

CA3033, CA3047 Types Operational Amplifiers

For High-Output-Current Applications

RCA-CA3033 is a high-performance integrated circuit operational amplifier featuring high input impedance, high gain, high power output, and low input-offset voltage and current. The device consists of two differential amplifiers in cascade and a single-ended class-B power output stage on a single monolithic silicon chip.

RCA-CA3033A has all the superior features and characteristics of the CA3033 but, in addition, can be operated at higher supply voltages to provide higher gain, higher common mode rejection, greater maximum output voltage swing, and more than double the power output.

RCA-CA3033 and CA3033A are hermetically sealed in 14-lead "dual-in-line" ceramic packages and are designed for operation over the full military temperature range of -55°C to +125°C.

ABSOLUTE-MAXIMUM RATINGS

INPUT SIGNAL VOLTAGE	CA3033 ±10 V	CA3033A -13 V, +10 V	CA3047 ±10 V	CA3047A -13V, +10 V
DEVICE DISSIPATION:				
Up to T _A = 25°C	1.2 W	1.2 W	750 mW	750 mW
Above T _A = 25°C	Derate at 8 mW/°C			
TEMPERATURE RANGE:				
Operating	-55°C to +125°C		0°C to +70°C	
Storage	-65°C to +150°C		-65°C to +150°C	
LEAD TEMPERATURE (During Soldering):				
At distance 1/16 ± 1/32 inch (1.59 ± 0.79mm) from case for 10 seconds max.				+265°C

MAXIMUM VOLTAGE RATINGS at T_A = 25°C

The following chart gives the range of voltages which can be applied to the terminals listed vertically with respect to the terminals listed horizontally. For example, the voltage range of the vertical terminal 1 with respect to the horizontal terminal 14 is 0 to +4 volts.

TERMINAL No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1		*	*	*	*	*	*	*	*	*	*	*	*	+4 0
2			*	*	*	*	*	*	*	*	*	*	*	+26 0
3				*	*	0 -26	*	*	*	*	*	*	*	+26 0
4					+5 -1	0 -15	*	*	*	*	*	*	*	+26 0
5						0 -26	*	+20 -1 Note 1	*	*	*	*	+20 -1 Note 1	*
6							+26 0	+26 0	+26 0	+26 0	+26 0	+26 0	+26 0	+26 0
7								+20 -1 Note 1	*	*	*	*	+20 -1 Note 1	+26 0
8									+20 -1 Note 2	+20 -2 Note 3	+20 -2 Note 3	+20 -1 Note 2	*	+26 0
9										+1 -5	*	+5 -5	+1 -20 Note 2	+26 -5
10											+10 -10	*	+2 -20 Note 3	+26 -10
11													+1 -5	+26 -10
12													+2 -20 Note 2	+26 -5
13														*
14														Substrate

- Notes: 1. This rating applies to the more positive terminal of terminals 8 and 13.
2. This rating applies to the more positive terminal of terminals 9 and 12.
3. This rating applies to the more positive terminal of terminals 10 and 11.

*Voltages are not normally applied between these terminals. Voltages appearing between these terminals will be safe if the specified limits between all other terminals are not exceeded.

The RCA-CA3047 and CA3047A are supplied in 14-lead, "dual-in-line" plastic packages and are designed to operate over the temperature range of 0°C to +70°C, ambient.

Companion Application Note, ICAN-5641 "Application of RCA CA3033 and CA3033A High Performance Integrated-Circuit Operational Amplifiers."

The resistance values included on the schematic diagram have been supplied as a convenience to assist Equipment Manufacturers in optimizing the selection of "outboard" components of equipment designs. The values shown may vary as much as ±30%.

RCA reserves the right to make any changes in the Resistance Values provided such changes do not adversely affect the published performance characteristics of the device.

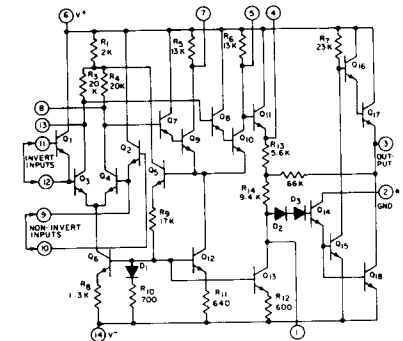
The RCA-CA3047 and CA3047A are electrically identical to the CA3033 and CA3033A, respectively, but are limited in operating and storage temperature range.

