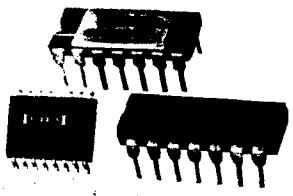
BURR-BROWN®



OPA404

MILITARY & DIE VERSIONS AVAILABLE

Quad High-Speed Precision *Difet*® OPERATIONAL AMPLIFIER

FEATURES

- WIDE BANDWIDTH: 6.4MHz
- HIGH SLEW RATE: 35V/μs
- LOW OFFSET: ±750μV max
- LOW BIAS CURRENT: ±4pA max
- FAST SETTLING: 1.5μs to 0.01%
- STANDARD QUAD PINOUT

APPLICATIONS

- PRECISION INSTRUMENTATION
- OPTOELECTRONICS
- SONAR, ULTRASOUND
- PROFESSIONAL AUDIO EQUIPMENT
- MEDICAL EQUIPMENT
- DETECTOR ARRAYS

DESCRIPTION

The OPA404 is a high performance monolithic *Difet*® (dielectrically-isolated FET) quad operational amplifier. It offers an unusual combination of very-low bias current together with wide bandwidth and fast slew rate.

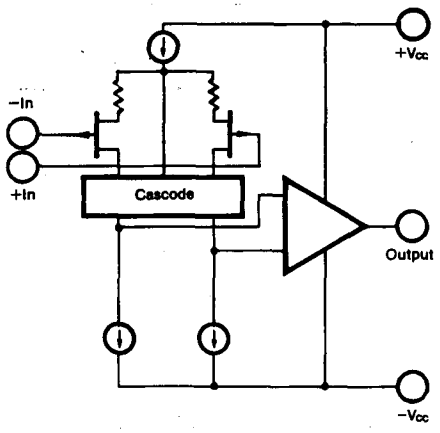
Noise, bias current, voltage offset, drift, and speed are superior to BIFET® amplifiers.

Laser trimming of thin-film resistors gives very-low offset and drift—the best available in a quad FET op amp.

The OPA404's input cascode design allows high precision input specifications and uncompromised high-speed performance.

Standard quad op amp pin configuration allows upgrading of existing designs to higher performance levels. The OPA404 is unity-gain stable.

Difet® Burr-Brown Corp., BIFET® National Semiconductor Corp.



OPA404 Simplified Circuit
(Each Amplifier)

International Airport Industrial Park - P.O. Box 11400 - Tucson, Arizona 85734 - Tel. (602) 746-1111 - Twx: 910-952-1111 - Cable: BBRCORP - Telex: 66-6491

PDS-677B

SPECIFICATION

ELECTRICAL

At V_{CC} = ±15VDC and T_A = +25°C uni

PARAMETER	
INPUT	
NOISE(1)	
Voltage: f_O = 10Hz	
f_O = 100Hz	
f_O = 1kHz	
f_O = 10kHz	
f_B = 10Hz to 10kHz	
f_B = 0.1Hz to 10Hz	
Current: f_B = 0.1Hz to 10Hz	
f_O = 0.1Hz to 20kHz	
OFFSET VOLTAGE	
Input Offset Voltage	
KP, KU	
Average Drift	
KP	
Supply Rejection	
KP, KU	
Channel Separation	
BIAS CURRENT	
Input Bias Current	
KP, KU	
OFFSET CURRENT	
Input Offset Current	
KP, KU	
IMPEDANCE	
Differential	
Common-Mode	
VOLTAGE RANGE	
Common-Mode Input Range	
Common-Mode Rejection	
KP, KU	
OPEN-LOOP GAIN, DC	
Open-Loop Voltage Gain	
FREQUENCY RESPONSE	
Gain Bandwidth	
Full,Power Response	
Slew Rate	
Settling Time: 0.1%	
0.01%	
RATED OUTPUT	
Voltage Output	
Current Output	
Output Resistance	
Load Capacitance Stability	
Short Circuit Current	
POWER SUPPLY	
Rated Voltage	
Voltage Range,	
Derated Performance	
Current, Quiescent	
TEMPERATURE RANGE	
Specification	
KP, KU	
Operating	
KP, KU	
Storage	
θ Junction-Ambient	
KP, KU	

*Specification same as OPA404A
NOTES: (1) Noise testing availat

SPECIFICATIONS

ELECTRICAL

At V_{CC} = ±15VDC and T_A = +25°C unless otherwise noted.

