HARRIS SEMICONDUCTOR

CA124, CA224, CA324 LM324*, LM2902*

Quad Operational Amplifiers for Commercial, Industrial, and Military Applications

March 1993

Features

- Operation from Single or Dual Supplies
- Unity-Gain Bandwidth ..... 1MHz (Typ.)
- DC Voltage Gain ..... 100dB (Typ.)
- Input Bias Current ..... 45nA (Typ.)
- Input Offset Voltage ..... 2mV (Typ.)
- Input Offset Current
  - CA224, CA324, LM324, LM2902 ..... 5nA (Typ.)
  - CA124 ..... 3nA (Typ.)
- Replacement for Industry Types 124, 224, 324

Applications

- Summing Amplifiers
- Multivibrators
- Oscillators
- Transducer Amplifiers
- DC Gain Blocks

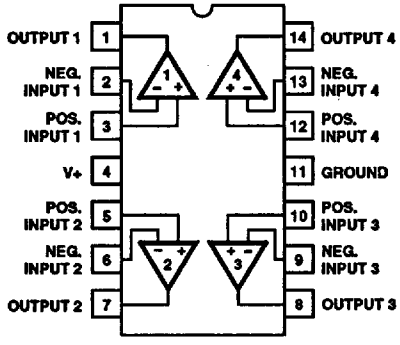
Description

The CA124, CA224, CA324, LM324, and LM2902 consist of four independent, high-gain operational amplifiers on a single monolithic substrate. An on-chip capacitor in each of the amplifiers provides frequency compensation for unity gain. These devices are designed specially to operate from either single or dual supplies, and the differential voltage range is equal to the power-supply voltage. Low power drain and an input common-mode voltage range from 0V to V+ -1.5V (single-supply operation) make these devices suitable for battery operation.

The CA124, CA224, CA324, LM324 and LM2902 are supplied in both 14-lead dual-in-line plastic (E suffix) and 14-lead (150 mil) small outline (M suffix) packages. The CA324 is available in chip form (H suffix).

Pinout

CA124, CA224, CA324, LM324, LM2902
(PDIP, SOIC)
TOP VIEW



* Technical Data on LM Branded types is identical to the corresponding CA Branded types.

CAUTION: These devices are sensitive to electrostatic discharge. Users should follow proper I.C. Handling Procedures.

File Number 796.2

Absolute Maximum Ratings

Supply Voltage . . . . . .32V to ±16V
Differential Input Voltage. 32V
Input Voltage. . . . . -0.3V to +32V
Input Current (V_I < -0.3V) (Note 1) 50mA
Output Short Circuit Duration (V+ ≤ 15V) (Note 2) . . . . . Continuous
Power Dissipation
  Up to T_A = +55°C 750mW
  Above T_A = +55°C. . . . . Derate Linearly at 6.67mW/°C
Junction Temperature. . . . . +175°C
Junction Temperature (Plastic Package) . . . . . +150°C
Lead Temperature (Soldering 10 Sec.). . . . . .+300°

Operating Conditions

Operating Temperature Range . . . . . -55°C to +125°C
Storage Temperature Range. . . . . -65°C to +150°C

Electrical Specifications

Values Apply for Each Operational Amplifier. Supply Voltage (V+) = 5V, Unless Otherwise Specified

