THOMSON SEMICONDUCTORS

LM124
LM224
LM324,A
LM2902

LOW POWER QUAD OPERATIONAL AMPLIFIERS

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.

- Large voltage gain : 100 dB.
- Very low supply current drain : 800 μA.
- Low input bias current : 45 nA.
- Low input offset voltage : 2 mV.
- Low input offset current : 5 nA.

Wide power supply range :

- Single supply : +3 V to +30 V.
- Dual supplies for LM124 : ±1.5 V to ±15 V.
- Single supply for LM2902 : +3 V to +26 V.

ORDERING INFORMATION

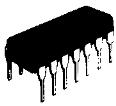
Hi-Rel versions available - See chapter 14

PART NUMBER	TEMPERATURE RANGE	PACKAGE			
		DP	DG	GC	FP
LM124	−55°C to +125°C		•	•	
LM224	−25°C to + 85°C	•	•		
LM324, A	0°C to + 70°C	•	•		•
LM2902	−40°C to + 85°C	•			•
Examples : LM124DG, LM124GC, LM224DP					

LOW POWER QUAD OPERATIONAL AMPLIFIERS

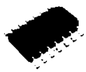
CASES

CB-2



DP SUFFIX
PLASTIC PACKAGE
DG SUFFIX
CERDIP PACKAGE

CB-511



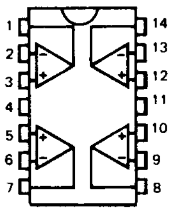
FP SUFFIX
PLASTIC
MICROPACKAGE

CB-705

GC SUFFIX
TRICECOP (LCC)

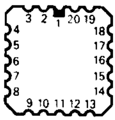
PIN ASSIGNMENTS
(Top views)

CB-2
CB-511



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

CB-705



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

Réf. 00305

Sales headquarters
45, av. de l'Europe - 78140 VELIZY - FRANCE
Tel. : (3) 946 97 19 / Telex : 204780 F

MAXIMUM RATINGS

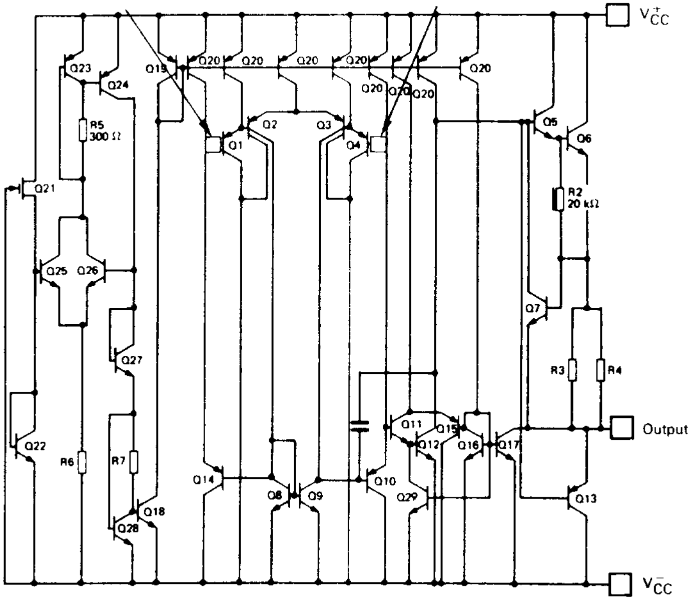
Rating	Symbol	LM124	LM224	LM324,A	LM2902	Unit
Supply voltage	V_{CC}	± 16 or 32	± 16 or 32	± 16 or 32	± 13 or 26	V
Differential input voltage	V_{ID}	32	32	32	26	V
Input voltage (Note 7)	V_I	− 0.3 to + 32	− 0.3 to + 32	− 0.3 to + 32	− 0.3 to + 26	V
Output short circuit duration (V_{CC} = ± 15 V, T_{amb} = + 25°C)	–	Indefinite for all amplifiers				–
Power dissipation (Note 1) LM124GC LM324FP, AFP/LM2902FP	P_{tot}	500 665	500	500 400	500 – 400	mW
Operating free-air temperature range	T_{oper}	− 55 to + 125	− 25 to + 85	0 to + 70	− 40 to + 85	°C
Storage temperature range	T_{stg}	− 65 to + 150	− 65 to + 150	− 65 to + 150	− 65 to + 150	°C

Input current for $V_I \leqslant -0.3, V_{OL}$: 50 mA

See notes page 4

Devices bonded on a 6 cm × 3 cm × 0.15 cm glass epoxy substrate with 30 mm² of 35 μm thick copper.