PARAMETER	CONDITIONS	OPA404AG, KP, KU MIN	OPA404AG, KP, KU TYP	OPA404AG, KP, KU MAX	OPA404BG MIN	OPA404BG TYP	OPA404BG MAX	OPA404SG MIN	OPA404SG TYP	OPA404SG MAX	UNITS
INPUT											
NOISE[1]											
Voltage: f_o = 10Hz			32			•			•		nV/√Hz
f_o = 100Hz			19			•			•		nV/√Hz
f_o = 1kHz			15			•			•		nV/√Hz
f_o = 10kHz			12			•			•		nV/√Hz
f_B = 10Hz to 10kHz			1.4			•			•		μV, rms
f_B = 0.1Hz to 10Hz			0.95			•			•		μV, p-p
Current: f_B = 0.1Hz to 10Hz			12			•			•		fA, p-p
f_o = 0.1Hz to 20kHz			0.6			•			•		fA/√Hz
OFFSET VOLTAGE											
Input Offset Voltage	V_{CM} = 0VDC		±260	±1mV		•	±750		•	•	μV
KP, KU			±750	±2.5mV							μV
Average Drift	$T_A = T_{MIN}$ to T_{MAX}		±3			•			•		μV/°C
KP			±5								μV/°C
Supply Rejection	$\pm V_{CC}$ = 12V to 18V	80	100		86	•		•	•		dB
KP, KU		76	100								dB
Channel Separation	100Hz, R_L = 2kΩ		125			•			•		dB
BIAS CURRENT											
Input Bias Current	V_{CM} = 0VDC		±1	±8		•	±4		•	•	pA
KP, KU			±1	±12							pA
OFFSET CURRENT											
Input Offset Current	V_{CM} = 0VDC		0.5	8		•	4		•	•	pA
KP, KU			0.5	12							pA
IMPEDANCE											
Differential			$10^{13} \parallel 1$			•			•		Ω ‖ pF
Common-Mode			$10^{14} \parallel 3$			•			•		Ω ‖ pF
VOLTAGE RANGE											
Common-Mode Input Range		±10.5	+13, −11		•	•		•	•		V
Common-Mode Rejection	V_{IN} = ±10VDC	88	100		92	•		•	•		dB
KP, KU		84	100								dB
OPEN-LOOP GAIN, DC											
Open-Loop Voltage Gain	$R_L \geq$ 2kΩ	88	100		92	•		•	•		dB
FREQUENCY RESPONSE											
Gain Bandwidth	Gain = 100	4	6.4		5	•		•	•		MHz
Full Power Response	20V p-p, R_L = 2kΩ		570			•			•		kHz
Slew Rate	V_O = ±10V, R_L = 2kΩ	24	35		28	•		•	•		V/μs
Settling Time: 0.1%	Gain = −1, R_L = 2kΩ		0.6			•			•		μs
0.01%	C_L = 100pF, 10V step		1.5			•			•		μs
RATED OUTPUT											
Voltage Output	R_L = 2kΩ	±11.5	+13.2, −13.8		•	•		•	•		V
Current Output	V_O = ±10VDC	±5	±10		•	•		•	•		mA
Output Resistance	1MHz, open loop		80			•			•		Ω
Load Capacitance Stability	Gain = +1		1000			•			•		pF
Short Circuit Current		±10	±18	±20	•	•	•	•	•	•	mA
POWER SUPPLY											
Rated Voltage			±15			•			•		VDC
Voltage Range,											
Derated Performance		±5		±18	•		•	•		•	VDC
Current, Quiescent	I_O = 0mADC		9	10		•	•		•	•	mA
TEMPERATURE RANGE											
Specification	Ambient temp.	−25		+85	•		•	−55		+125	°C
KP, KU		0		+70							°C
Operating	Ambient temp.	−55		+125	•		•	•		•	°C
KP, KU		−25		+85							°C
Storage	Ambient temp.	−65		+150	•		•	•		•	°C
θ Junction-Ambient			100			•			•		°C/W
KP, KU			120/100								°C/W

*Specification same as OPA404AG.

NOTES: (1) Noise testing available—inquire.

$15.15 Inv 1-24 Kay

ELECTRICAL (FULL TEMPERATURE RANGE SPECIFICATIONS)

At V_{CC} = ±15VDC and $T_A = T_{MIN}$ to T_{MAX} unless otherwise noted.

PARAMETER	CONDITIONS	OPA404AG, KP, KU			OPA404BG			OPA404SG			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
TEMPERATURE RANGE											
Specification Range	Ambient temp.	−25		+85	*		*	−55		+125	°C
KP, KU		0		+70							°C
INPUT											
OFFSET VOLTAGE											
Input Offset Voltage	V_{CM} = 0VDC		±450	2mV		*	±1.5mV		±550	±2.5mV	µV
KP, KU			±1	±3.5							mV
Average Drift			±3			*			*		µV/°C
KP, KU			±5								µv/°C
Supply Rejection		75	96		80	*		70	93		dB
BIAS CURRENT											
Input Bias Current	V_{CM} = 0VDC		±32	±200		*	±100		±500	±5nA	pA
OFFSET CURRENT											
Input Offset Current	V_{CM} = 0VDC		17	100		*	50		260	2.5nA	pA
VOLTAGE RANGE											
Common-Mode Input Range		±10.2	+12.7, −10.6		*	*		±10	+12.6, −10.5		V
Common-Mode Rejection	V_{IN} = ±10VDC	82	99		86	*		80	88		dB
KP, KU		80	99								dB
OPEN-LOOP GAIN, DC											
Open-Loop Voltage Gain	$R_L \geq 2k\Omega$	82	94		86	*		80	88		dB
RATED OUTPUT											
Voltage Output	R_L = 2kΩ	±11.5	+12.9, −13.8		*	*		±11	+12.7, −13.8		V
Current Output	V_O = ±10VDC	±5	±9		*	*		*	±8		mA
Short Circuit Current	V_O = 0VDC	±5	±12	±30	*	*	*	±8	±10	*	mA
POWER SUPPLY											
Current, Quiescent	I_O = 0mADC		9.3	10.5		*	*		9.4	11	mA

*Specification same as OPA404AG.

ORDERING INFORMATION

OPA404 ( ) ( )

Basic model number

Performance grade
- K = 0°C to +70°C
- A, B = −25°C to +85°C
- S = −55°C to +125°C

Package code
- G = 14-pin ceramic DIP
- P = 14-pin plastic DIP
- U = 16-Pin plastic SOIC

ABSOLUTE MAXIMUM RATINGS

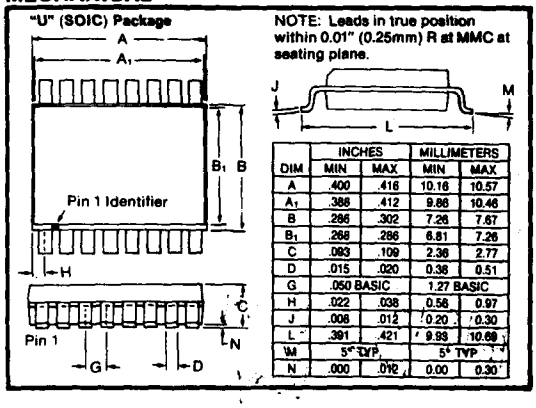
Supply	±18VDC
Internal Power Dissipation(1)	1000mW
Differential Input Voltage(2)	±36VDC
Input Voltage Range(2)	±18VDC
Storage Temperature Range	P, U = −40/+85°C, G = −65/+150°C
Operating Temperature Range	P, U = −25/+85°C, G = −55/+125°C
Lead Temperature (soldering, 10 seconds)	+300°C
Output Short Circuit Duration(3)	Continuous
Junction Temperature	+175°C

NOTES:
(1) Packages must be derated based on θ_{JC} = 30°C/W or θ_{JA} = 120°C/W.
(2) For supply voltages less than ±18VDC the absolute maximum input voltage is equal to: 18V > V_{IN} > $-V_{CC}$ − 8V. See Figure 2.
(3) Short circuit may be to power supply common only. Rating applies to +25°C ambient. Observe dissipation limit and T_J.