PARAMETERS	SYMBOL	TEST CONDITIONS	CA124 LIMITS MIN	CA124 LIMITS TYP	CA124 LIMITS MAX	UNITS
T_A = +25°C						
Input Offset Voltage	V_{IO}	(Note 5)	-	2	5	mV
Output Voltage Swing	V_{OPP}	R_L = 2kΩ	0	-	V+ -1.5	V
Input Common Mode Voltage Range	V_{ICR}	(Note 4), V+ = 30V	0	-	V+ -1.5	V
Input Offset Current	I_{IO}	I_I+ - I_I-	-	3	30	nA
Input Bias Current	I_{IB}	I_I+ or I_I-, (Note 3)	-	45	150	nA
Output Current (Source)	I_O	V_I+ = +1V, V_I- = 0V, V+ = 15V	20	40	-	mA
Output Current (Sink)	I_O	V_I+ = 0V, V_I- = 1V, V+ = 15V	10	20	-	mA
		V_I+ = 0V, V_I- = 1V, V_O = 200mV	12	50	-	µA
Large Signal Voltage Gain	A_{OL}	R_L ≥ 2kΩ, V+ = 15V (For large V_O swing)	94	100	-	dB
Common Mode Rejection Ratio	CMRR	DC	70	85	-	dB
Power Supply Rejection Ratio	PSRR	DC	65	100	-	dB
Amplifier-to-Amplifier Coupling		f = 1 to 20kHz (Input referred)	-	-120	-	dB
T_A = -55°C to +125°C						
Input Offset Voltage	V_{IO}	(Note 5)	-	-	7	mV
Temperature Coefficient of Input Offset Voltage	$\propto V_{IO}$	R_S = 0Ω	-	7	-	µV/°C
Input Offset Current	I_{IO}	I_I+ - I_I-	-	-	100	nA
Temperature Coefficient of Input Offset Current	$\propto I_{IO}$		-	10	-	pA/°C
Input Bias Current	I_{IB}	I_I+ or I_I-	-	-	300	nA
Total Supply Current	I+	R_L = ∞ On all amplifiers	-	0.8	2	mA
Input Common Mode Voltage Range	V_{ICR}	V+ = 30V	0	-	V+ -2	V
Large Signal Voltage Gain	A_{OL}	R_L ≥ 2kΩ, V+ = 15V (For large V_O swing)	88	-	-	dB
OUTPUT VOLTAGE SWING						
High Level	V_{OH}	R_L = 2kΩ, V+ = 30V	26	-	-	V
		R_L = 10kΩ	27	28	-	V
Low Level	V_{OL}	R_L = 10kΩ	-	5	20	mV

Electrical Specifications Values Apply for Each Operational Amplifier. Supply Voltage (V+) = 5V, Unless Otherwise Specified **(Continued)**

PARAMETERS	SYMBOL	TEST CONDITIONS	CA124 LIMITS MIN	CA124 LIMITS TYP	CA124 LIMITS MAX	UNITS
OUTPUT CURRENT						
Source	I_O	V_{I+} = 1V_{DC}, V_{I-} = 0, V+ = 15V	10	20	-	mA
Sink	I_O	V_{I-} = 1V_{DC}, V_{I+} = 0, V+ = 15V	5	8	-	mA
Differential Input Voltage		(Note 2)	-	-	V+	V

NOTES:

1. This input current will only exist when the voltage at any of the input leads is driven negative. This current is due to the collector base junction of the input p-n-p transistors becoming forward biased and thereby acting as input diode clamps. In addition to this diode action, there is also lateral n-p-n parasitic transistor action on the IC chip. This transistor action can cause the output voltages of the amplifiers to go to the V+ voltage level (or to ground for a large overdrive) for the time duration that an input is driven negative. This transistor action is not destructive and normal output states will re-establish when the input voltage, which was negative, again returns to a value greater than -0.3V_{DC}.
2. The maximum output current is approximately 40mA independent of the magnitude of V+. Continuous short circuits at V+ > 15V can cause excessive power dissipation and eventual destruction. Short circuits from the output to V+ can cause overheating and eventual destruction of the device.
3. Due to the p-n-p input stage the direction of the input current is out of the IC. No loading change exists on the input lines because the current is essentially constant, independent of the state of the output.
4. The input signal voltage and the input common mode voltage should not be allowed to go negative by more than 0.3V. The positive limit of the common mode voltage range is V+ - 1.5V, but either or both inputs can go to +32V without damage.
5. V_O = 1.4V_{DC}, R_S = 0Ω with V+ from 5V to 30V; and over the full input common mode voltage range (0V to V+ - 1.5V).