FEATURES

	CA3033 CA3047	CA3033A CA3047A	
Output Current	36	76	mA min.
Input Offset Current	36	25	nA max.
Open Loop Differential Gain	84	87	dB min.
Output Voltage Swing	18	23	V _{p-p} min.
Input Bias Current	350	180	nA max.
Power Output	80	220	mW min.
Common Mode Rejection Ratio	84	93	dB min.

APPLICATIONS

- Comparator
- Integrator
- Differentiator
- Audio Amplifier
- Summing Amplifier
- Servo Driver
- DC Amplifier
- Multivibrator
- Narrow Band and Band Pass Amplifier



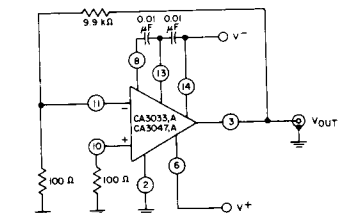
* (SEE OPERATION CONSIDERATIONS)

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Fig. 1 - Schematic diagram of operational amplifiers, CA3033, CA3033A, CA3047, CA3047A.

MAXIMUM CURRENT RATINGS

TERMINAL No.	I _{IN} mA	I _{OUT} mA
1	5	5
2	20	-
3	50	50
4	10	10
5	5	5
6	-	-
7	5	5
8	1	1
9	1	0.1
10	1	0.1
11	1	0.1
12	1	0.1
13	1	1
14	-	-



PROCEDURE: INPUT OFFSET VOLTAGE-MEASURE V_{OUT} AND RECORD INPUT OFFSET VOLTAGE (V_{IO}) IN VOLTS AS V_{OUT}/100. THUS

$$V_{IO} (\text{IN VOLTS}) = \frac{V_{OUT}}{100}$$

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Fig. 2a - Input offset voltage, input offset voltage sensitivity, and device dissipation test circuit.

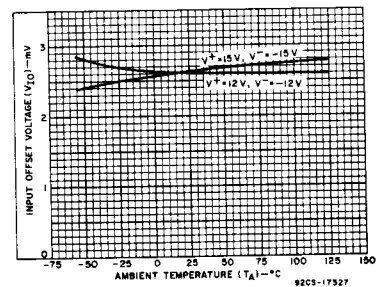


Fig. 2b - Typical input offset voltage vs. ambient temperature.

CA3033, CA3047 Types

MAXIMUM VOLTAGE RATINGS at T_A = 25° C

CA3033A, CA3047A

The following chart gives the range of voltages which can be applied to the terminals listed vertically with respect to the terminals listed horizontally. For example, the voltage range of the vertical terminal 1 with respect to the horizontal terminal 14 is 0 to +4 volts.

TERMINAL No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1		*	*	*	*	*	*	*	*	*	*	*	*	+4 0
2			*	*	*	*	*	*	*	*	*	*	*	+38 0
3				*	*	0 -38	*	*	*	*	*	*	*	+38 0
4					+5 -1	0 -22	*	*	*	*	*	*	*	+38 0
5						0 -38	*	+30 -1 Note 1	*	*	*	*	+30 -2 Note 1	*
6							+38 0	+38 0	+38 0	+38 0	+38 0	+38 0	+38 0	+38 0
7								+30 -2 Note 1	*	*	*	*	+20 -2 Note 1	+38 0
8									+30 -1 Note 2	+30 -2 Note 3	+30 -2 Note 3	+30 -1 Note 2	*	+38 0
9										+1 -5	+5 -5	+5 -5	+1 -30 Note 2	+38 -5
10											+10 -10	*	+2 -20 Note 3	+38 -10
11												+1 -5	+2 -30 Note 3	+38 -10
12													+1 -30 Note 2	+38 -5
13														*
14														Substrate

Notes: See CA3033, CA3047 Rating Chart Notes.

MAXIMUM CURRENT RATINGS

are identical for all four types (See CA3033, CA3047 chart)

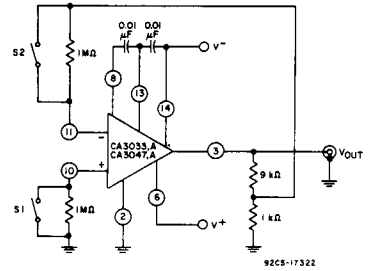


Fig. 3a - Input offset current and input bias current test circuit.

