μA3303 • μA3403 • μA3503

QUAD OPERATIONAL AMPLIFIERS

FAIRCHILD LINEAR INTEGRATED CIRCUITS

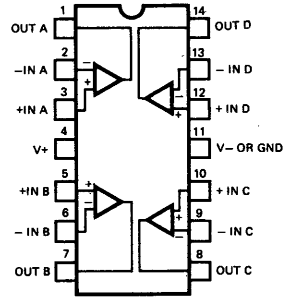
GENERAL DESCRIPTION — The 3303, 3403 and 3503 are monolithic Quad Operational Amplifiers consisting of four independent high gain, internally frequency compensated operational amplifiers designed to operate from a single power supply or dual power supplies over a wide range of voltages. The common mode input range includes the negative supply, thereby eliminating the necessity for external biasing components in many applications. The output voltage range also includes the negative power supply voltage. They are constructed using the Fairchild Planar* epitaxial process.

- **INPUT COMMON MODE VOLTAGE RANGE INCLUDES GROUND OR NEGATIVE SUPPLY**
- **OUTPUT VOLTAGE CAN SWING TO GROUND OR NEGATIVE SUPPLY**
- **FOUR INTERNALLY COMPENSATED OPERATIONAL AMPLIFIERS IN A SINGLE PACKAGE**
- **WIDE POWER SUPPLY RANGE: SINGLE SUPPLY OF 3.0 TO 36 V**
  DUAL SUPPLY OF ±1.5 TO ±18 V
- **CLASS AB OUTPUT STAGE FOR MINIMAL CROSSOVER DISTORTION**
- **SHORT CIRCUIT PROTECTED OUTPUTS**
- **HIGH OPEN LOOP GAIN — 200k**
- **μA741 OPERATIONAL AMPLIFIER TYPE PERFORMANCE**

ABSOLUTE MAXIMUM RATINGS

Supply Voltage Between V+ and V−		36 V
Differential Input Voltage (Note 1)		±30 V
Input Voltage (V−) (Note 1)		−0.3 V(V−) to V+
Internal Power Dissipation (Note 2)		670 mW
Operating Temperature Range	μA3303	−40°C to +85°C
	μA3403	0°C to +70°C
	μA3503	−55°C to +125°C
Storage Temperature Range		
Molded Package		−55°C to +125°C
Hermetic Package		−65°C to +150°C
Lead Temperature		
Molded Package (Soldering, 10 s)		260°C
Hermetic Package (Soldering, 60 s)		300°C

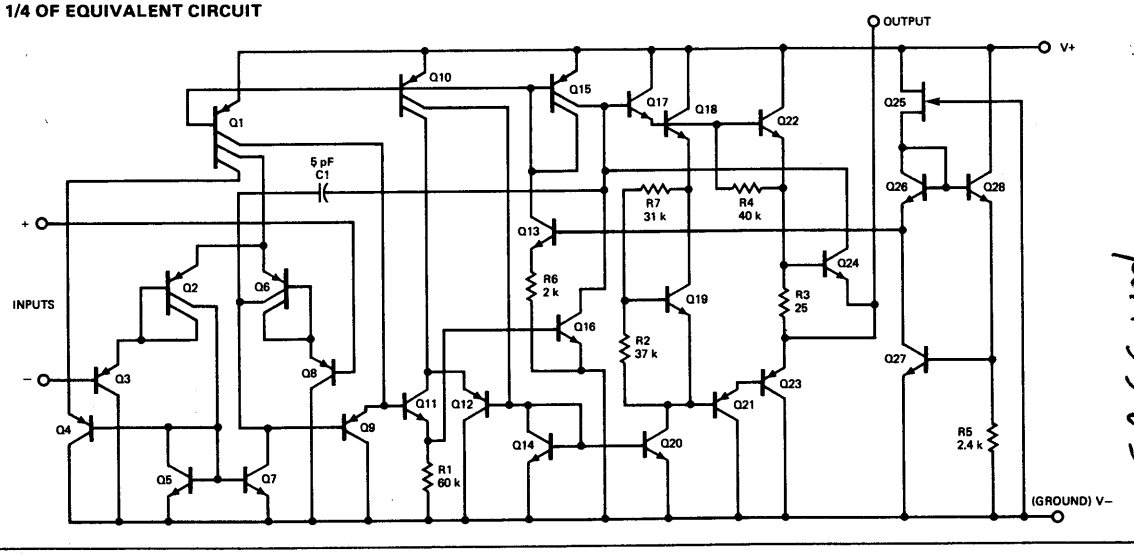
CONNECTION DIAGRAM
14-LEAD DIP
(TOP VIEW)
PACKAGE OUTLINES 6A 9A
PACKAGE CODES D P