Electrical Specifications Values Apply for Each Operational Amplifier. Supply Voltage (V+) = 5V, Unless Otherwise Specified

PARAMETERS	SYMBOL	TEST CONDITIONS	CA224, CA324 LIMITS MIN	CA224, CA324 LIMITS TYP	CA224, CA324 LIMITS MAX	UNITS
T_A = +25°C						
Input Offset Voltage	V_{IO}	(Note 3)	-	2	7	mV
Output Voltage Swing	V_{OPP}	R_L = 2kΩ	0	-	V+ -1.5	V
Input Common Mode Voltage Range	V_{ICR}	(Note 2), V+ = 30V	0	-	V+ -1.5	V
Input Offset Current	I_{IO}	I_{I+} - I_{I-}	-	5	50	nA
Input Bias Current	I_{IB}	I_{I+} or I_{I-}, (Note 1)	-	45	250	nA
Output Current (Source)	I_O	V_{I+} = +1V, V_{I-} = 0V, V+ = 15V	20	40	-	mA
Output Current (Sink)	I_O	V_{I+} = 0V, V_{I-} = 1V, V+ = 15V	10	20	-	mA
		V_{I+} = 0V, V_{I-} = 1V, V_O = 200mV	12	50	-	µA
Large Signal Voltage Gain	A_{OL}	R_L ≥ 2kΩ, V+ = 15V (For large V_O swing)	88	100	-	dB
Common Mode Rejection Ratio	CMRR	DC	65	70	-	dB
Power Supply Rejection Ratio	PSRR	DC	65	100	-	dB
Amplifier-to-Amplifier Coupling		f = 1 to 20kHz (Input referred)	-	-120	-	dB
T_A = -40°C to +85°C (CA224), T_A = 0°C to +70°C (CA324)						
Input Offset Voltage	V_{IO}	(Note 3)	-	-	9	mV
Temperature Coefficient of Input Offset Voltage	αV_{IO}	R_S = 0Ω	-	7	-	µV/°C
Input Offset Current	I_{IO}	I_{I+} - I_{I-}	-	-	150	nA

Electrical Specifications Values Apply for Each Operational Amplifier. Supply Voltage (V+) = 5V, Unless Otherwise Specified (Continued)

PARAMETERS	SYMBOL	TEST CONDITIONS	CA224, CA324 LIMITS MIN	TYP	MAX	UNITS
T_A = -40°C to +85°C (CA224), T_A = 0°C to +70°C (CA324) (Continued)						
Temperature Coefficient of Input Offset Current	$\propto I_{IO}$		-	10	-	pA/°C
Input Bias Current	I_{IB}	I_I+ or I_I-	-	-	500	nA
Total Supply Current	I+	$R_L = \infty$ On all amplifiers	-	0.8	2	mA
Input Common Mode Voltage Range	V_{ICR}	V+ = 30V	0	-	V+ -2	V
Large Signal Voltage Gain	A	$R_L \geq 2k\Omega$, V+ = 15V (For large V_O swing)	83	-	-	dB
OUTPUT VOLTAGE SWING						
High Level	V_{OH}	R_L = 2kΩ, V+ = 30V	26	-	-	V
		R_L = 10kΩ	27	28	-	V
Low Level	V_{OL}	R_L = 10kΩ	-	5	20	mV
OUTPUT CURRENT						
Source	I_O	V_I+ = $1V_{DC}$, V_I- = 0, V+ = 15V	10	20	-	mA
Sink	I_O	V_I- = $1V_{DC}$, V_I+ = 0, V+ = 15V	5	8	-	mA
Differential Input Voltage		(Note 2)	-	-	V+	V

NOTES:

1. Due to the p-n-p input stage the direction of the input current is out of the IC. No loading change exists on the input lines because the current is essentially constant, independent of the state of the output.
2. The input signal voltage and the input common mode voltage should not be allowed to go negative by more than 0.3V. The positive limit of the common mode voltage range is V+ - 1.5V, but either or both inputs can go to +32V without damage.
3. V_O = $1.4V_{DC}$, R_S = 0Ω with V+ from 5V to 30V; and over the full input common mode voltage range (0V to V+ - 1.5V).

