

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

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.

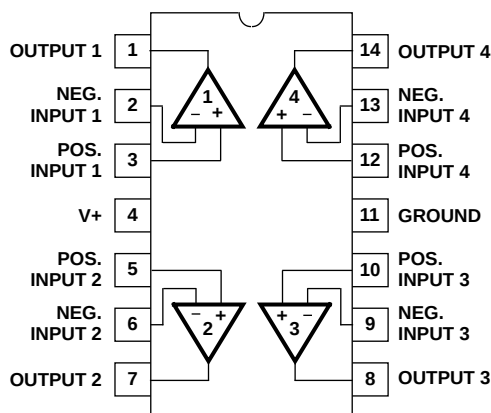
The CA124, CA224, CA324, LM324 and LM2902 are supplied in both 14-lead dual-in-line plastic (E suffix) and 14-lead (150 mil) small outline (M suffix) packages. The CA324 is available in chip form (H suffix).

Applications

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

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.

Copyright © Harris Corporation 1993

Specifications CA124, CA224, CA324, LM324, LM2902

Absolute Maximum Ratings

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

Operating Conditions

Operating Temperature Range -55°C to $+125^\circ\text{C}$
Storage Temperature Range. -65°C to $+150^\circ\text{C}$

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

PARAMETERS	SYMBOL	TEST CONDITIONS	CA124 LIMITS			UNITS
			MIN	TYP	MAX	
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	∝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	∝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

Specifications CA124, CA224, CA324, LM324, LM2902

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

PARAMETERS	SYMBOL	TEST CONDITIONS	CA124 LIMITS			UNITS
			MIN	TYP	MAX	
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. $V_O = 1.4V_{DC}$, $R_S = 0\Omega$ 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			UNITS
			MIN	TYP	MAX	
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	∝V _{IO}	R _S = 0Ω	-	7	-	μV/°C
Input Offset Current	I _{IO}	I _I + - I _I -	-	-	150	nA

Specifications CA124, CA224, CA324, LM324, LM2902

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

PARAMETERS	SYMBOL	TEST CONDITIONS	CA224, CA324 LIMITS			UNITS
			MIN	TYP	MAX	
T _A = -40°C to +85°C (CA224), T _A = 0°C to +70°C (CA324) (Continued)						
Temperature Coefficient of Input Offset Current	∞I _{IO}		-	10	-	pA/°C
Input Bias Current	I _{IB}	I _I + or I _I -	-	-	500	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	R _L ≥ 2kΩ, 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:

- 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.
- 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.
- 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			UNITS
			MIN	TYP	MAX	
T _A = -40°C to +85°C						
Input Offset Voltage	V _{IO}	(Note 3)	-	-	10	mV
Temperature Coefficient of Input Offset Voltage	∞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	∞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 = ∞ On all amplifiers	-	0.7	1.2	mA
		R _L = ∞, 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

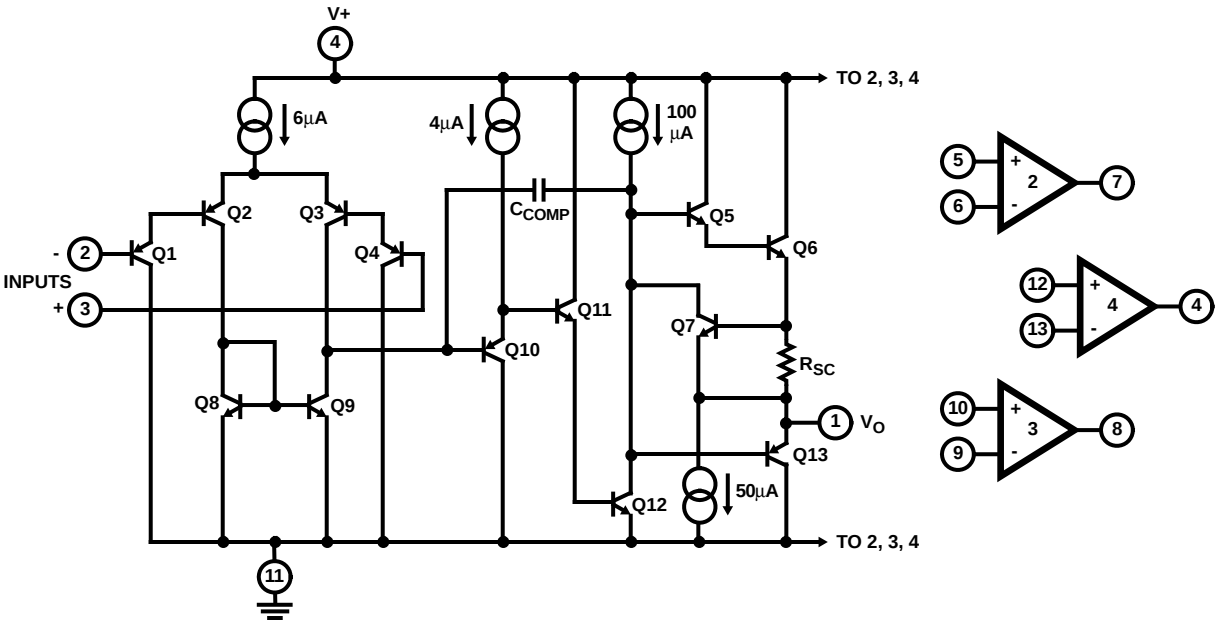
Specifications CA124, CA224, CA324, LM324, LM2902