SCHEMATIC DIAGRAM



CASE	Inverting inputs	Non-inverting inputs	V_{CC}^-	V_{CC}^+	Outputs	N.C.
CB-2/CB-511	2, 6, 9, 13	3, 5, 10, 12	11	4	1, 7, 8, 14	
CB-705	3, 9, 13, 19	4, 8, 14, 18	16	6	1, 2, 12, 20	*

* **CB-705** : Other pins are not connected.

ELECTRICAL CHARACTERISTICS

$V_{CC}^{+} = +5$ V, $V_{CC}^{-} = GND$
LM124 : $-55°C \leq T_{amb} \leq +125°C$
LM224 : $-25°C \leq T_{amb} \leq +85°C$
LM324,A : $0°C \leq T_{amb} \leq +70°C$
LM2902 : $-40°C \leq T_{amb} \leq +85°C$
(Unless otherwise specified)

Characteristic	Symbol	LM124, LM224			LM324,A/LM2902			Unit
		Min	Typ	Max	Min	Typ	Max	
Input offset voltage	V_{IO}							mV
$R_S = 0\ \Omega$, $T_{amb} = +25°C$ - (Note 4)		–	2	5	–	2	7	
LM324A		–	–	–	–	2	3	
$R_S = 0\ \Omega$ - (Note 4)		–	–	7	–	–	9	
LM324A		–	–	–	–	–	5	
LM2902		–	–	–	–	–	10	
Input offset current	I_{IO}							nA
$T_{amb} = +25°C$		–	3	30	–	5	50	
LM324A		–	–	–	–	5	30	
$T_{min} \leq T_{amb} \leq T_{max}$		–	–	100	–	–	150	
LM324A		–	–	–	–	–	75	
LM2902		–	–	–	–	–	200	
Input bias current	I_{IB}							nA
$T_{amb} = +25°C$ - (Note 3)		–	45	100	–	45	250	
LM324A		–	–	–	–	45	100	
$T_{min} \leq T_{amb} \leq T_{max}$		–	40	300	–	40	500	
LM324A		–	–	–	–	40	200	
Large signal voltage gain ($V_{CC} = \pm 15$ V)	A_{VD}							V/mV
$T_{amb} = +25°C$		50	100	–	25	100	–	
LM2902		–	–	–	–	100	–	
$T_{min} \leq T_{amb} \leq T_{max}$, $R_L = 2\ k\Omega$		25	–	–	15	–	–	
Supply voltage rejection ratio ($T_{amb} = +25°C$)	SVR	65	100	–	65	100	–	dB
LM2902		–	–	–	–	100	–	
Supply current ($R_L = \infty$ for all amplifiers)	I_{CC}^{+}, I_{CC}^{-}							mA
$T_{amb} = +25°C$		–	0.7	1.2	–	0.8	1.2	
$V_{CC}^{+} = +30$ V		–	1.5	3	–	1.5	3	
$T_{min} \leq T_{amb} \leq T_{max}$		–	0.8	1.2	–	0.8	1.2	
$V_{CC}^{+} = +30$ V (except for LM2902)		–	1.5	3	–	1.5	3	
Temperature coefficient of input offset voltage ($R_S = 0\ \Omega$)	αV_{IO}	–	7	–	–	7	–	μV/°C
LM324A		–	–	–	–	7	30	
Temperature coefficient of input offset current	αI_{IO}	–	10	–	–	10	–	pA/°C
LM324A		–	–	–	–	10	300	
Input voltage range ($V_{CC}^{+} = +30$ V*) - Note 5	V_I							V
$T_{amb} = +25°C$		0	–	$V_{CC}^{+} - 1.5$	0	–	$V_{CC}^{+} - 1.5$	
$T_{min} \leq T_{amb} \leq T_{max}$		0	–	$V_{CC}^{+} - 2$	0	–	$V_{CC}^{+} - 2$	
Common-mode rejection ratio	CMR	70	85	–	65	70	–	dB
LM324A		–	–	–	65	85	–	
LM2902		–	–	–	50	70	–	
Output short-circuit current ($T_{amb} = +25°C$)	I_{OS}	–	40	60	–	40	60	mA
Output current ($V_{CC}^{+} = +15$ V, $V_I^{+} = +1$ V, $V_I^{-} = 0$ V)	I_O							mA
$T_{amb} = +25°C$		20	40	–	20	40	–	
$T_{min} \leq T_{amb} \leq T_{max}$		10	20	–	10	20	–	
Output current sink ($V_I^{+} = 0$ V, $V_I^{-} = +1$ V)	$I_{O(sink)}$							mA
$V_{CC}^{+} = +15$ V, $T_{amb} = +25°C$		10	20	–	10	20	–	
$V_O = +200$ mV, $T_{amb} = +25°C$		0.012	0.05	–	0.012	0.05	–	
$V_{CC}^{+} = +15$ V, $T_{min} \leq T_{amb} \leq T_{max}$		5	8	–	5	8	–	
Output voltage swing	V_{OPP}							V
$V_{CC}^{+} = +5$ V, $T_{amb} = +25°C$, $R_L \geq 2\ k\Omega$ ($R_L \geq 10\ k\Omega$ for LM2902)		0	–	$V_{CC}^{+} - 1.5$	0	–	$V_{CC}^{+} - 1.5$	
High level output voltage ($V_{CC}^{+} = +30$ V)*	V_{OH}							V
$R_L = 2\ k\Omega$		26	–	–	26	–	–	
LM2902		–	–	–	22	–	–	
$R_L = 10\ k\Omega$		27	28	–	27	28	–	
LM2902		–	–	–	23	24	–	
Low level output voltage ($R_L \leq 10\ k\Omega$)	V_{OL}	–	5	20	–	5	20	mV
LM2902		–	–	–	–	5	100	
Amplifier to amplifier coupling	–							dB
1 kHz $\leq f \leq$ 20 kHz, $T_{amb} = +25°C$ - (Note 6)		–	– 120	–	–	– 120	–	

