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μA3303 • μA3403 • μA3503 Quad Operational Amplifiers

Description
The μA3303, μA3403, and μA3503 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. They are constructed using the Fairchild Planar Epitaxial process.

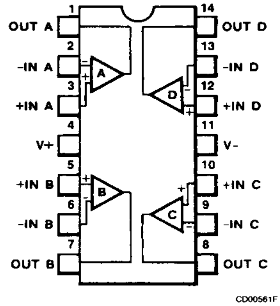
- **Input Common Mode Voltage Range Includes Ground Or Negative Supply**
- **Output Voltage Can Swing To Ground Or Negative Supply**
- **Four Internally Compensated Operational Amplifiers In A Single Package**
- **Wide Power Supply Range Single Supply Of 3.0 V To 36 V Dual Supply Of ± 1.5 To ± 18 V**
- **Class AB Output Stage For Minimal Crossover Distortion**
- **Short Circuit Protected Outputs**
- **High Open Loop Gain 200K Typically**
- **μA741 Operational Amplifier Type Performance**

Absolute Maximum Ratings

Storage Temperature Range	
Ceramic DIP	-65°C to +175°C
Molded DIP and SO-14	-65°C to +150°C
Operating Temperature Range	
Extended (μA3503M)	-55°C to +125°C
Industrial (μA3303V)	-40°C to +85°C
Commercial (μA3403C)	0°C to +70°C
Lead Temperature	
Ceramic DIP (soldering, 60 s)	300°C
Molded DIP and SO-14 (soldering, 10 s)	265°C
Internal Power Disisipation[1, 2]	
14L-Ceramic DIP	1.36 W
14L-Molded DIP	1.04 W
SO-14	0.93 W
Supply Voltage Between V+ and V−	36 V
Differential Input Voltage[3]	±30 V
Input Voltage (V − 1)[3]	−0.3 V (V−) to V+

Notes
1. $T_{J\ Max}$ = 150°C for the Molded DIP and SO-14, and 175°C for the Ceramic DIP.
2. Ratings apply to ambient temperature at 25°C. Above this temperature, derate the 14L-Ceramic DIP at 9.1 mW/°C, the 14L-Molded DIP at 8.3 mW/°C, and the SO-14 at 7.5 mW/°C.
3. For supply voltage less than 30 V between V+ and V−, the absolute maximum input voltage is equal to the supply voltage.

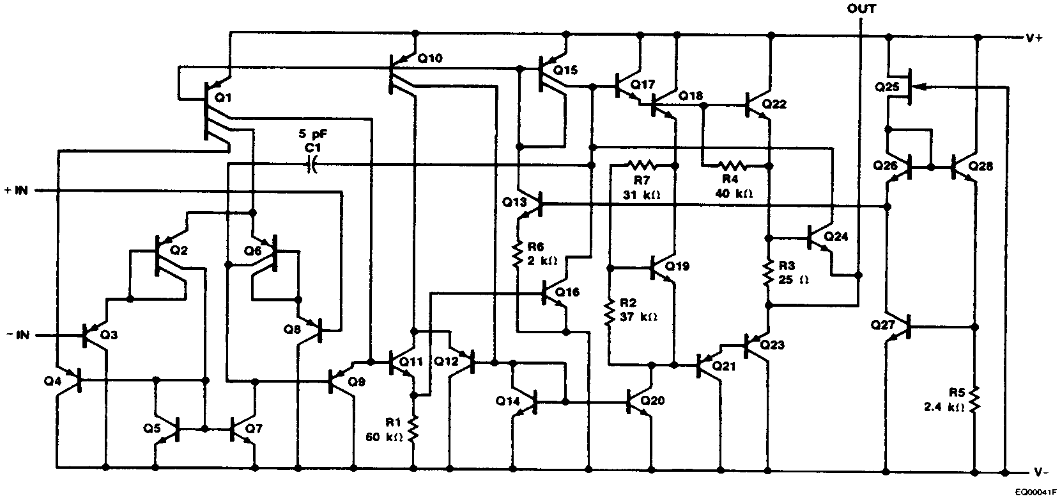
Connection Diagram
14-Lead DIP and SO-14 Package (Top View)



Order Information

Device Code	Package Code	Package Description
μA3303DV	6A	Ceramic DIP
μA3303PV	9A	Molded DIP
μA3403DC	6A	Ceramic DIP
μA3403PC	9A	Molded DIP
μA3403SC	KD	Molded Surface Mount
μA3503DM	6A	Ceramic DIP

Equivalent Circuit (1/4 of Circuit)



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μA3303 and μA3403
Electrical Characteristics $T_A = 25°C$, $V_{CC} = \pm 15$ V, unless otherwise specified.