ORDER INFORMATION

TYPE	PART NO.
μA3403	μA3403D
μA3503	μA3503D
μA3303	μA3303P
μA3403	μA3403P

1/4 OF EQUIVALENT CIRCUIT



*Planar is a patented Fairchild process.

μA3503

ELECTRICAL CHARACTERISTICS (V_S = ±15 V, T_A = 25°C unless otherwise noted)

PARAMETER	CONDITION	MIN	TYP	MAX	UNITS
Input Offset Voltage			2.0	5.0	mV
Input Offset Current			30	50	nA
Input Bias Current			−200	−500	nA
Input Impedance	f = 20 Hz	0.3	1.0		MΩ
Input Common Mode Voltage Range		+13 to $-V_S$	+13.5 to $-V_S$		V
Common Mode Rejection Ratio	$R_S \leq 10$ kΩ	70	90		dB
Large Signal Open Loop Voltage Gain	V_{OUT} = ±10 V, R_L = 2kΩ	50	200		V/mV
Power Bandwidth	A_V = 1, R_L = 2 kΩ, V_{OUT} = 20 V pk-pk		9.0		kHz
Small Signal Bandwidth	A_V = 1, R_L = 10 kΩ, V_{OUT} = 50 mV		1.0		MHz
Slew Rate	A_V = 1, V_{IN} = −10 V to +10 V		0.6		V/μs
Rise Time	A_V = 1, R_L = 10 kΩ, V_{OUT} = 50 mV		0.3		μs
Fall Time	A_V = 1, R_L = 10 kΩ, V_{OUT} = 50 mV		0.3		μs
Overshoot	A_V = 1, R_L = 10 kΩ, V_{OUT} = 50 mV		20		%
Phase Margin	A_V = 1, R_L = 2k Ω, C_L = 200 pF		60		Degree
Crossover Distortion at f = 10 kHz	V_{IN} = 30 mV pk-pk, V_{OUT} = 2 V pk-pk		1.0		%
Output Voltage Range	R_L = 10k Ω	±12	±13.5		V
	R_L = 2 kΩ	±10	±13		V
Individual Output Short Circuit Current	(Note 3)	±20	±30	±45	mA
Output Impedance	f = 20 Hz		800		Ω
Power Supply Rejection Ratio	Positive		30	150	μV/V
	Negative		30	150	μV/V
Power Supply Current	V_{OUT} = 0, R_L = ∞		2.8	4.0	mA
The following specification apply for $-55°C \leq T_A \leq +125°C$					
Input Offset Voltage				6.0	mV
Average Temperature Coefficient of Input Offset Voltage			10		μV/°C
Input Offset Current				200	nA
Average Temperature Coefficient of Input Offset Current			50		pA/°C
Input Bias Current			−300	−1500	nA
Large Signal Open Loop Voltage Gain	R_L = 2 kΩ, V_{OUT} = ±10 V	25	300		V/mV
Output Voltage Range	R_L = 2 kΩ	±10			V