* $V_{CC}^{+} = +26$ V for LM2902

Note 1 : $R_{th(j-a)}$ = 175°C/W, T_j max = +125°C (LM324) for T_{case} = +25°C
T_j max = +150°C (LM124, 224, 2902) for T_{case} = +50°C
* $R_{th(j-a)}$ = 250°C/W, T_j max = +125°C (LM324FP, LM2902FP) for T_{case} = +25°C
The dissipation is the total of all four amplifiers.

Note 2 : Short-circuits from the output to V_{CC}^+ can cause excessive heating and eventual destruction. The maximum output current is approximately 40 mA independent of the magnitude of V_{CC}^+. At values of supply voltage in excess of +15 V, continuous short-circuits can exceed the power dissipation ratings and cause eventual destruction. Destructive dissipation can result from simultaneous shorts on all amplifiers.

Note 3 : The direction of the output current is out of the IC due to the PNP input stage. This current is essentially constant, independent of the state of the output so no loading change exists on the input lines.

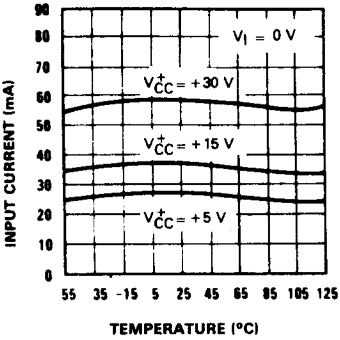
Note 4 : V_O = +1.4 V, R_S = 0 Ω, +5 V ≤ V_{CC}^+ ≤ +30 V, V_{CC}^- = Ground, 0 ≤ V_I ≤ (V_{CC}^+ − 1.5 V).

Note 5 : 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.

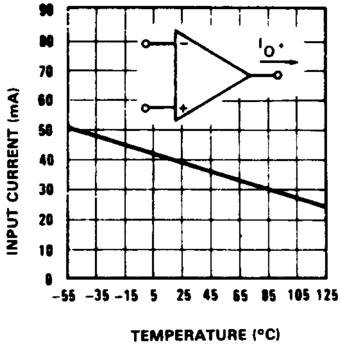
Note 6 : Due to proximity of external components, insure that coupling is not originating via stray capacitance between these external parts. This typically can be detected as this type of capacitive coupling increases at higher frequencies.

Note 7 : This input current will 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 transistors becoming forward biased and thereby acting as input diode clamps. In addition to this diode action, there is also lateral NPN parasitic transistor 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 that an input is driven negative. This is not destructive and normal output states will re-establish when the input voltage, which was negative, again returns to a value greater than −0.3 V_{DC}.