Symbol	Characteristic		Condition	μA3303 Min	μA3303 Typ	μA3303 Max	μA3403 Min	μA3403 Typ	μA3403 Max	Unit
V_{IO}	Input Offset Voltage				2.0	8.0		2.0	8.0	mV
I_{IO}	Input Offset Current				30	75		30	50	nA
I_{IB}	Input Bias Current				200	500		200	500	nA
Z_I	Input Impedance			0.3	1.0		0.3	1.0		MΩ
I_{CC}	Supply Current		$V_O = 0$ V, $R_L = \infty$		2.8	7.0		2.8	7.0	mA
CMR	Common Mode Rejection		$R_S \leqslant 10$ kΩ	70	90		70	90		dB
V_{IR}	Input Voltage Range			+12 to V−	+12.5 to V−		+13 to V−	+13.5 to V−		V
PSRR	Power Supply Rejection Ratio				30	150		30	150	μV/V
I_{OS}	Output Short Circuit Current (Per Amplifier)[1]			±10	±30	±45	±10	±30	±45	mA
A_{VS}	Large Signal Voltage Gain		$V_O = \pm 10$ V, $R_L \geqslant 2.0$ kΩ	20	200		20	200		V/mV
V_{OP}	Output Voltage Swing		$R_L = 10$ kΩ	±12	12.5		±12	+13.5		V
			$R_L = 2.0$ kΩ	±10	12		±10	±13		
TR	Transient Response	Rise time/ Fall time	$V_O = 50$ mV, $A_V = 1.0$, $R_L = 10$ kΩ		0.3			0.3		μs
		Overshoot	$V_O = 50$ mV, $A_V = 1.0$, $R_L = 10$ kΩ		5.0			5.0		%
BW	Bandwidth		$V_O = 50$ mV, $A_V = 1.0$, $R_L = 10$ kΩ		1.0			1.0		MHz
SR	Slew Rate		$V_I = -10$ V to $+10$ V, $A_V = 1.0$		0.6			0.6		V/μs

The following specifications apply for $-40°C \leqslant T_A \leqslant +85°C$ for the μA3303, and $0°C \leqslant T_A \leqslant +70°C$ for the μA3403.

Symbol	Characteristic	Condition	μA3303 Min	μA3303 Typ	μA3303 Max	μA3403 Min	μA3403 Typ	μA3403 Max	Unit
V_{IO}	Input Offset Voltage				10			10	mV
$\Delta V_{IO}/\Delta T$	Input Offset Voltage Temperature Sensitivity			10			10		μV/°C
I_{IO}	Input Offset Current				250			200	nA
$\Delta I_{IO}/\Delta T$	Input Offset Current Temperature Sensitivity			50			50		pA/°C
I_{IB}	Input Bias Current				1000			800	nA
A_{VS}	Large Signal Voltage Gain	$V_O = \pm 10$ V, $R_L \geqslant 2.0$ kΩ	15			15			V/mV
V_{OP}	Output Voltage Swing	$R_L = 2.0$ kΩ	±10			±10			V

μA3303 and μA3403 (Cont.)
Electrical Characteristics $T_A = 25°C$, $V+ = 5.0$ V, $V- =$ Gnd, unless otherwise specified.

Symbol	Characteristic	Condition	μA3303 Min	μA3303 Typ	μA3303 Max	μA3403 Min	μA3403 Typ	μA3403 Max	Unit
V_{IO}	Input Offset Voltage				8.0		2.0	8.0	mV
I_{IO}	Input Offset Current				75		30	50	nA
I_{IB}	Input Bias Current				500		200	500	nA
I_{CC}	Supply Current			2.5	7.0		2.5	7.0	mA
PSRR	Power Supply Rejection Ratio				150			150	μV/V
A_{VS}	Large Signal Voltage Gain	$R_L \geq 2.0$ kΩ	20	200		20	200		V/mV
V_{OP}	Output Voltage Swing[2]	$R_L = 10$ kΩ	3.3			3.3			V
		5.0 V ≤ V+ ≤ 30 V, $R_L = 10$ kΩ	(V+) −2.0			(V+) −2.0			
CS	Channel Separation	1.0 Hz ≤ f ≤ 20 kHz (Input Referenced)		−120			−120		dB

μA3503
Electrical Characteristics $T_A = 25°C$, $V_{CC} = \pm 15$ V, unless otherwise specified.