MECHANICAL

"U" (SOIC) Package

NOTE: Leads in true position within 0.01" (0.25mm) R at MMC at seating plane.

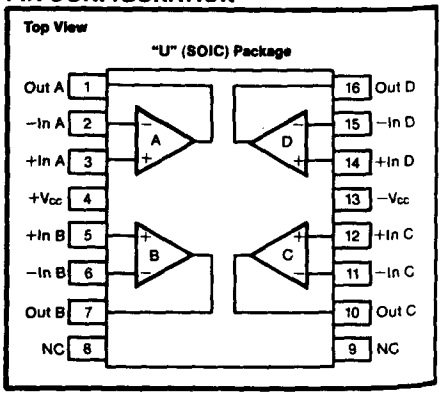


DIM	INCHES MIN	INCHES MAX	MILLIMETERS MIN	MILLIMETERS MAX
A	.400	.416	10.16	10.57
A_1	.388	.412	9.86	10.46
B	.286	.302	7.26	7.67
B_1	.268	.286	6.81	7.26
C	.093	.109	2.36	2.77
D	.015	.020	0.38	0.51
G	.050 BASIC		1.27 BASIC	
H	.022	.038	0.56	0.97
J	.008	.012	0.20	0.30
L	.391	.421	9.93	10.69
M	5° TYP.		5° TYP.	
N	.000	.012	0.00	0.30

PIN CONFIGURATION

Top View

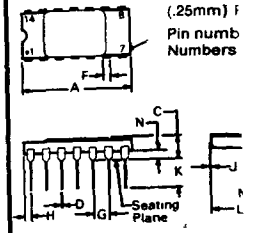
"U" (SOIC) Package



MECHANICAL

"G" Package

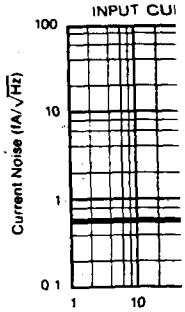
NOTE: L
(.25mm) F
Pin numb
Numbers

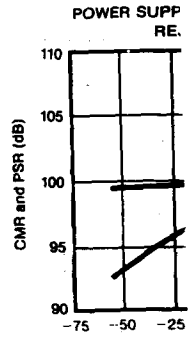


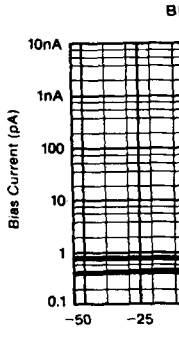
Pin material and plating compos
conform to Method 2003 (solde
of MIL-STD-883 (except paragr

TYPICAL PERF

T_A = +25°C, V_{CC} = ±15VDC unles





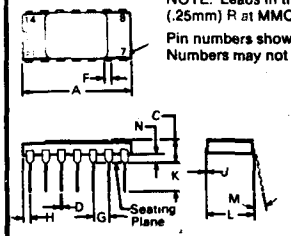


Cindy Cox
(201) 386-6233

$3.54 → $3.61

MECHANICAL

"G" Package



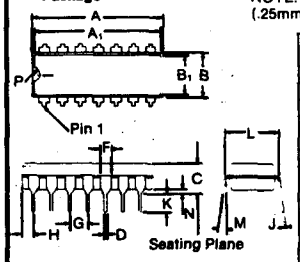
NOTE: Leads in true position within .010" (.25mm) R at MMC at seating plane.

Pin numbers shown for reference only. Numbers may not be marked on package.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	.670	.710	17.02	18.03
C	.065	.170	1.65	4.32
D	.015	.021	0.38	0.53
F	.045	.060	1.14	1.52
G	.100 BASIC		2.54 BASIC	
H	.025	.070	0.64	1.78
J	.008	.012	0.20	0.30
K	.120	.240	3.05	6.10
L	.300 BASIC		7.62 BASIC	
M	—	10°	—	10°
N	.009	.060	0.23	1.52

Pin material and plating composition conform to Method 2003 (solderability) of MIL-STD-883 (except paragraph 3.2).

"P" Package



NOTE: Leads in true position within .010" (.25mm) R at MMC at seating plane.

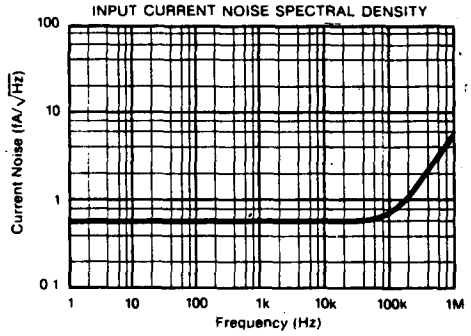
DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	.700	.800	17.78	20.32
A_1	.685	.785	17.40	19.94
B	.230	.290	5.85	7.38
B_1	.200	.250	5.09	6.36
C	.120	.200	3.05	5.09
D	.015	.023	0.38	0.59
F	.030	.070	0.76	1.78
G	.100 BASIC		2.54 BASIC	
H	.050	.100	1.27	2.54
J	.008	.015	0.20	0.38
K	.070	.150	1.78	3.82
L	.300 BASIC		7.63 BASIC	
M	0°	15°	0°	15°
N	.010	.030	0.25	0.76
P	.025	.050	0.64	1.27

Pin material and plating composition conform to Method 2003 (solderability) of MIL-STD-883 (except paragraph 3.2).

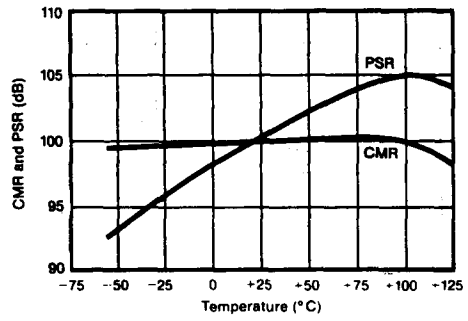
TYPICAL PERFORMANCE CURVES

T_A = +25°C, V_{CC} = ±15VDC unless otherwise noted.