PROCEDURES:

A. Inverting Input Current,

Set switch, S₁ in closed position and set switch, S₂ in open position.

Measure output voltage and convert this reading to inverting input current using the following relation:

$$I_1 \text{ inverting (in } \mu\text{A)} = \frac{V_{OUT} \text{ (in volts)}}{10}$$

B. Non-inverting Input Current

Set switch, S₁ in open position and set switch, S₂ in closed position.

Measure output voltage and convert this reading to non-inverting input current using the following relation:

$$I_1 \text{ non-inverting (in } \mu\text{A)} = \frac{-V_{OUT} \text{ (in volts)}}{10}$$

C. Input Offset Current

Set switches, S₁ and S₂ in open positions.

Measure output voltage and convert this reading to input offset current using the following relation:

$$I_{IO} \text{ (in } \mu\text{A)} = \frac{V_{OUT} \text{ (in volts)}}{10}$$

ELECTRICAL CHARACTERISTICS

For Equipment Design

Characteristics	Symbols	Circuit	Test Conditions	LIMITS						Units	
				CA3033 CA3047		CA3033A CA3047A					
				DC Supply Voltage V ⁺ = 12 V V ⁻ = -12 V		V ⁺ = 15 V V ⁻ = -15 V					
Fig.	T _A = 25° C	Typical Characteristics Curves	Fig.	Min.	Typ.	Max.	Min.	Typ.	Max.		
Input Offset Voltage	V _{IO}	2a		2b	-	2.6	5	-	2.9	5	mV
Input Offset Current	I _{IO}	3a		3b	-	5	35	-	9	25	nA
Input Bias Current	I _I	3a		3c	-	70	350	-	100	180	nA
Input Offset Voltage Sensitivity:											
Positive	ΔV _{IO} /ΔV ⁺	2a		-	-	0.3	0.5	-	0.2	0.5	mV/V
Negative	ΔV _{IO} /ΔV ⁻	2a		-	-	0.3	0.5	-	0.2	0.5	mV/V
Device Dissipation	P _T	2a		-	60	120	180	80	170	300	mW
Open-Loop Differential Voltage Gain	A _{OL}	-	f = 1 kHz	4	84	90	-	87	93	-	dB
Common-Mode Rejection Ratio	CMRR	-		5	84	100	-	93	105	-	dB
Common-Mode Input-Voltage Range	V _{ICR}	-		-	-7.5	+5, -9	+3.5	-9.7	6, -11	4.7	V
Maximum Output-Voltage Swing	V _{O(P-P)}	-	f = 1 kHz								V _{P-P}
					R _L = 500 Ω	18	22	-	-	-	
					R _L = 300 Ω	-	-	-	23	25	
Input Impedance	Z _I	-		-	0.25	1.5	-	0.6	1	-	MΩ
Output Current	I _O	-		6	35	44	-	-	-	-	mA (P-P)
					R _L = 500 Ω	-	-	-	76	83	
					R _L = 300 Ω	-	-	-	-	-	
Power Output THD <5%	P _O	-		7	80	122	-	-	-	-	mW
					R _L = 500 Ω	-	-	-	220	255	
					R _L = 300 Ω	-	-	-	-	-	

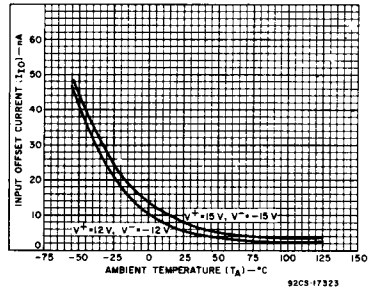


Fig. 3b - Typical input offset current vs. ambient temperature.

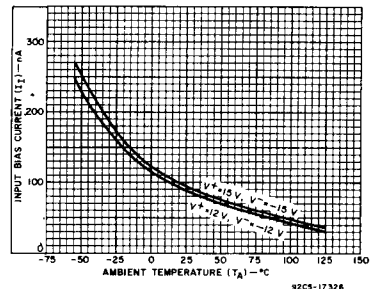


Fig. 3c - Typical input bias current vs. ambient temperature.