Symbol	Characteristic		Condition	μA3503 Min	μA3503 Typ	μA3503 Max	Unit
V_{IO}	Input Offset Voltage				2.0	5.0	mV
I_{IO}	Input Offset Current				30	50	nA
I_{IB}	Input Bias Current				200	500	nA
Z_I	Input Impedance			0.3	1.0		MΩ
I_{CC}	Supply Current		$V_O = 0$, $R_L = \infty$		2.8	4.0	mA
CMR	Common Mode Rejection		$R_S \leq 10$ kΩ	70	90		dB
V_{IR}	Input Voltage Range			+13 to V−	+13.5 to V−		V
PSRR	Power Supply Rejection Ratio				30	150	μV/V
I_{OS}	Output Short Circuit Current (Per Amplifier)[1]			±10	±30	±45	mA
A_{VS}	Large Signal Voltage Gain		$V_O = \pm 10$ V, $R_L \geq 2.0$ kΩ	50	200		V/mV
V_{OP}	Output Voltage Swing		$R_L = 10$ kΩ	±12	±13.5		V
			$R_L = 2.0$ kΩ	±10	±13		
TR	Transient Response	Rise time	$V_O = 50$ mV, $A_V = 1.0$, $R_L = 10$ kΩ		0.3		μs
		Overshoot	$V_O = 50$ mV, $A_V = 1.0$, $R_L = 10$ kΩ		5.0		%
BW	Bandwidth		$V_O = 50$ mV, $A_V = 1.0$, $R_L = 10$ kΩ		1.0		MHz
SR	Slew Rate		$V_I = -10$ V to $+10$ V, $A_V = 1.0$		0.6		V/μs

μA3503

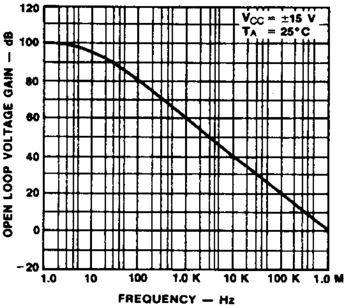
Electrical Characteristics $-55°C \leqslant T_A \leqslant +125°C$, $V_{CC} = \pm 15$ V, unless otherwise specified.

Symbol	Characteristic	Condition	μA3503 Min	Typ	Max	Unit
V_{IO}	Input Offset Voltage				6.0	mV
$\Delta V_{IO}/\Delta T$	Input Offset Voltage Temperature Sensitivity			10		μV/°C
I_{IO}	Input Offset Current				200	nA
$\Delta I_{IO}/\Delta T$	Input Offset Current Temperature Sensitivity			50		pA/°C
I_{IB}	Input Bias Current				1200	nA
A_{VS}	Large Signal Voltage Gain	$V_O = \pm 10$ V, $R_L \geqslant 2.0$ kΩ	25			V/mV
V_{OP}	Output Voltage Swing	$R_L = 2.0$ kΩ	±10			V
The following specifications apply for $T_A = 25°C$, V+ = +5.0 V, V– = GND.						
V_{IO}	Input Offset Voltage			2.0	5.0	mV
I_{IO}	Input Offset Current			30	50	nA
I_{IB}	Input Bias Current			200	500	nA
I_{CC}	Supply Current			2.5	4.0	mA
PSRR	Power Supply Rejection Ratio				150	μV/V
A_{VS}	Large Signal Voltage Gain	$R_L \geqslant 2.0$ kΩ	20	200		V/mV
V_{OP}	Output Voltage Swing[2]	$R_L = 10$ kΩ	3.3			V
		5.0 V ≤ V+ ≤ 30 V, $R_L = 10$ kΩ	(V+) −2.0			
CS	Channel Separation	1.0 Hz ≤ f ≤ 20 kHz (Input Referenced)		−120		dB

Notes
1. Not to exceed maximum package power dissipation.
2. Output will swing to ground.