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

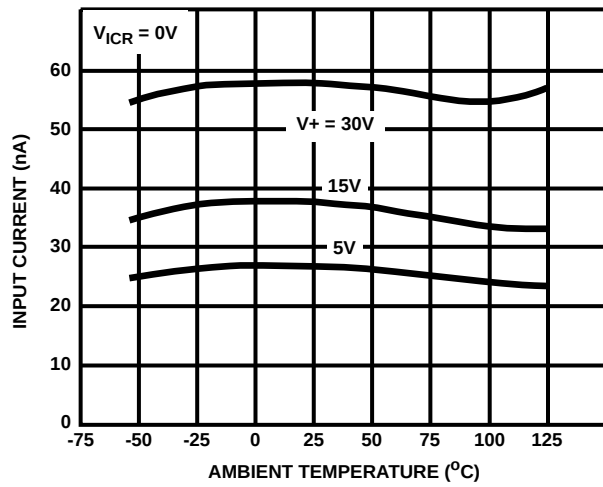


FIGURE 1. INPUT CURRENT vs AMBIENT TEMPERATURE

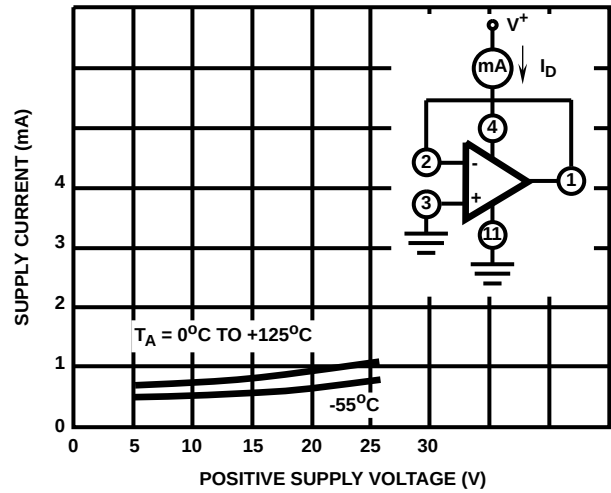


FIGURE 2. SUPPLY CURRENT vs SUPPLY VOLTAGE

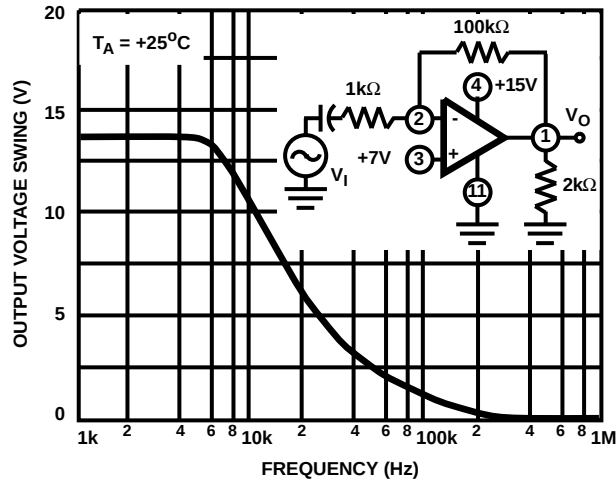


FIGURE 3. LARGE SIGNAL FREQUENCY RESPONSE

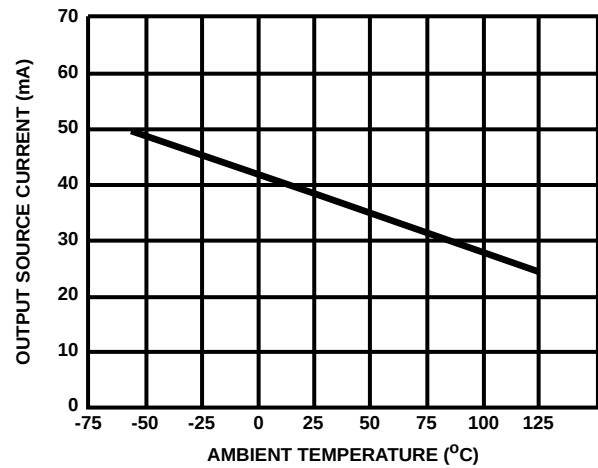


FIGURE 4. OUTPUT CURRENT vs AMBIENT TEMPERATURE

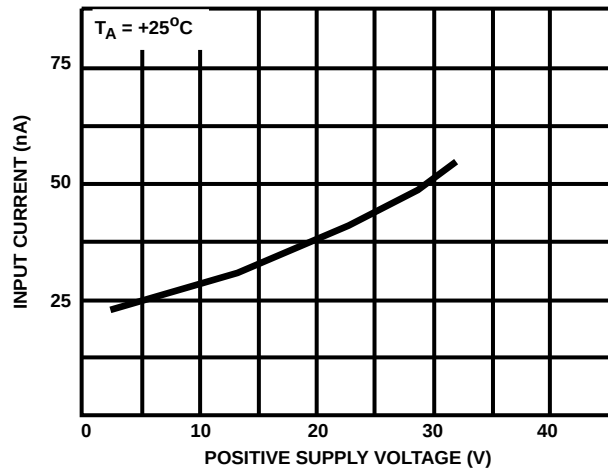