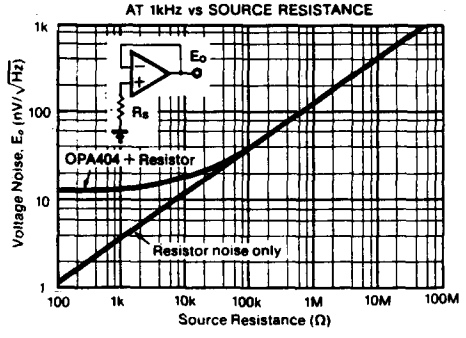
INPUT CURRENT NOISE SPECTRAL DENSITY



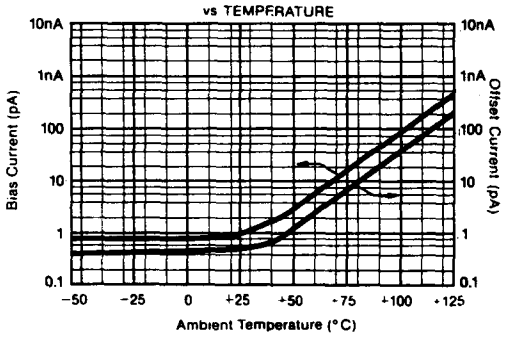
POWER SUPPLY REJECTION AND COMMON-MODE REJECTION vs TEMPERATURE



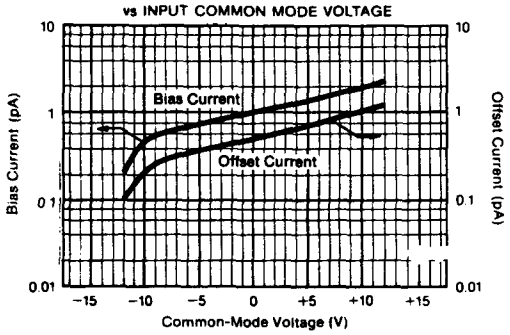
TOTAL INPUT VOLTAGE NOISE SPECTRAL DENSITY AT 1kHz vs SOURCE RESISTANCE



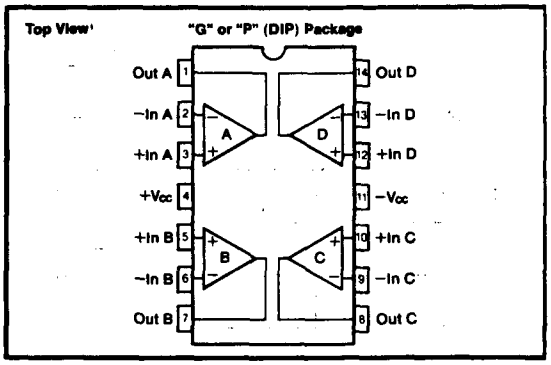
BIAS AND OFFSET CURRENT vs TEMPERATURE



BIAS AND OFFSET CURRENT vs INPUT COMMON MODE VOLTAGE



CONNECTION DIAGRAM



OPA404

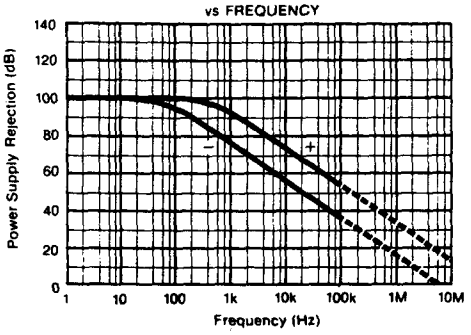
2

OPERATIONAL AMPLIFIERS

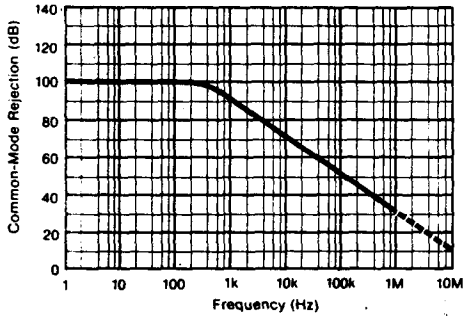
TYPICAL PERFORMANCE CURVES [CONT]

T_A = +25°C, V_{CC} = ±15VDC unless otherwise noted.

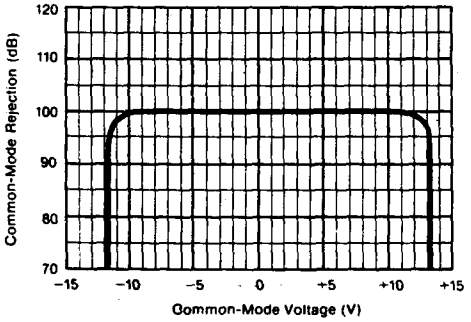
POWER SUPPLY REJECTION vs FREQUENCY



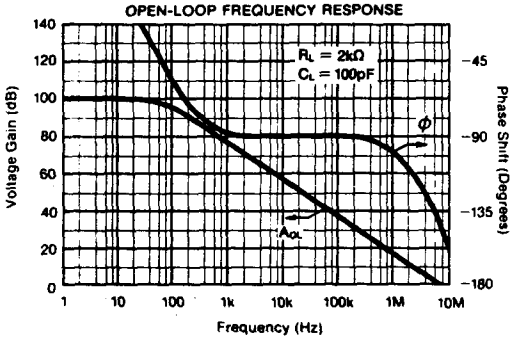
COMMON-MODE REJECTION vs FREQUENCY



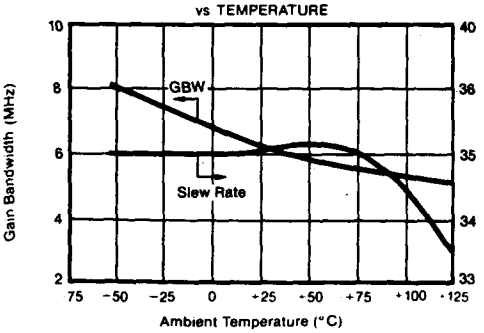
COMMON-MODE REJECTION vs INPUT COMMON MODE VOLTAGE