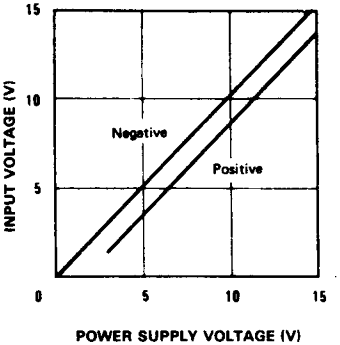
INPUT CURRENT (Note 8)



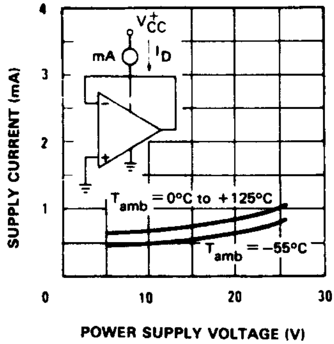
CURRENT LIMITING (Note 8)



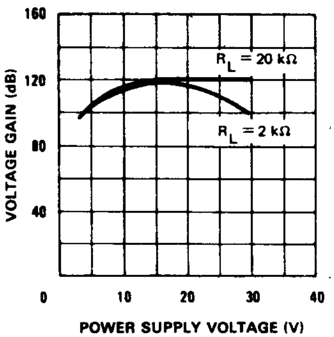
INPUT VOLTAGE RANGE



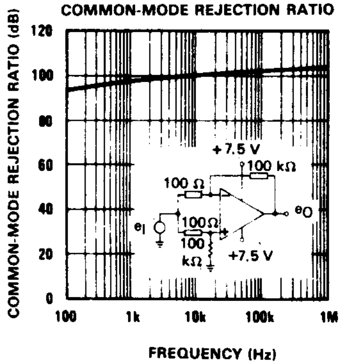
SUPPLY CURRENT



VOLTAGE GAIN

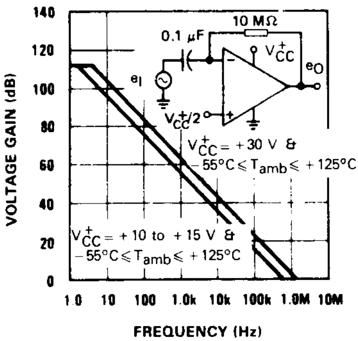


COMMON-MODE REJECTION RATIO

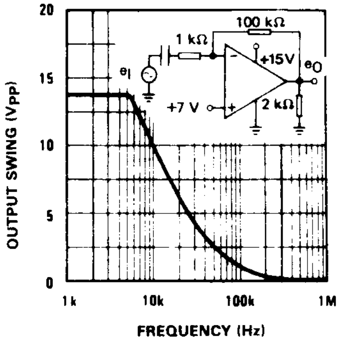


Note 8 : LM124 : $-55°C \leq T_{amb} \leq +125°C$
LM224 : $-25°C \leq T_{amb} \leq +85°C$
LM324,A : $0°C \leq T_{amb} \leq +70°C$
LM2902 : $-40°C \leq T_{amb} \leq +85°C$

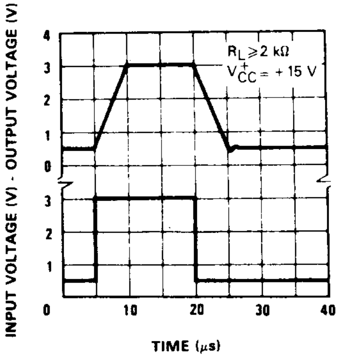
OPEN LOOP FREQUENCY RESPONSE



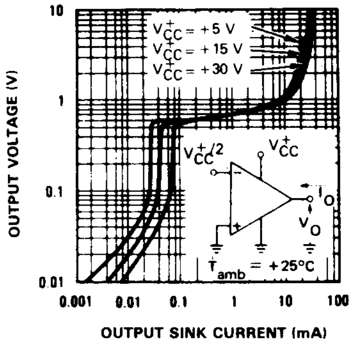
LARGE SIGNAL FREQUENCY RESPONSE



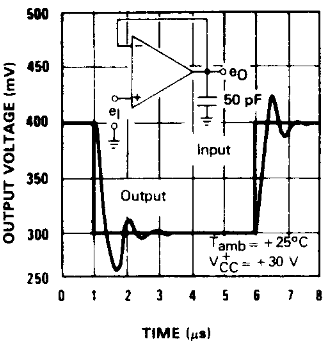
VOLTAGE FOLLOWER PULSE RESPONSE



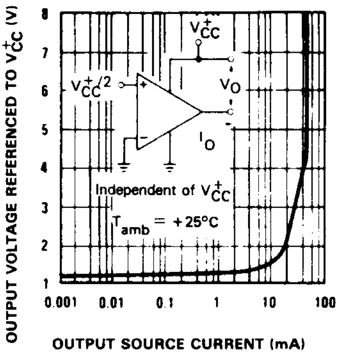
OUTPUT CHARACTERISTICS
(CURRENT SINKING)