CA3033, CA3047 Types

ELECTRICAL CHARACTERISTICS

Typical Values Intended Only for Design Guidance

Input Offset Voltage Drift -55°C to 125°C	$V_{IO}/\Delta T$	2a	2b	6.6	6.6	$\mu V/^\circ C$
Input Offset Current Drift -55°C to 25°C	$I_{IO}/\Delta T$	3a	3b	1	1	nA/ $^\circ C$
25°C to 125°C				0.08	0.08	
60-dB Amplifier Bandwidth	BW	8a	8b,c	230	350	kHz
Slew Rate	SR	9	(amplifier circuit only)	2.7	3	V/ μs

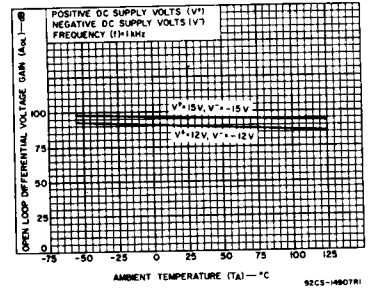


Fig. 4 - Typical open-loop differential voltage gain vs. ambient temperature.

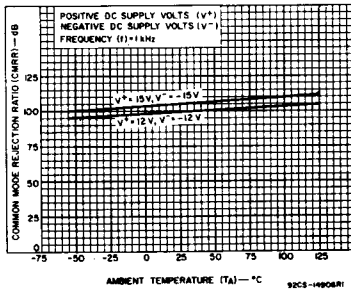


Fig. 5 - Typical common mode rejection ratio vs. ambient temperature.

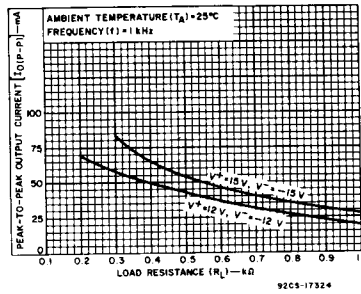


Fig. 6 - Typical peak-to-peak output current vs. load resistance.

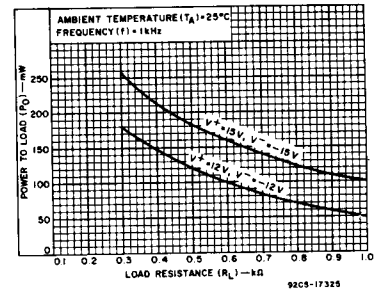


Fig. 7 - Typical power output vs. load resistance.

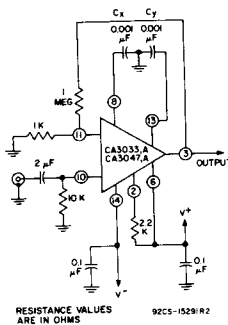


Fig. 8a - Typical 60-dB amplifier.

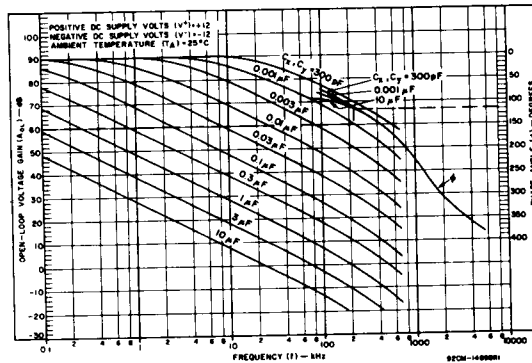


Fig. 8b - Typical phase compensation characteristics for CA3033, CA3047 ($V^+ = +12 V, V^- = -12 V$)

For any desired closed loop gain (in decibels), read horizontally along the gain line to the attenuation curve which provides the desired closed loop bandwidth. The required values for the compensation capacitors is shown on the curve. Move vertically from the intersection of the gain and attenuation lines until the phase angle curve (ϕ) is reached and read the phase angle between the input and output on the right-hand scale. The difference between the indicated phase angle and 180° is the typical phase margin. (A minimum phase margin of 45° is recommended to allow for component variations and differences among amplifiers.) If the phase margin is smaller than required, the desired bandwidth can be stably achieved through the use of a more complex feedback network. As the closed loop gain approaches unity, the compensating capacitors required ($0.3 \mu F$

to $1.0 \mu F$) are bulky and costly. A capacitor one-half the value shown on the chart, connected between terminals 8 and 13, and a $0.001 \mu F$ capacitor from either terminals 8 or 13 to ground or V^- is an acceptable alternative method. This arrangement provides the same gain-phase roll-off shown on the curves and permits the use of more readily available, lower-voltage disc capacitors which are smaller and cost less. For linear operation, the maximum expected difference voltage between the two collectors is less than 1 volt.