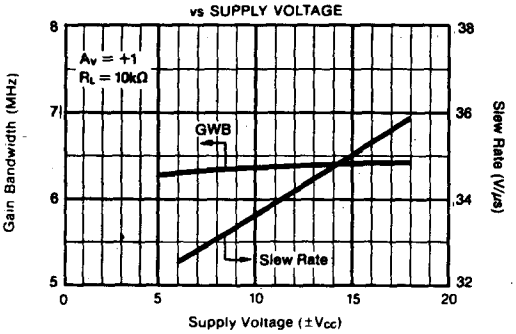
OPEN-LOOP FREQUENCY RESPONSE



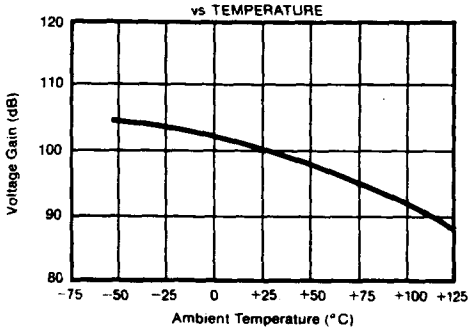
GAIN-BANDWIDTH AND SLEW RATE vs TEMPERATURE



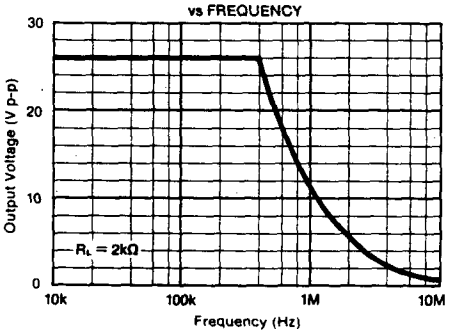
GAIN-BANDWIDTH AND SLEW RATE vs SUPPLY VOLTAGE



OPEN-LOOP GAIN vs TEMPERATURE

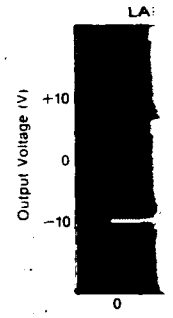


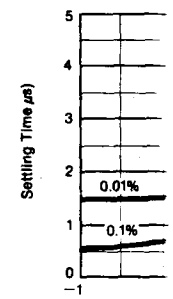
MAXIMUM OUTPUT VOLTAGE SWING vs FREQUENCY

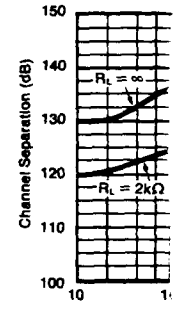


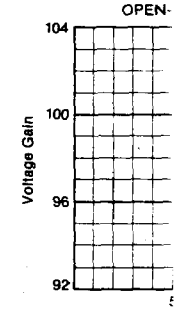
TYPICAL

T_A = +25°C, V_{CC} = ±1





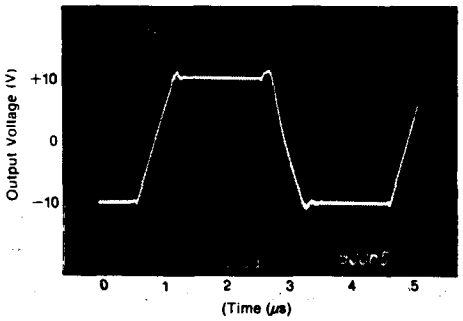




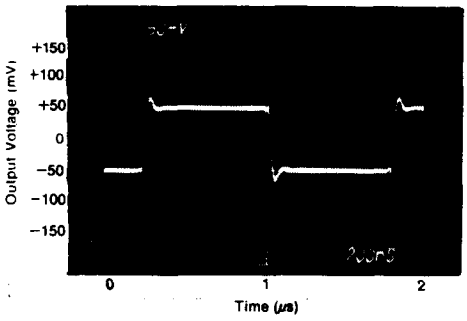
TYPICAL PERFORMANCE CURVES [CONT]

