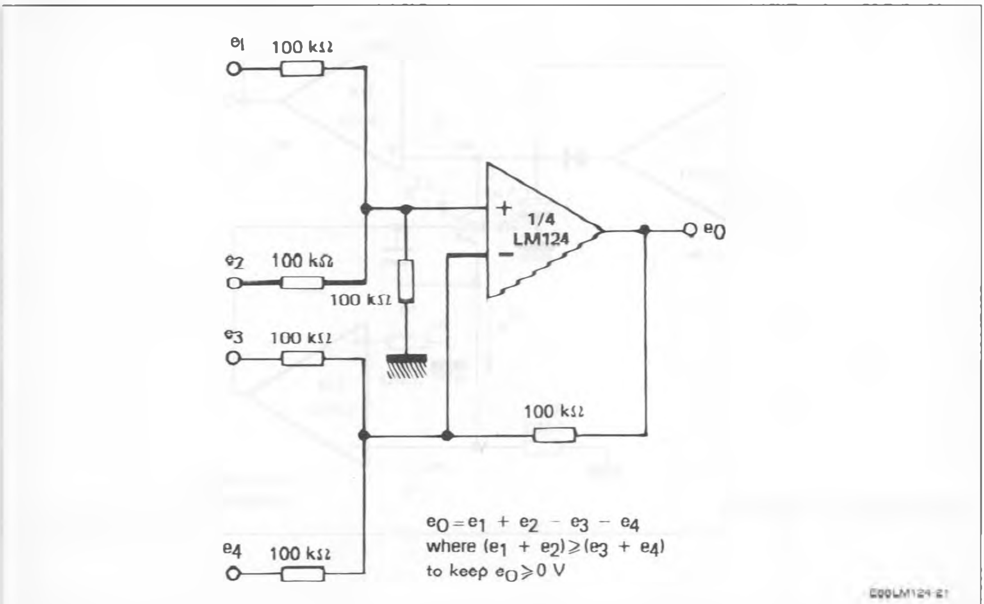
E88LM124-19

TYPICAL SINGLE - SUPPLY APPLICATIONS (continued)

NON-INVERTING DC GAIN



DC SUMMING AMPLIFIER



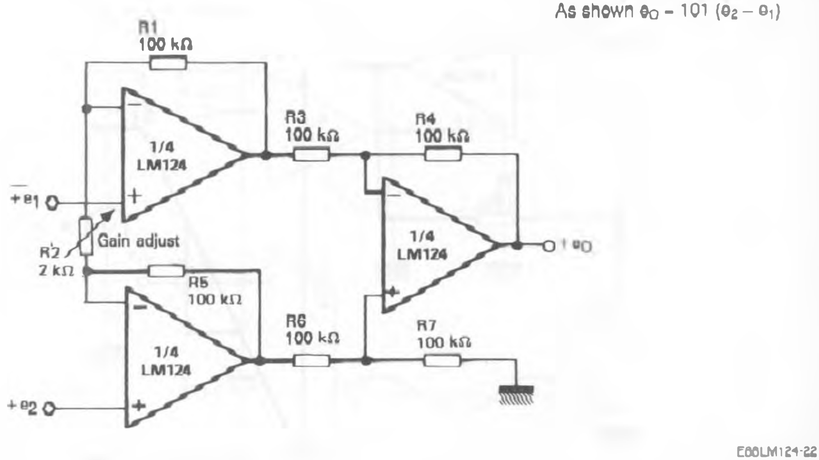
TYPICAL SINGLE SUPPLY APPLICATIONS (continued)

HIGH INPUT Z ADJUSTABLE GAIN DC INSTRUMENTATION AMPLIFIER

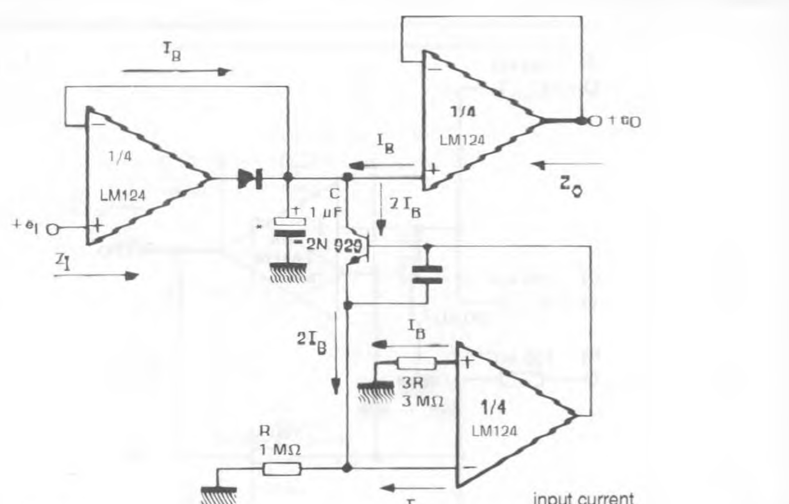
If $R_1 = R_5$ and $R_3 = R_4 = R_6 = R_7$