Electrical Specifications Values Apply for Each Operational Amplifier. Supply Voltage (V+) = 5V, Unless Otherwise Specified

PARAMETERS	SYMBOL	TEST CONDITIONS	LM2902 LIMITS MIN	TYP	MAX	UNITS
T_A = -40°C to +85°C						
Input Offset Voltage	V_{IO}	(Note 3)	-	-	10	mV
Temperature Coefficient of Input Offset Voltage	$\propto V_{IO}$	R_S = 0	-	7	-	µV/°C
Input Offset Current	I_{IO}	I_I+ - I_I-	-	45	200	nA
Temperature Coefficient of Input Offset Current	$\propto I_{IO}$		-	10	-	pA/°C
Input Bias Current	I_{IB}	I_I+ or I_I-, (Note 1)	-	40	500	nA
Total Supply Current	I+	$R_L = \infty$ On all amplifiers	-	0.7	1.2	mA
		$R_L = \infty$, V+ = 26V	-	1.5	3	mA
Input Common Mode Voltage Range	V_{ICR}	V+ = 26V, (Note 2)	0	-	V+ -2	V
Large Signal Voltage Gain	A_{OL}	R_L > 2kΩ, V+ = 15V (For large V_O swing)	83	-	-	dB

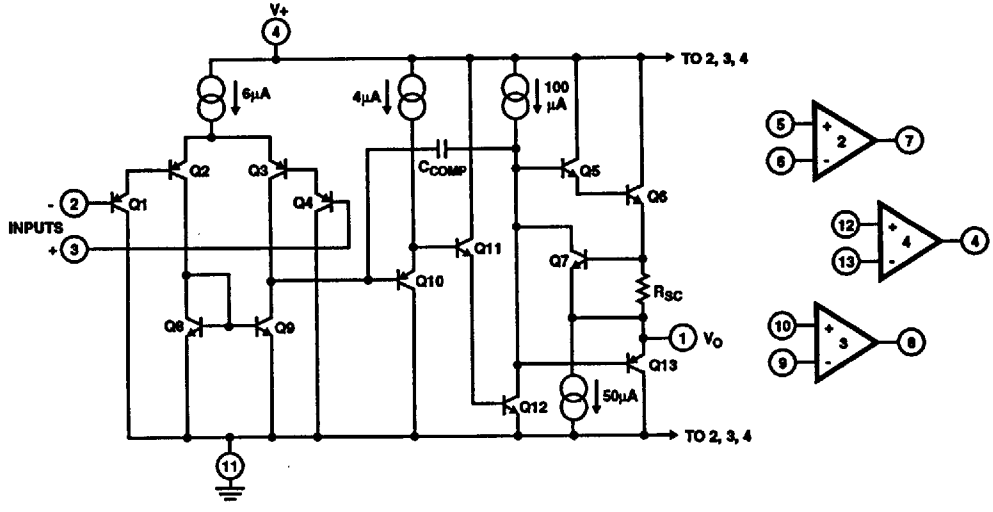
Electrical Specifications Values Apply for Each Operational Amplifier. Supply Voltage (V+) = 5V, Unless Otherwise Specified **(Continued)**

PARAMETERS	SYMBOL	TEST CONDITIONS	LM2902 LIMITS			UNITS
			MIN	TYP	MAX	
OUTPUT VOLTAGE SWING						
High Level	V_{OH}	R_L = 2kΩ, V+ = 26V	22	-	-	V
		R_L = 10kΩ	23	28	-	V
Low Level	V_{OL}	R_L = 10kΩ	-	5	100	mV
OUTPUT CURRENT						
Source	I_O	V_I+ = 1V_{DC}, V_I- = 0, V+ = 15V	10	20	-	mA
Sink	I_O	V_I- = 1V_{DC}, V_I+ = 0, V+ = 15V	5	8	-	mA
Differential Input Voltage		(Note 2)	-	-	V+	V