T_A = +25°C, V_{CC} = ±15VDC unless otherwise noted

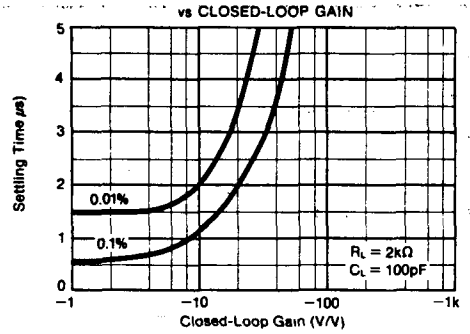
LARGE SIGNAL TRANSIENT RESPONSE



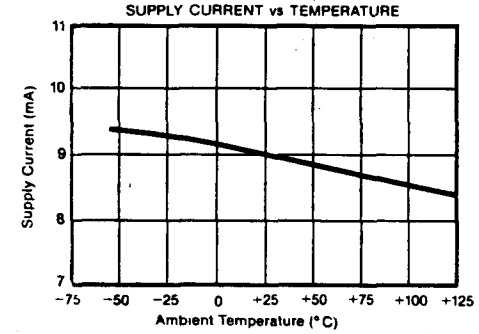
SMALL SIGNAL TRANSIENT RESPONSE



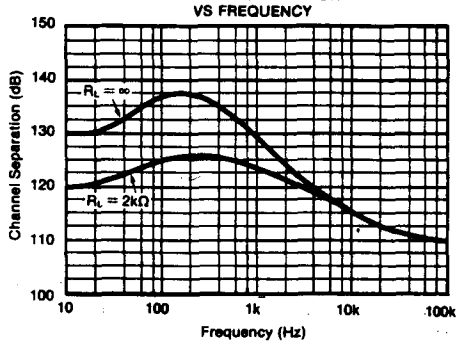
SETTLING TIME vs CLOSED-LOOP GAIN



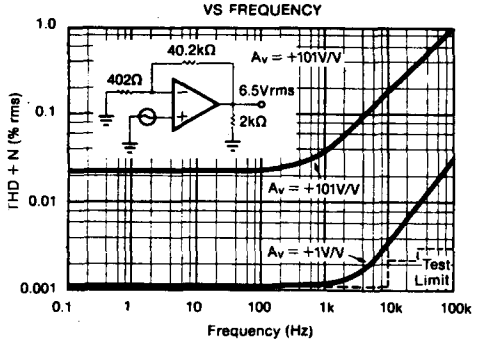
SUPPLY CURRENT vs TEMPERATURE



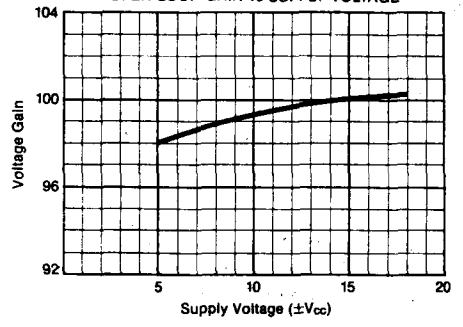
CHANNEL SEPARATION VS FREQUENCY



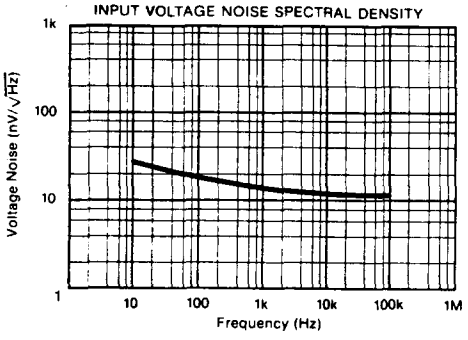
TOTAL HARMONIC DISTORTION VS FREQUENCY



OPEN-LOOP GAIN vs SUPPLY VOLTAGE



INPUT VOLTAGE NOISE SPECTRAL DENSITY



APPLICATIONS INFORMATION

OFFSET VOLTAGE ADJUSTMENT

The OPA404 offset voltage is laser-trimmed and will require no further trim for most applications. If desired, offset voltage can be trimmed by summing (see Figure 1). With this trim method there will be no degradation of input offset drift.

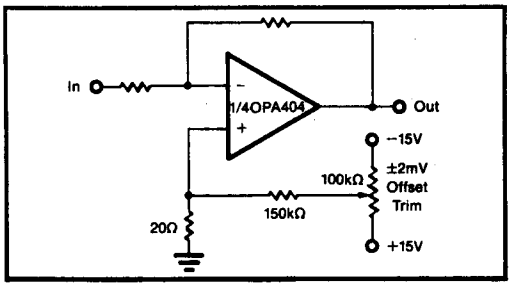


FIGURE 1. Offset Voltage Trim.

INPUT PROTECTION

Conventional monolithic FET operational amplifiers require external current-limiting resistors to protect their inputs against destructive currents that can flow when input FET gate-to-substrate isolation diodes are forward-biased. Most BIFET® amplifiers can be destroyed by the loss of $-V_{CC}$

Unlike BIFET® amplifiers, the ***Difet®*** OPA404 requires input current limiting resistors only if its input voltage can exceed −8V. A 10kΩ series resistor will limit the input current to a safe value with up to ±15V input levels even if both supply voltages are lost. (See Figure 2 and Absolute Maximum Ratings).

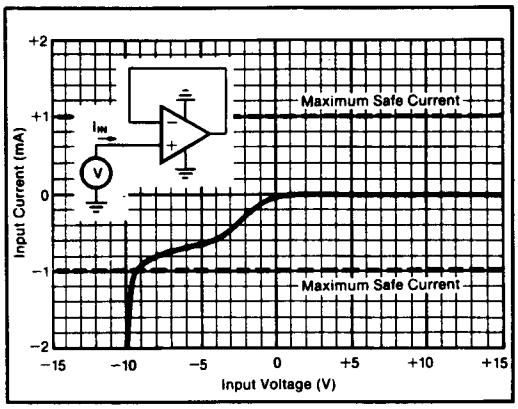


FIGURE 2. Input Current vs Input Voltage with $\pm V_{CC}$ Pins Grounded.

Static damage can cause subtle changes in amplifier input characteristics without necessarily destroying the device. In precision operational amplifiers (both bipolar and FET types), this may cause a noticeable degradation of offset voltage and drift.

Static protection is recommended when handling any precision IC operational amplifier.

GUARDING AND SHIELDING

As in any situation where high impedances are involved, careful shielding is required to reduce "hum" pickup in input leads. If large feedback resistors are used, they should also be shielded along with the external input circuitry.

Leakage currents across printed circuit boards can easily exceed the bias current of the OPA404. To avoid leakage, utmost care must be used in planning the board layout. A "guard" pattern should completely surround the high impedance input leads and should be connected to a low impedance point which is at the signal input ptotential (see Figure 3).

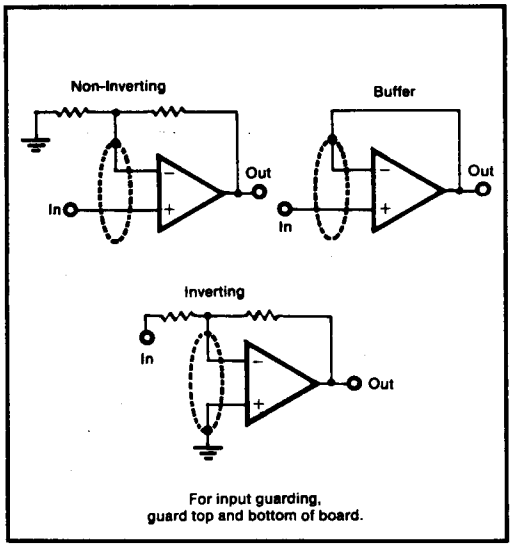


FIGURE 3. Connection of Input Guard.

HANDLING AND TESTING

Measuring the unusually low bias current of the OPA404 is difficult without specialized test equipment; most commercial benchtop testers cannot accurately measure the OPA404 bias current. Low-leakage test sockets and special test fixtures are recommended if incoming inspection of bias current is to be performed.