Figure 8a shows the phase compensating capacitors (C_x, C_y) returned to ground. In some systems with large parasitic impedances in the power supply system, returning these capacitors to the negative (V^-) supply may result in more stable operation.

CA3033, CA3047 Types

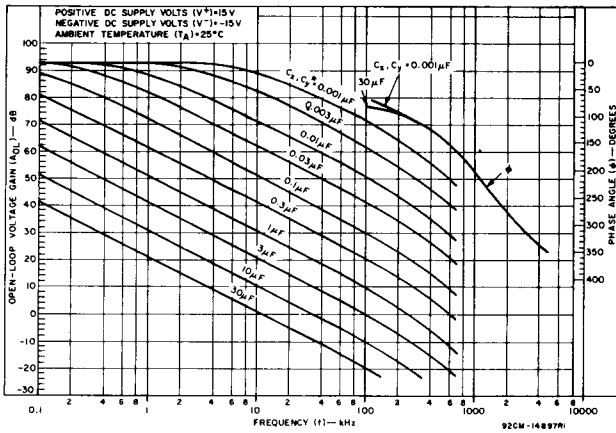
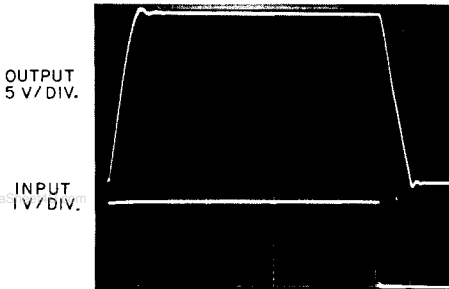


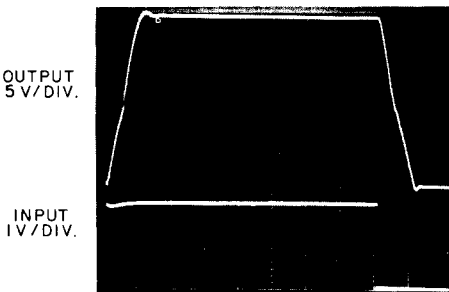
Fig. 8c - Typical phase compensation characteristics for CA3033A, CA3047A ($V^+ = 15\text{ V}$, $V^- = -15\text{ V}$).

$V^+ = 30\text{ V}$, $R_L = \infty$



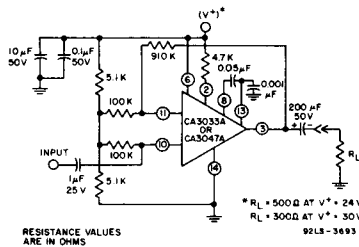
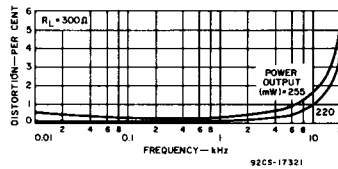
TIME - $10\ \mu\text{s}$ / DIV.
(a)

$V^+ = 30\text{ V}$, $R_L = 1\text{ k}\Omega$



TIME - $10\ \mu\text{s}$ / DIV.
(b)

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RESISTANCE VALUES ARE IN OHMS

* $R_L = 500\ \Omega$ AT $V^+ = 24\text{ V}$

$R_L = 300\ \Omega$ AT $V^+ = 30\text{ V}$

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Fig. 9 - Amplifier with single voltage supply and associated pulse response waveforms and distortion curves.

OPERATING CONSIDERATIONS

The CA3033, CA3033A, CA3047, and CA3047A operational amplifiers have very high peak-pulse current capability. The open-loop output impedance is typically less than 30 ohms at 10 kHz and the peak short-circuit output current may exceed 100 milliamperes. To prevent possible damage to the chip because of excessive dissipation it is important that the output stage is not subjected to sustained high peak currents. To minimize the possibility of dam-

age from accidental shorts, it is recommended that a 51-ohm resistor be placed in series with the output circuit.

When high peak output currents are required of the amplifier, it is desirable to provide a current-limiting resistor of about 2200 ohms in series with the collector of transistor Q14. This resistor may be returned to ground, or, if its value is increased to 4700 ohms, it may be returned to the V^+ terminal.