ELECTRICAL CHARACTERISTICS (V_S = +5 V and Ground, T_A = 25°C unless otherwise noted)

PARAMETER	CONDITION	MIN	TYP	MAX	UNITS
Input Offset Voltage			2.0	5.0	mV
Input Offset Current			30	50	nA
Input Bias Current			−200	−500	nA
Large Signal Open Loop Voltage Gain	R_L = 2 kΩ	20	200		V/mV
Power Supply Rejection Ratio				150	μV/V
Output Voltage Range (Note 4)	R_L = 10 kΩ	3.5			V pk-pk
	R_L = 10 kΩ, $5.0\text{ V} \leq V_S \leq 30\text{ V}$	(V+) −1.7			V pk-pk
Power Supply Current			2.5	4.0	mA
Channel Separation	f = 1 kHz to 20 kHz (Input Referenced)		−120		dB

NOTES:

1. For supply voltage less than 30 V between V+ and V−, the absolute maximum input voltage is equal to the supply voltage.
2. Rating applies to ambient temperature up to 70°C. Above T_A = 70°C, derate linearly at 8.3 mW/°C.
3. Not to exceed maximum package power dissipation.
4. Output will swing to ground.

μA3403

ELECTRICAL CHARACTERISTICS (V_S = ±15 V, T_A = 25°C unless otherwise noted)

PARAMETER	CONDITION	MIN	TYP	MAX	UNITS
Input Offset Voltage			2.0	8.0	mV
Input Offset Current			30	50	nA
Input Bias Current			−200	−500	nA
Input Impedance	f = 20 Hz	0.3	1.0		MΩ
Input Common Mode Voltage Range		+13 to $-V_S$	+13.5 to $-V_S$		V
Common Mode Rejection Ratio	$R_S \leq 10$ kΩ	70	90		dB
Large Signal Open Loop Voltage Gain	V_{OUT} = ±10 V, R_L = 2 kΩ	20	200		V/mV
Power Bandwidth	$A_V = 1$, R_L = 2 kΩ, V_{OUT} = 20 V pk-pk THD = 5%		9.0		kHz
Small Signal Bandwidth	$A_V = 1$, R_L = 10 kΩ, V_{OUT} = 50 mV		1.0		MHz
Slew Rate	$A_V = 1$, V_{IN} = −10 V to +10 V		0.6		V/μs
Rise Time	$A_V = 1$, R_L = 10 kΩ, V_{OUT} = 50 mV		0.3		μs
Fall Time	$A_V = 1$, R_L = 10 kΩ, V_{OUT} = 50 mV		0.3		μs
Overshoot	$A_V = 1$, R_L = 10 kΩ, V_{OUT} = 50 mV		20		%
Phase Margin	$A_V = 1$, R_L = 2 kΩ, C_L = 200 pF		60		Degree
Crossover Distortion	V_{IN} = 30 mV pk-pk, V_{OUT} = 2 V pk-pk f = 10 kHz		1.0		%
Output Voltage Range	R_L = 10 kΩ	±12	±13.5		V
	R_L = 2 kΩ	±10	±13		V
Individual Output Short Circuit Current		±10	±30	±45	mA
Output Impedance	f = 20 Hz		800		Ω
Power Supply Rejection Ratio	Positive		30	150	μV/V
	Negative		30	150	μV/V
Power Supply Current	$V_{OUT} = 0$, $R_L = \infty$		2.8	7.0	mA
The following specification apply for 0°C ≤ T_A ≤ 70°C					
Input Offset Voltage				10	mV
Average Temperature Coefficient of Input Offset Voltage			10		μV/°C
Input Offset Current				200	nA
Average Temperature Coefficient of Input Offset Current			50		pA/°C
Input Bias Current				−800	nA
Large Signal Open Loop Voltage Gain	R_L = 2 kΩ, V_{OUT} = ±10 V	15			V/mV
Output Voltage Range	R_L = 2 kΩ	±10			V