To prevent surface leakage between pins, the DIP package should not be handled by bare fingers. Oils and salts from fingerprints or careless handling can create leakage currents that exceed the specified OPA404 bias currents.

If necessary, DIP packages and PC board assemblies can be cleaned with Freon TF®, baked for 30 minutes at 85°C, rinsed with de-ionized water, and baked again for 30 minutes at 85°C. Surface contamination can be prevented by the application of a high-quality conformal coating to the cleaned PC board assembly.

BIAS CURRENT
COMMON-MOD

The input bias cu
tional amplifiers
(Figure 4). High
causes leakage an
Due to its cascoc

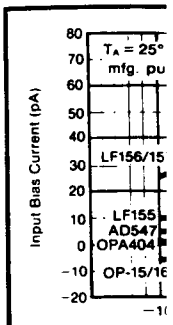


FIGURE 4. Inp
Volt

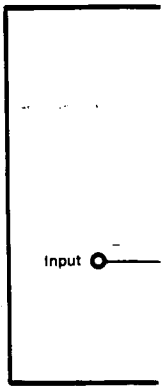


FIGURE 6. Lo

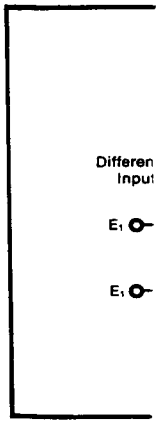


FIGURE 7. V

BIAS CURRENT CHANGE VERSUS COMMON-MODE VOLTAGE

The input bias currents of most popular BIFET® operational amplifiers are affected by common-mode voltage (Figure 4). Higher input FET gate-to-drain voltage causes leakage and ionization (bias) currents to increase. Due to its cascode input stage, the extremely-low bias current of the OPA404 is not compromised by common-mode voltage.

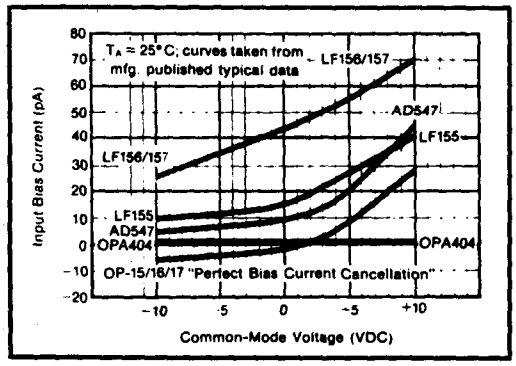


FIGURE 4. Input Bias Current Versus Common-Mode Voltage.

APPLICATIONS CIRCUITS

Figures 5 through 11 are circuit diagrams of various applications for the OPA404.

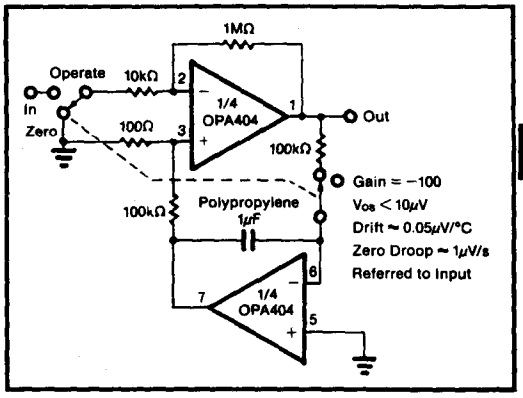


FIGURE 5. Auto-Zero Amplifier.

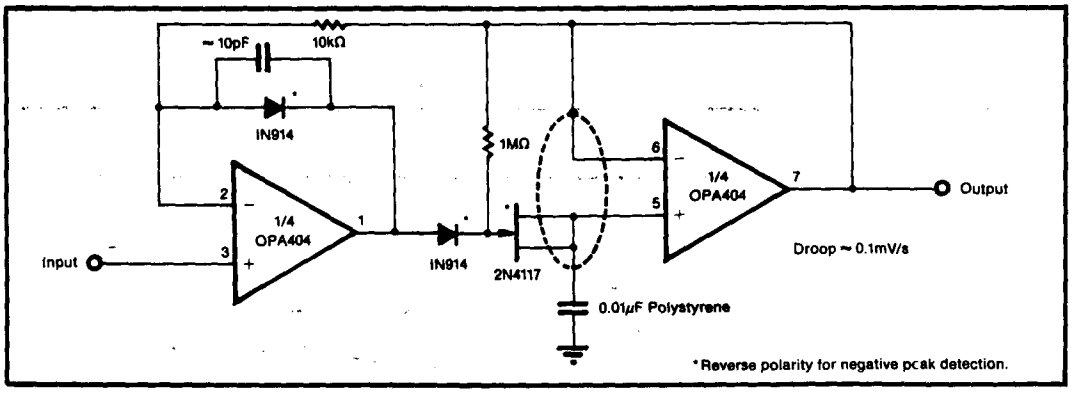


FIGURE 6. Low-Droop Positive Peak Detector.

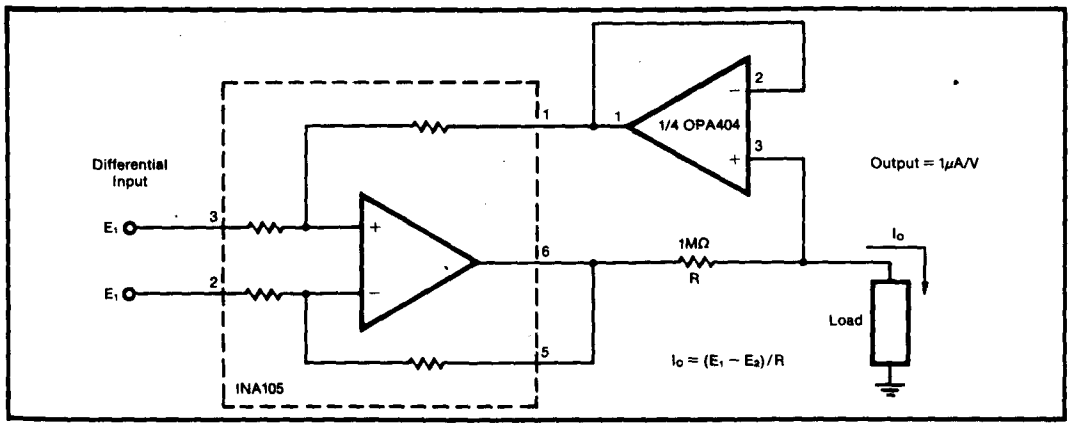


FIGURE 7. Voltage-Controlled Microamp Currrent Source.