Typical Performance Curves

Open Loop Frequency Response



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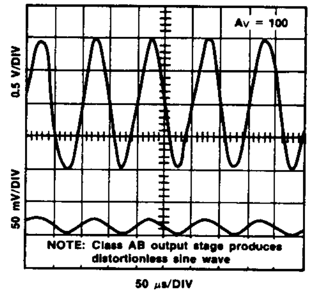
Sine Wave Response



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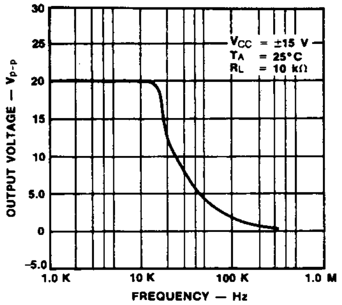
Output Voltage vs Frequency



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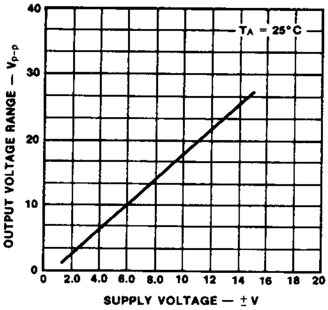
Output Swing vs Supply Voltage



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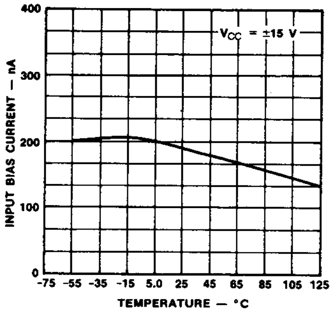
Input Bias Current vs Temperature



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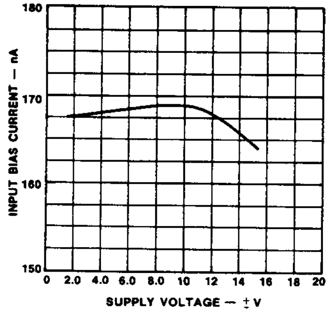
Input Bias Current vs Supply Voltage



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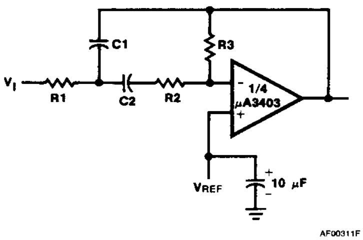
Typical Applications

Multiple Feedback Bandpass Filter



f_o = center frequency

BW = Bandwidth
R in kΩ
C in μF

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

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

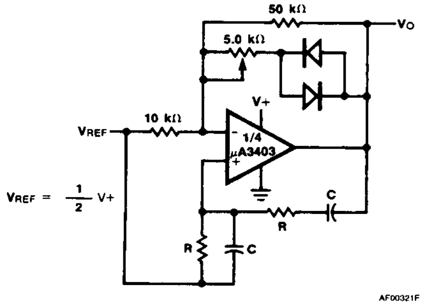
R1 = R2 = 1
R3 = 9Q^2–1 } Use scaling factors in these expressions.

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

Design example:
given: Q = 5, f_o = 1 kHz
Let R1 = R2 = 10 kΩ
then R3 = $9(5)^2 - 10$
R3 = 215 kΩ

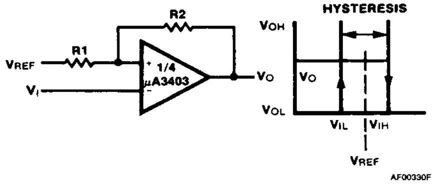
$$C = \frac{5}{3} = 1.6 \text{ nF}$$

Wein Bridge Oscillator



$$f_o = \frac{1}{2\pi RC} \text{ for } f_o = 1 \text{ kHz}$$
R = 16 kΩ
C = 0.01 μF

Comparator With Hysteresis



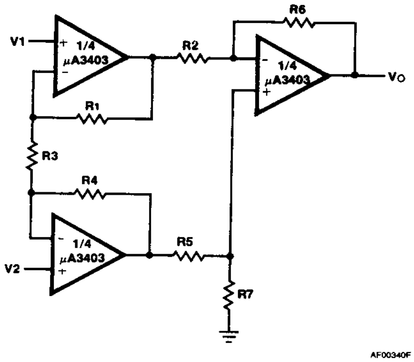
$$V_{IL} = \frac{R1}{R1 + R2}(V_{OL} - V_{REF}) + V_{REF}$$

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

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

Typical Applications (Cont.)

High Impedance Differential Amplifier



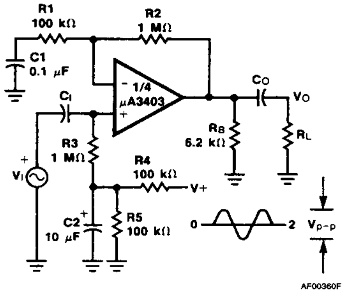
$V_{OUT} = C(1 + a + b)(V2 - V1)$

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

R1 = R4
R2 = R5

$$\text{Gain} = \frac{R6}{R5}\left(1 + \frac{2R1}{R3}\right) = C\,(1 + a + b)$$

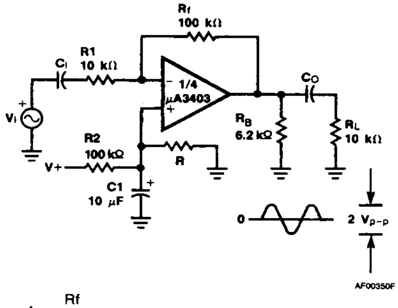
AC Coupled Non-Inverting Amplifier



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

$A_V = 11$ (as shown)