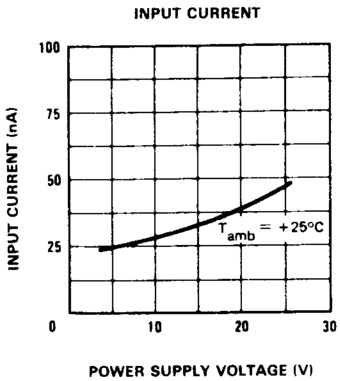


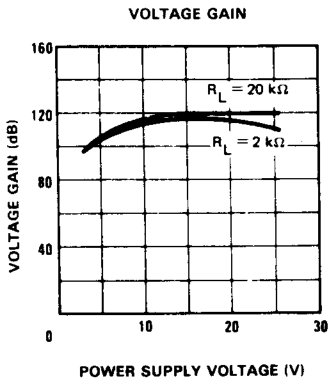
VOLTAGE FOLLOWER PULSE RESPONSE
(SMALL SIGNAL)



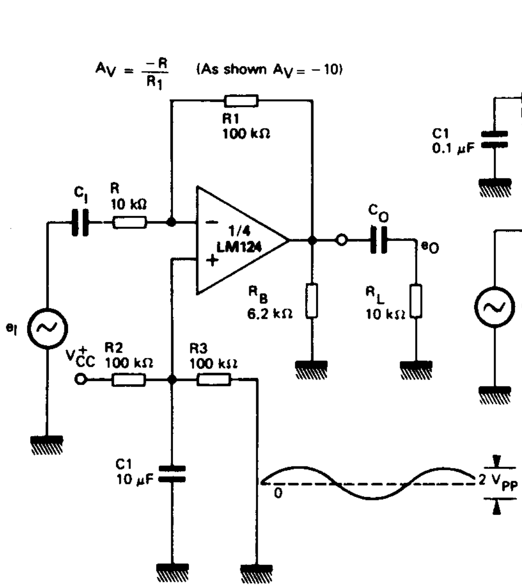
OUTPUT CHARACTERISTICS
(CURRENT SOURCING)



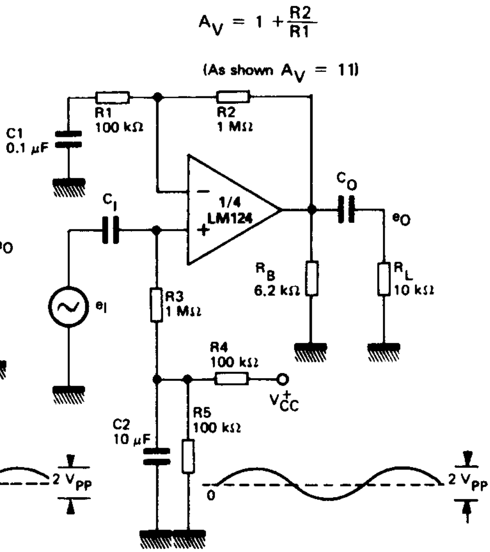

INPUT CURRENT
100
75
50
25
0
10
20
30
INPUT CURRENT (nA)
T amb = +25°C
POWER SUPPLY VOLTAGE (V)


VOLTAGE GAIN
160
120
80
40
0
10
20
30
VOLTAGE GAIN (dB)
R L = 20 kΩ
R L = 2 kΩ
POWER SUPPLY VOLTAGE (V)