$$e_O = \left(1 + \frac{2R_1}{R_2}\right)(e_2 - e_1)$$

As shown $e_O = 101\,(e_2 - e_1)$



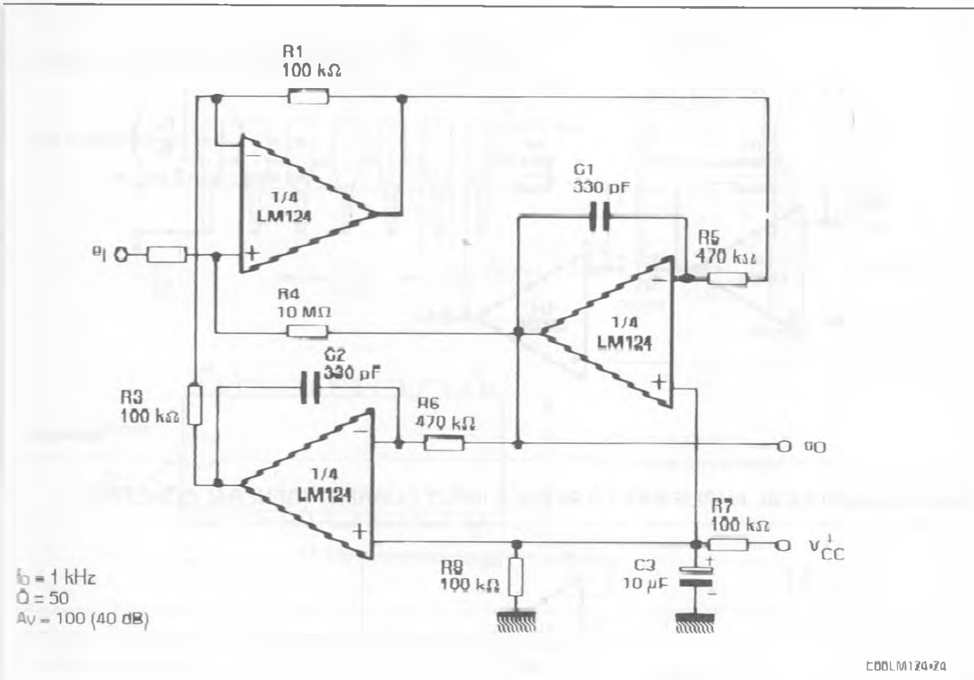
LOW DRIFT PEAK DETECTOR



* Polycarbonate or polyethylene

TYPICAL SINGLE SUPPLY APPLICATIONS (continued)

ACTIVE BANDPASS FILTER



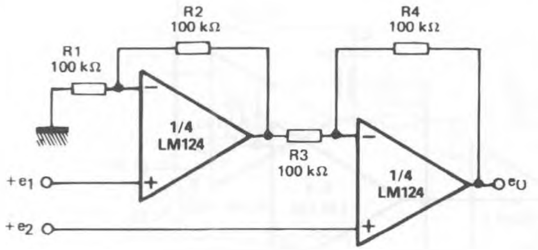
TYPICAL SINGLE SUPPLY APPLICATIONS (continued)

HIGH INPUT Z, DC DIFFERENTIAL AMPLIFIER

For $\frac{R_1}{R_2} = \frac{R_4}{R_3}$ (CMRR depends on this resistor ratio match)

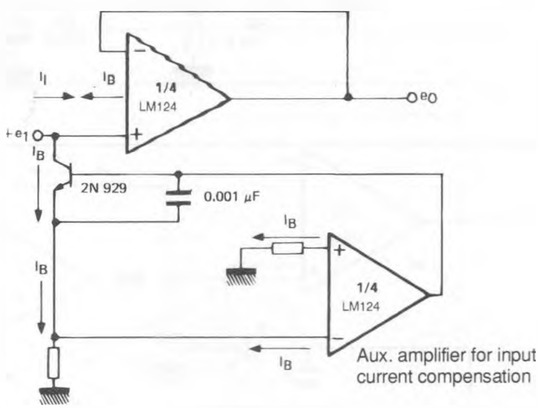
$$e_O = \left(1 + \frac{R_4}{R_3}\right)(e_2 - e_1)$$