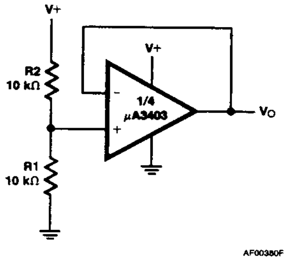
AC Coupled Inverting Amplifier



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

$A_V = 10$ (as shown)

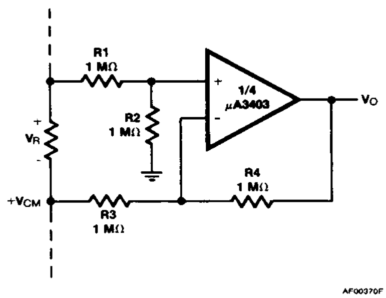
Voltage Reference



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

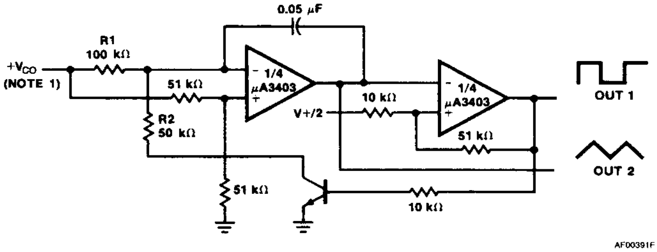
$$V_O = \frac{1}{2}\,V+$$

Ground Referencing A Differential Input Signal

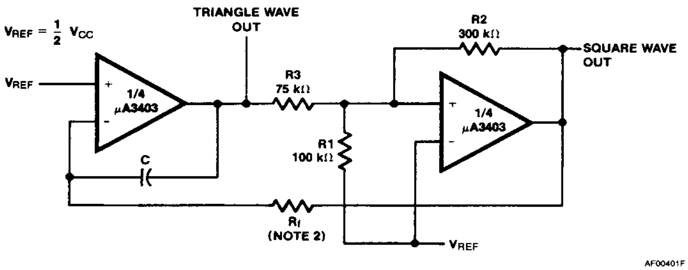


Typical Applications (Cont.)

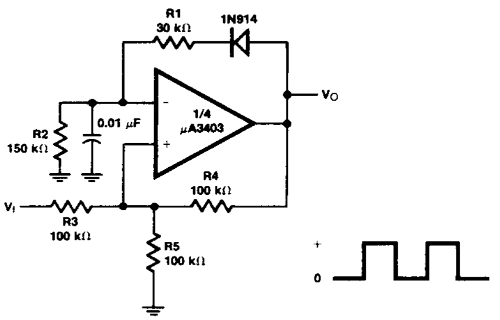
Voltage Controlled Oscillator



Function Generator



Pulse Generator

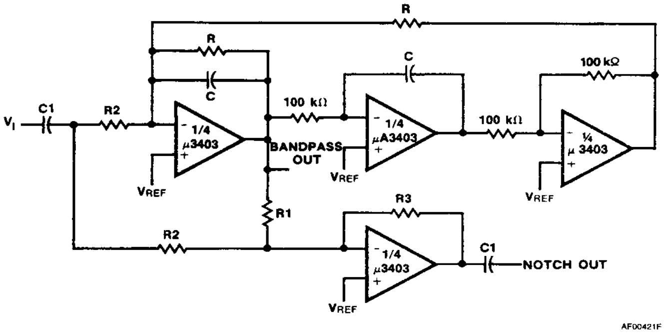


Note

1. Wide Control Voltage Range: $0V \leq V_{CO} \leq 2\ (V+ - 1.5\ V)$
2. $f = \frac{R1 + R2}{4CR_fR1}$ if $R3 = \frac{R2R1}{R2 + R1}$

Typical Applications (Cont.)

Bi-Quad Filter



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

where

T_{BP} = Center Frequency Gain

T_N = Bandpass Notch Gain

$f_o = \frac{1}{2\pi RC}$, $V_{REF} = \frac{1}{2} V_{CC}$

$R1 = QR$

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

$R3 = T_N R2$

$C1 = 10\ C$

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

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