ELECTRICAL CHARACTERISTICS (V_S = +5.0 V and Ground, T_A = 25°C unless otherwise noted)

PARAMETER	CONDITION	MIN	TYP	MAX	UNITS
Input Offset Voltage			2.0	10	mV
Input Offset Current			30	50	nA
Input Bias Current			−200	−500	nA
Large Signal Open Loop Voltage Gain	R_L = 2 kΩ	20	200		V/mV
Power Supply Rejection Ratio				150	μV/V
Output Voltage Range	R_L = 10 kΩ	3.5			V pk-pk
	R_L = 10 kΩ, 5.0 V ≤ V_S ≤ 30 V	(V+) −1.7			V pk-pk
Power Supply Current			2.5	7.0	mA
Channel Separation	f = 1 kHz to 20 kHz (Input Referenced)		−120		dB

μA3303

ELECTRICAL CHARACTERISTICS ($V+ = +14$ V, $V- =$ GND, $T_A = 25°C$ unless otherwise noted)

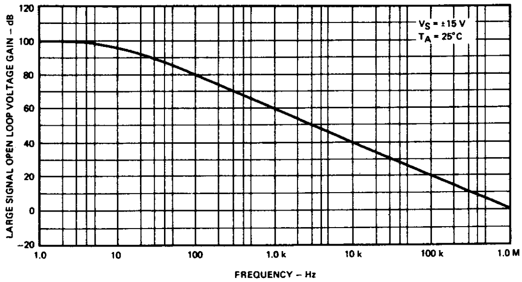
PARAMETER	CONDITION	MIN	TYP	MAX	UNITS
Input Offset Voltage			2.0	8.0	mV
Input Offset Current			30	75	nA
Input Bias Current			200	–500	nA
Input Impedance	f = 20 Hz	0.3	1.0		MΩ
Input Common Mode Voltage Range		+12 to GND	+12.5 to GND		V
Common Mode Rejection Ratio	$R_S \leq 10$ kΩ	70	90		dB
Large Signal Open-Loop Voltage Gain	$R_L = 2$ kΩ	20	200		V/mV
Power Bandwidth	$A_V = 1$, $R_L = 2$ kΩ, $V_{OUT} = 10$ V pk-pk THD = 5%		18		kHz
Small Signal Bandwidth	$A_V = 1$, $R_L = 10$ kΩ, $V_{OUT} = 50$ mV		1.0		MHz
Slew Rate	$A_V = 1$		0.6		V/μs
Rise Time	$A_V = 1$, $R_L = 10$ kΩ, $V_{OUT} = 50$ mV		0.3		μs
Fall Time	$A_V = 1$, $R_L = 10$ kΩ, $V_{OUT} = 50$ mV		0.3		μs
Overshoot	$A_V = 1$, $R_L = 10$ kΩ, $V_{OUT} = 50$ mV		20		%
Phase Margin	$A_V = 1$, $R_L = 2$ kΩ, $C_L = 200$ pF		60		Degree
Crossover Distortion	$V_{IN} = 30$ mV pk-pk, $V_{OUT} = 2$ V pk-pk f = 10 kHz		1.0		%
Output Voltage Range	$R_L = 10$ kΩ $R_L = 2$ kΩ	12 10	12.5 12		V V
Individual Output Short Circuit Current		±10	±30	±45	mA
Output Impedance	f = 20 Hz		800		Ω
Power Supply Rejection Ratio			30	150	μV/V
Power Supply Current	$V_{OUT} = 0$, $R_L = \infty$		2.8	7.0	mA
The following specification apply for $-40°C \leq T_A \leq 85°C$					
Input Offset Voltage				10	mV
Average Temperature Coefficient of Input Offset Voltage			10		μV/°C
Input Offset Current				250	nA
Average Temperature Coefficient of Input Offset Current			50		pA/°C
Input Bias Current				-1000	nA
Large Signal Open Loop Voltage Gain	$R_L = 2$ kΩ	15			V/mV
Output Voltage Range	$R_L = 2$ kΩ	+10			V