NOTES:

1. Due to the p-n-p input stage the direction of the input current is out of the IC. No loading change exists on the input lines because the current is essentially constant, independent of the state of the output.
2. The input signal voltage and the input common mode voltage should not be allowed to go negative by more than 0.3V. The positive limit of the common mode voltage range is V+ - 1.5V, but either or both inputs can go to +32V without damage.
3. V_O = 1.4V_{DC}, R_S = 0Ω with V+ from 5V to 30V; and over the full input common mode voltage range (0V to V+ - 1.5V).

Schematic Diagram (One of Four Operational Amplifiers)



Typical Performance Curves

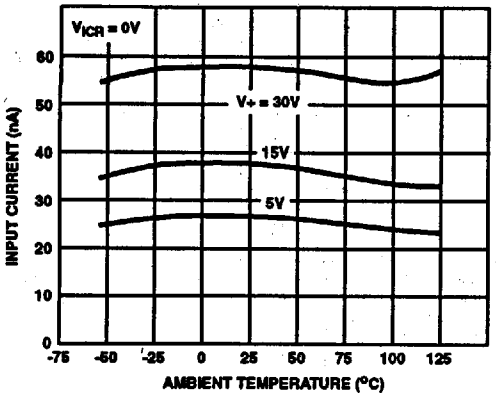


FIGURE 1. INPUT CURRENT vs AMBIENT TEMPERATURE