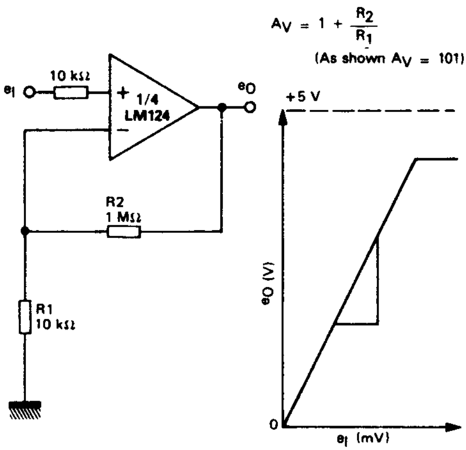
TYPICAL SINGLE - SUPPLY APPLICATIONS



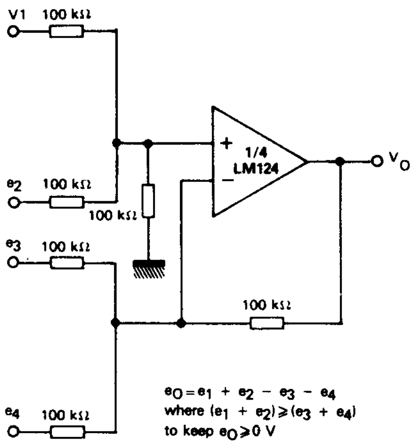
AC COUPLED INVERTING AMPLIFIER



AC COUPLED NON-INVERTING AMPLIFIER



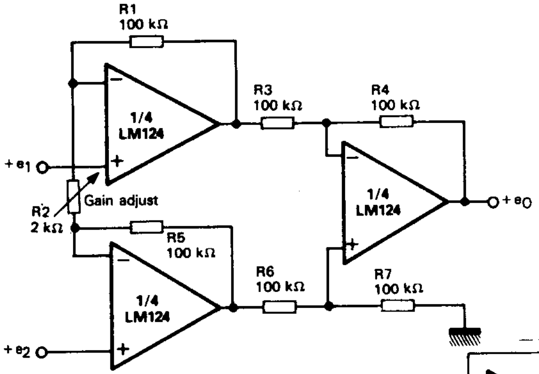
NON-INVERTING DC GAIN



DC SUMMING AMPLIFIER

TYPICAL SINGLE SUPPLY APPLICATIONS (continued)

HIGH INPUT Z ADJUSTABLE GAIN DC INSTRUMENTATION AMPLIFIER

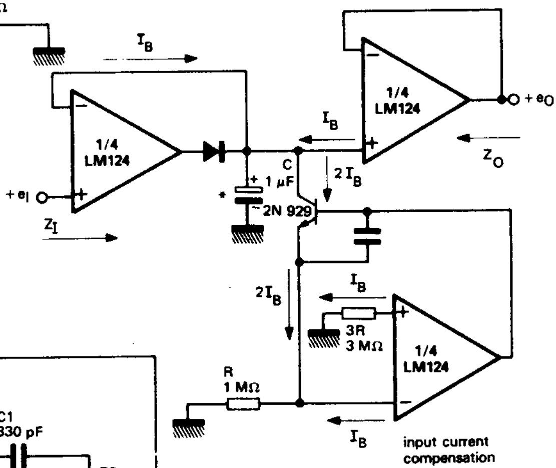


If $R_1 = R_5$ and $R_3 = R_4 = R_6 = R_7$

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

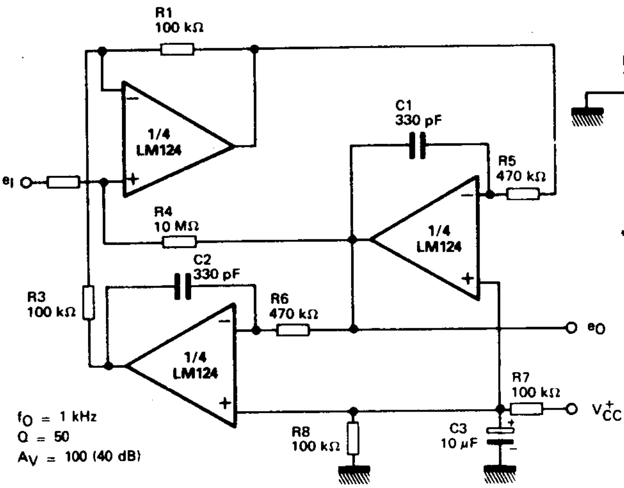
As shown $e_O = 101\,(e_2 - e_1)$

LOW DRIFT PEAK DETECTOR



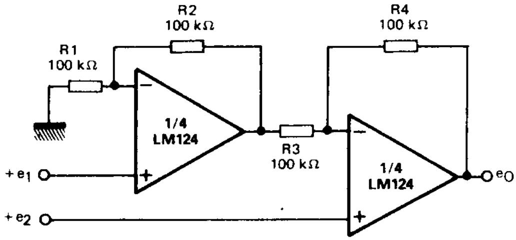
* Polycarbonate or polyethylene

ACTIVE BANDPASS FILTER



TYPICAL SINGLE - SUPPLY APPLICATIONS (continued)