FIGURE 5. INPUT CURRENT vs SUPPLY VOLTAGE

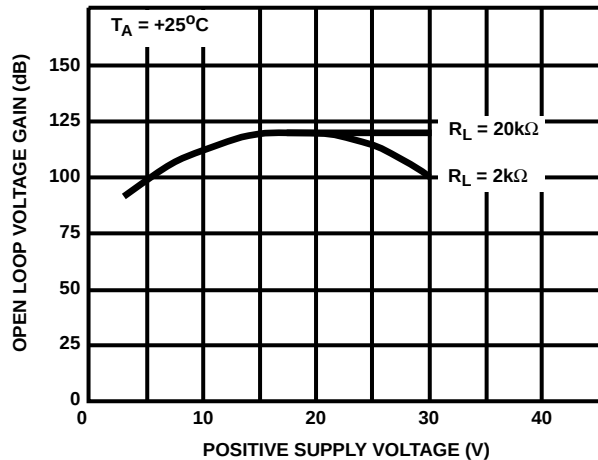


FIGURE 6. VOLTAGE GAIN vs SUPPLY VOLTAGE

Typical Performance Curves (Continued)

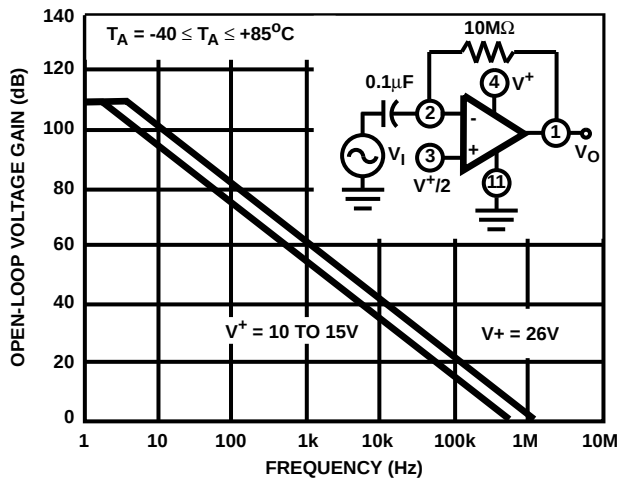


FIGURE 7. OPEN LOOP FREQUENCY RESPONSE

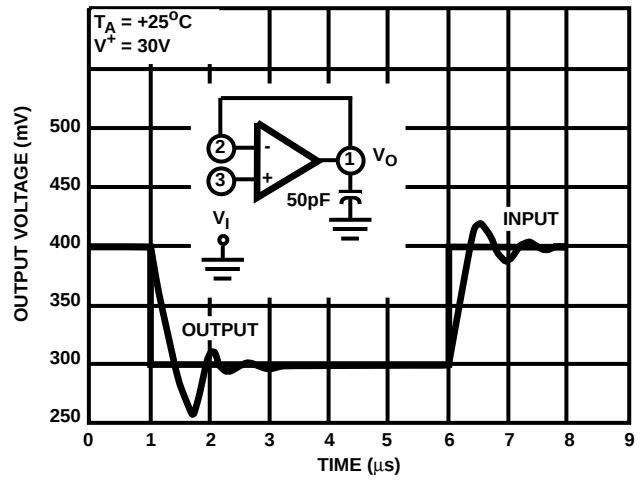


FIGURE 8. VOLTAGE FOLLOWER PULSE RESPONSE (SMALL SIGNAL)

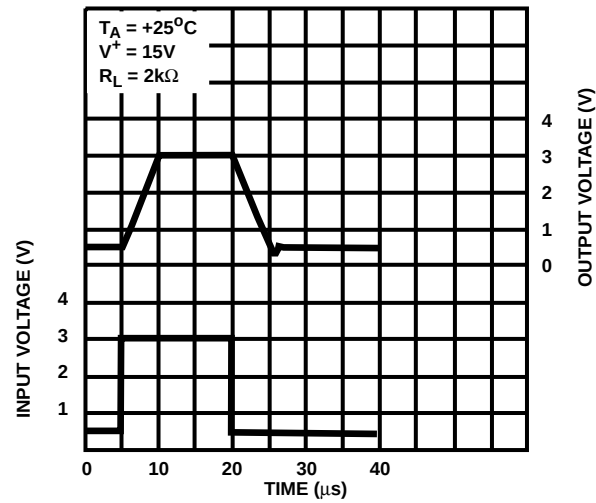


FIGURE 9. VOLTAGE FOLLOWER PULSE RESPONSE (LARGE SIGNAL)