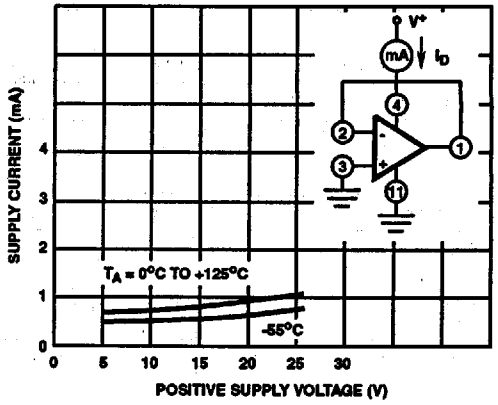


FIGURE 2. SUPPLY CURRENT vs SUPPLY VOLTAGE

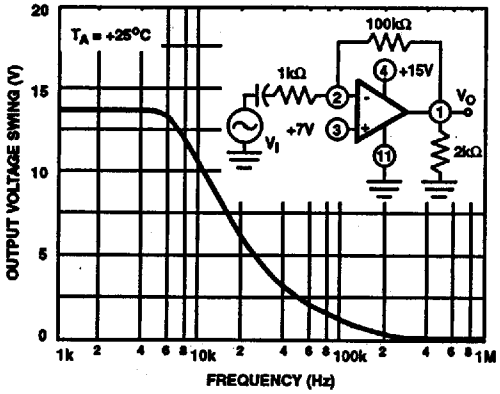


FIGURE 3. LARGE SIGNAL FREQUENCY RESPONSE

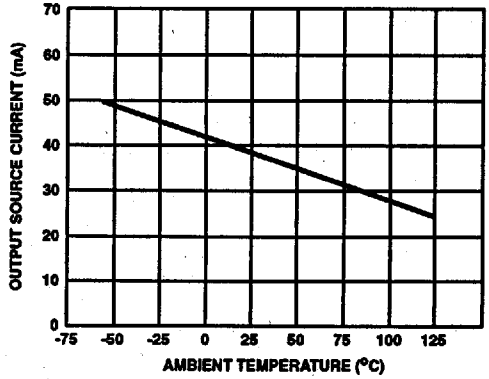


FIGURE 4. OUTPUT CURRENT vs AMBIENT TEMPERATURE

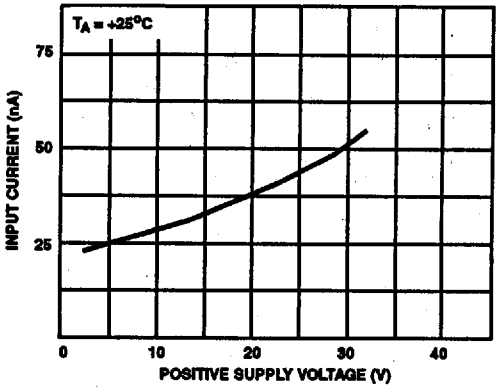


FIGURE 5. INPUT CURRENT vs SUPPLY VOLTAGE

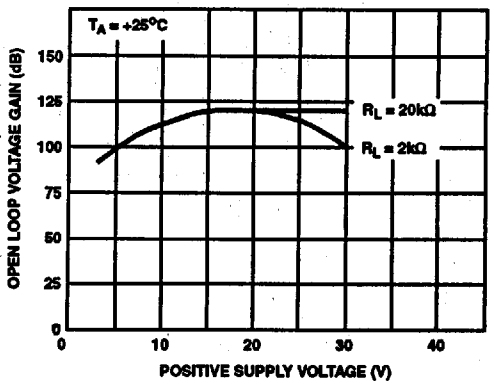


FIGURE 6. VOLTAGE GAIN vs SUPPLY VOLTAGE

Typical Performance Curves (Continued)

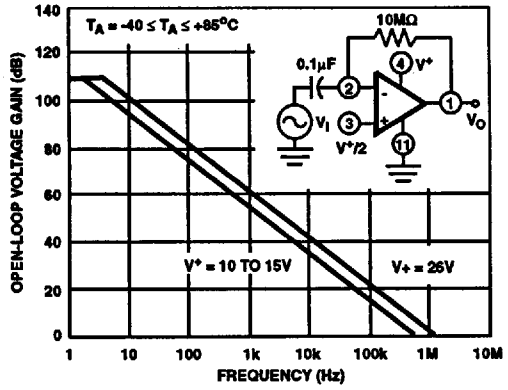


FIGURE 7. OPEN LOOP FREQUENCY RESPONSE

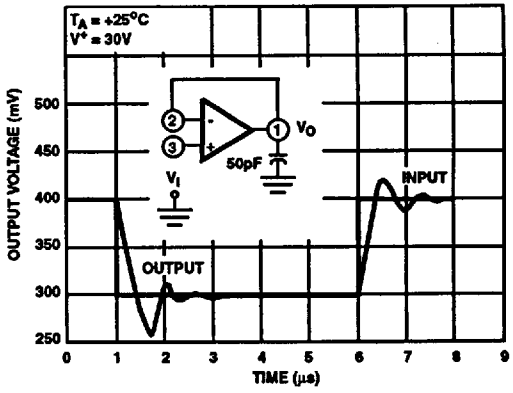


FIGURE 8. VOLTAGE FOLLOWER PULSE RESPONSE (SMALL SIGNAL)

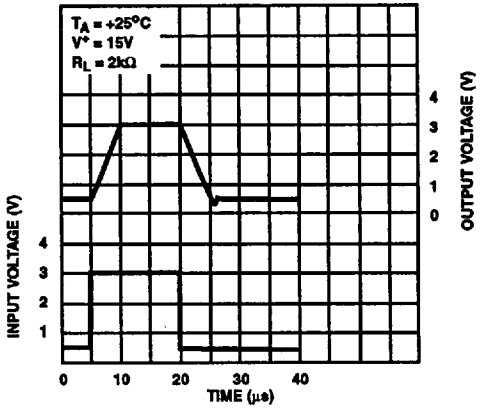


FIGURE 9. VOLTAGE FOLLOWER PULSE RESPONSE (LARGE SIGNAL)