ELECTRICAL CHARACTERISTICS ($V+ = +5.0$ V, $V- =$ GND, $T_A = 25°C$ unless otherwise noted)

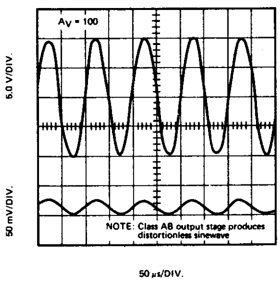
PARAMETER	CONDITION	MIN	TYP	MAX	UNITS
Input Offset Voltage				10	mV
Input Offset Current				75	nA
Input Bias Current				–500	nA
Large Signal Open Loop Voltage Gain	$R_L = 2$ kΩ	20	200		V/mV
Power Supply Rejection Ratio				150	μV/V
Output Voltage Range	$R_L = 10$ kΩ $R_L = 10$ kΩ, $5.0\text{ V} \leq V_S \leq 30$ V	3.5 (V+) –1.7			V pk-pk V pk-pk
Power Supply Current			2.5	7.0	mA
Channel Separation	f = 1 kHz to 20 kHz (Input Referenced)		–120		dB

TYPICAL PERFORMANCE CURVES

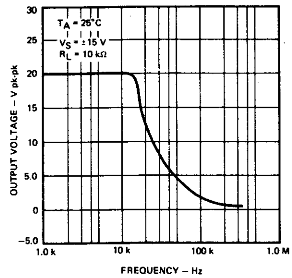
LARGE SIGNAL OPEN LOOP VOLTAGE GAIN AS A FUNCTION OF FREQUENCY



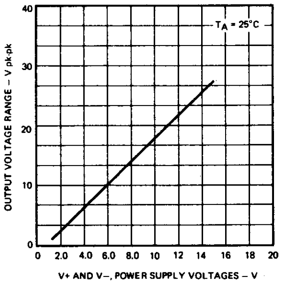
SINEWAVE RESPONSE



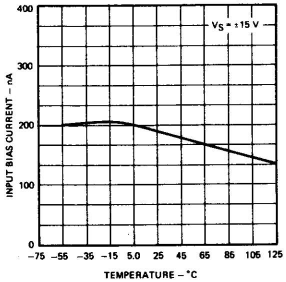
OUTPUT VOLTAGE AS A FUNCTION OF FREQUENCY



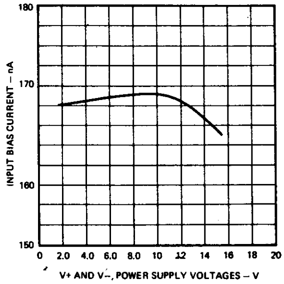
OUTPUT SWING AS A FUNCTION OF SUPPLY VOLTAGE



INPUT BIAS CURRENT AS A FUNCTION OF TEMPERATURE

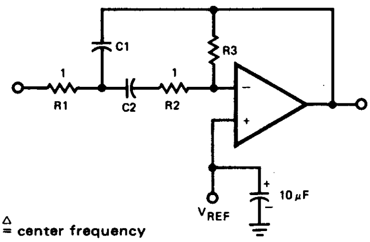


INPUT BIAS CURRENT AS A FUNCTION OF SUPPLY VOLTAGE



TYPICAL APPLICATIONS

MULTIPLE FEEDBACK BANDPASS FILTER



$f_o \triangleq$ center frequency

$BW \triangleq$ Bandwidth

R in kΩ

C in µF

$Q = \frac{f_o}{BW} < 10$

$C1 = C2 = \frac{Q}{3}$

$R1 = R2 = 1$
$R3 = 9Q^2 - 1$ } Use scaling factors in these expressions.