HIGH INPUT Z, DC DIFFERENTIAL AMPLIFIER

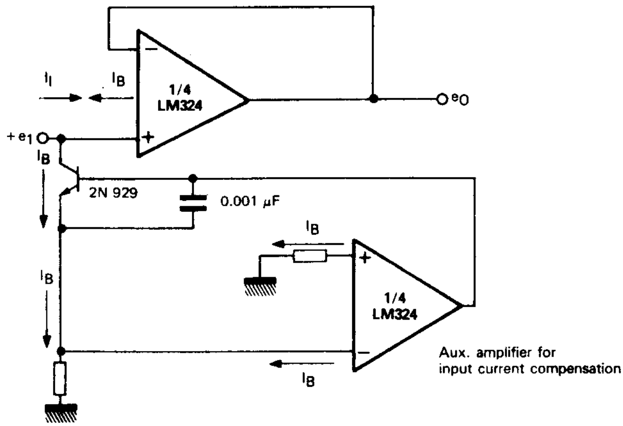


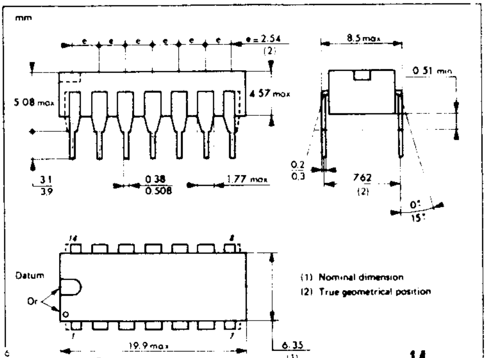
For $\frac{R_1}{R_2} = \frac{R_4}{R_3}$ (CMRR depends on this resistor ratio match)

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

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

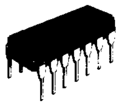
USING SYMMETRICAL AMPLIFIERS TO REDUCE INPUT CURRENT (GENERAL CONCEPT)



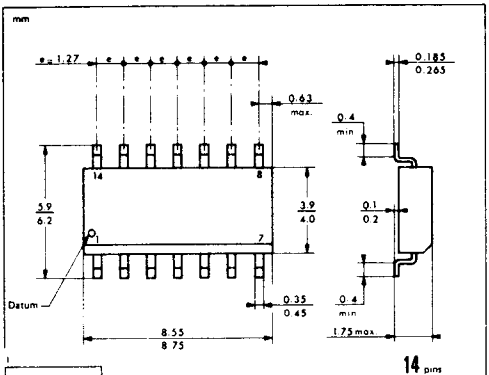


DIN				
A50B CEI	TO-116 DATA	TO-116 JEDEC	F 105 SITELESC	CB-2 THOMSON SEMICONDUCTORS

CB-2



DP SUFFIX
PLASTIC PACKAGE
DG SUFFIX
CERDIP PACKAGE



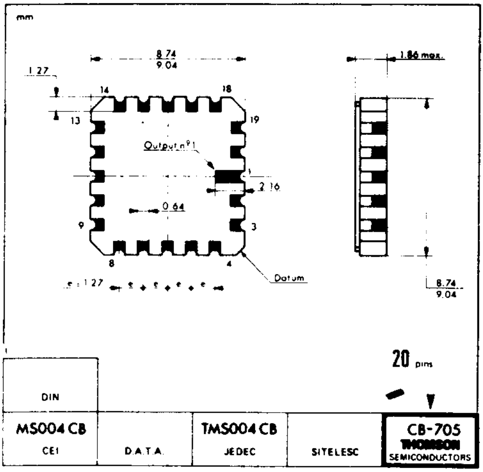
DIN	SO14			
CEI	DATA	JEDEC	SITELESC	CB-511 THOMSON SEMICONDUCTORS

CB-511

FP SUFFIX
PLASTIC MICROPACKAGE

CB-705

GC SUFFIX
TRICECOP (LCC)



These specifications are subject to change without notice.
Please inquire with our sales offices about the availability of the different packages.