As shown $e_O = 2\,(e_2 - e_1)$



E88LM124-25

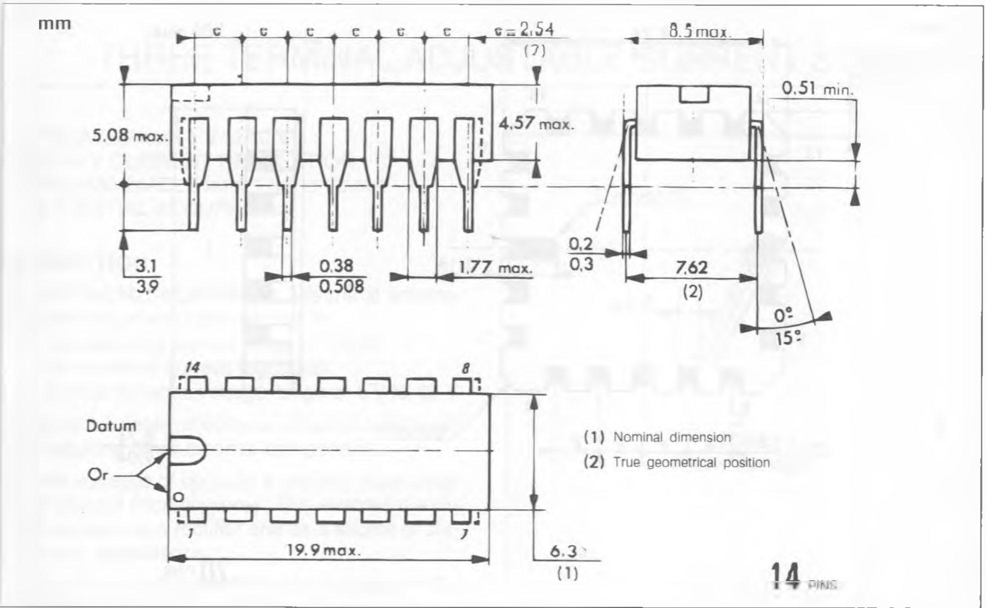
USING SYMMETRICAL AMPLIFIERS TO REDUCE INPUT CURRENT (GENERAL CONCEPT)



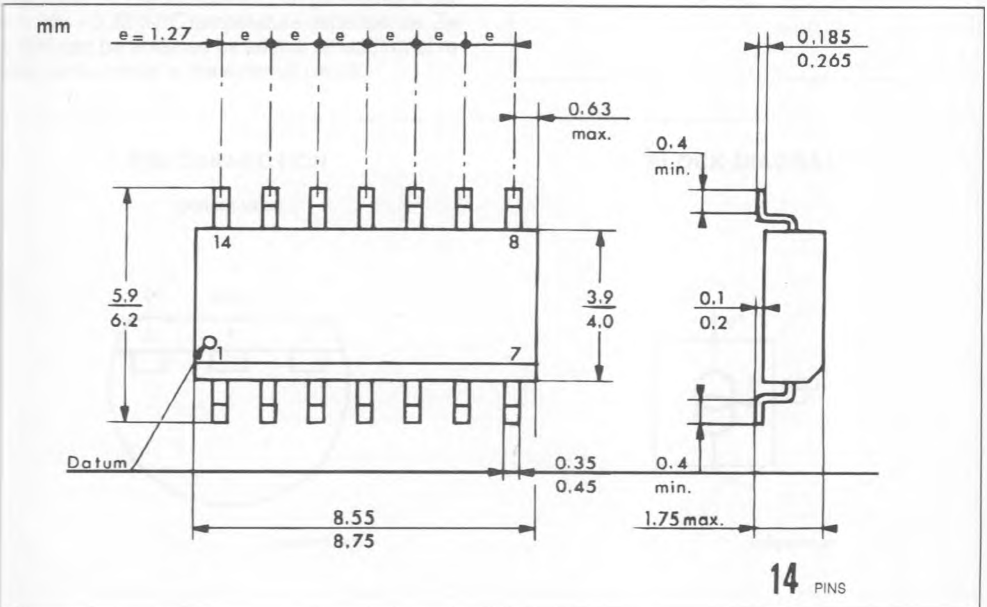
E88LM124-26

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)