Design example:

given: $Q = 5$, $f_o = 1$ kHz

Let $R1 = R2 = 10$ kΩ

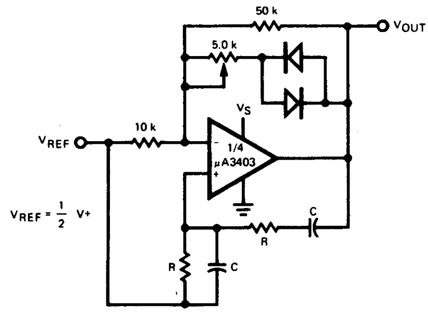
then $R3 = 9(5)^2 - 10$

$R3 = 215$ kΩ

$C = \frac{5}{3} = 1.6$ nF

If source impedance is high or varies, filter may be preceeded with voltage follower buffer to stabilize filter parameters.

WEIN BRIDGE OSCILLATOR

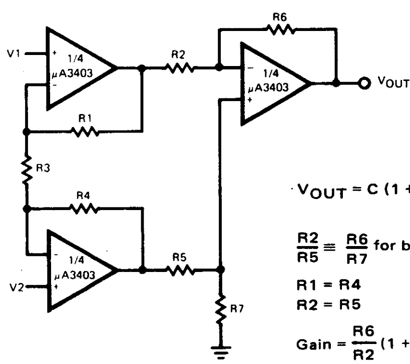


$f_o = \frac{1}{2\pi RC}$ for $f_o = 1$ kHz

$R = 16$ kΩ

$C = 0.01$ µF

HIGH IMPEDANCE DIFFERENTIAL AMPLIFIER



$V_{OUT} = C\ (1 + a + b)(V2 - V1)$

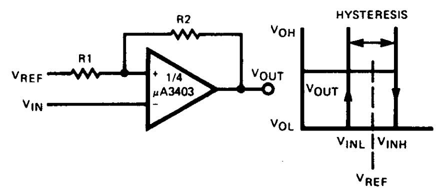
$\frac{R2}{R5} = \frac{R6}{R7}$ for best CMRR

$R1 = R4$

$R2 = R5$

$\text{Gain} = \frac{R6}{R2}\left(1 + \frac{2R1}{R3}\right) = C\ (1 + a + b)$

COMPARATOR WITH HYSTERESIS

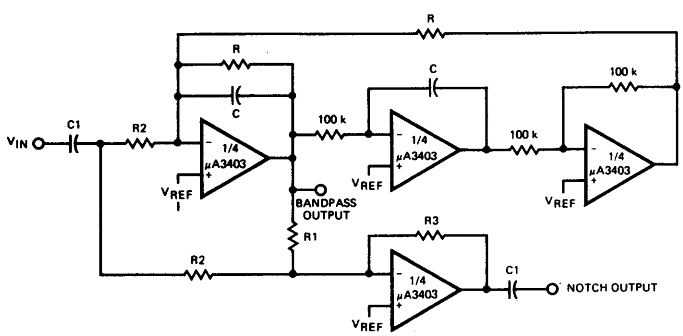


$$V_{INL} = \frac{R1}{R1 + R2}(V_{OL} - V_{REF}) + V_{REF}$$

$$V_{INH} = \frac{R1}{R1 + R2}(V_{OH} - V_{REF}) + V_{REF}$$

$$H = \frac{R1}{R1 + R2}(V_{OH} - V_{OL})$$

BI-QUAD FILTER



$Q = \frac{f_o}{BW}$

where

T_{BP} = Center Frequency Gain

T_N = Bandpass Notch Gain

$f_o = \frac{1}{2\pi RC}$

$R1 = QR$

$R2 = \frac{R1}{T_{BP}}$

$R3 = T_N R2$

$C1 = 10C$

Example:

$f_o = 1000$ Hz

$BW = 100$ Hz

$T_{BP} = 1$

$T_N = 1$

$R = 160$ kΩ

$R1 = 1.6$ MΩ

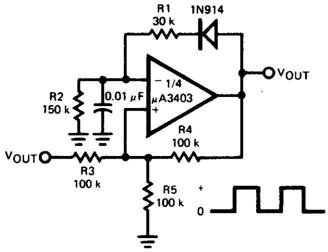
$R2 = 1.6$ MΩ

$R3 = 1.6$ MΩ

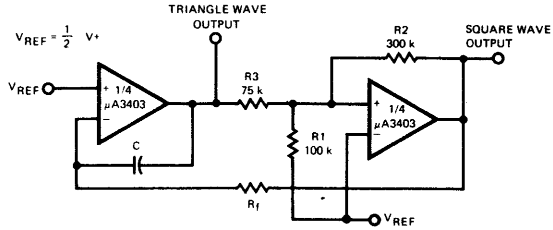
$C = 0.001$ µF

TYPICAL APPLICATIONS (Cont'd)

PULSE GENERATOR

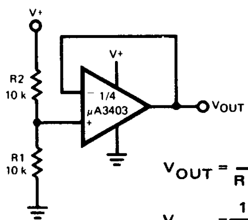


FUNCTION GENERATOR



$$f = \frac{R1 + R2}{4CR_fR1} \quad \text{if} \quad R3 = \frac{R2R1}{R2 + R1}$$

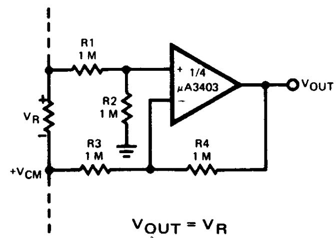
VOLTAGE REFERENCE



$$V_{OUT} = \frac{R1}{R1 + R2} \left(= \frac{V+}{2} \text{ as shown} \right)$$

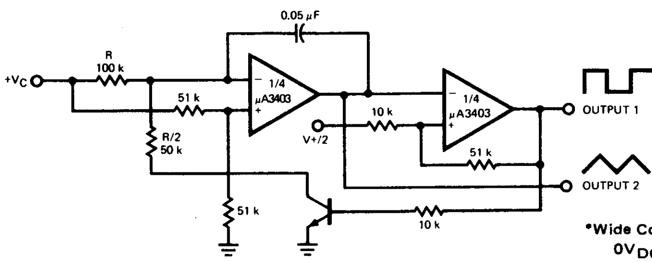
$$V_{OUT} = \frac{1}{2} V_{CC}$$

GROUND REFERENCING A DIFFERENTIAL INPUT SIGNAL



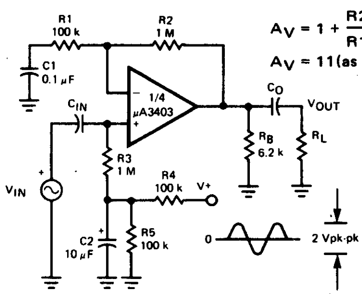
$$V_{OUT} = V_R$$

VOLTAGE CONTROLLED OSCILLATOR



*Wide Control Voltage Range:
$0V_{DC} \leq V_C \leq 2(V+ - 1.5\ V_{DC})$

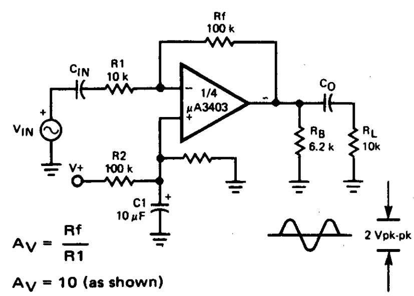
AC COUPLED NON-INVERTING AMPLIFIER



$$A_V = 1 + \frac{R2}{R1}$$

$A_V = 11$ (as shown)

AC COUPLED INVERTING AMPLIFIER



$$A_V = \frac{Rf}{R1}$$

$A_V = 10$ (as shown)