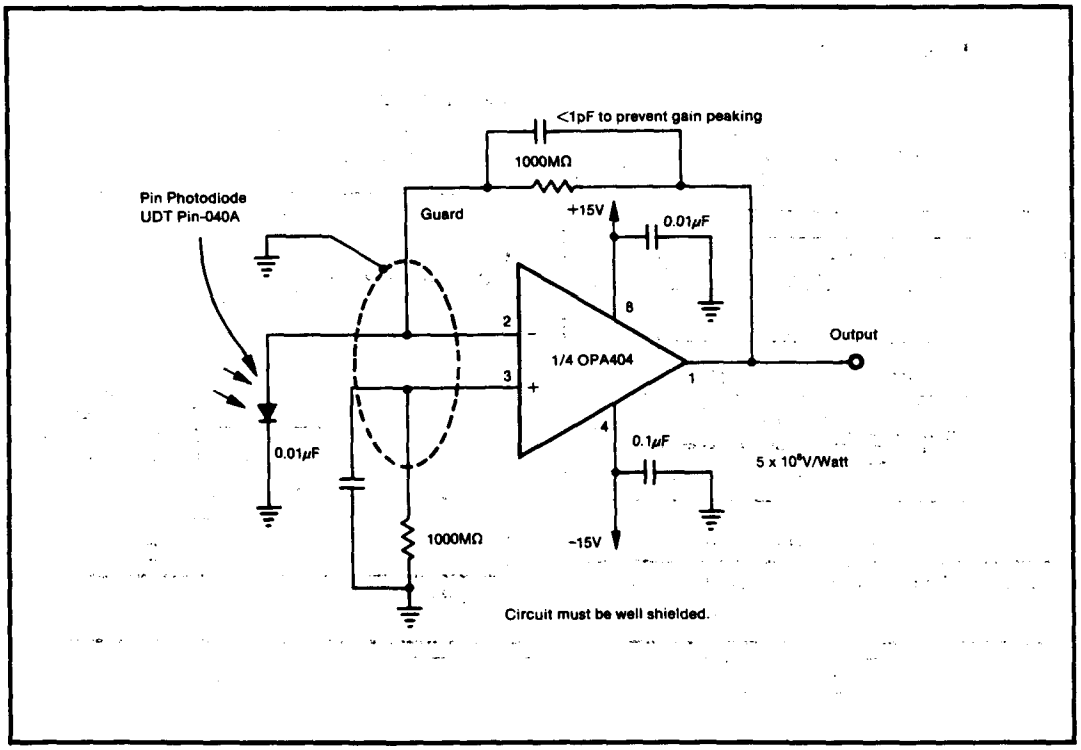


FIGURE 8. Sensitive Photodiode Amplifier.

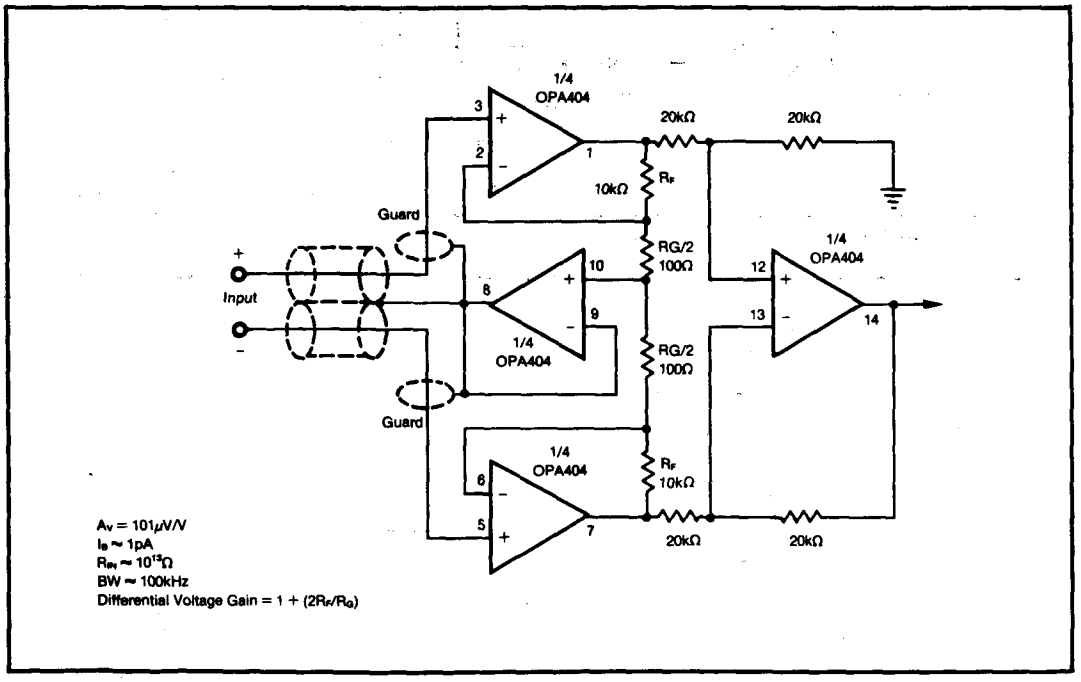


FIGURE 9. FET Instrumentation Amplifier with Shield Driver.

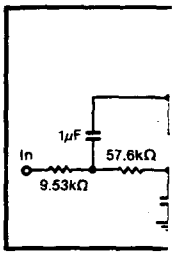


FIGURE 10. 8-P

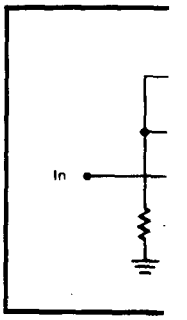


FIGURE 11. Wi

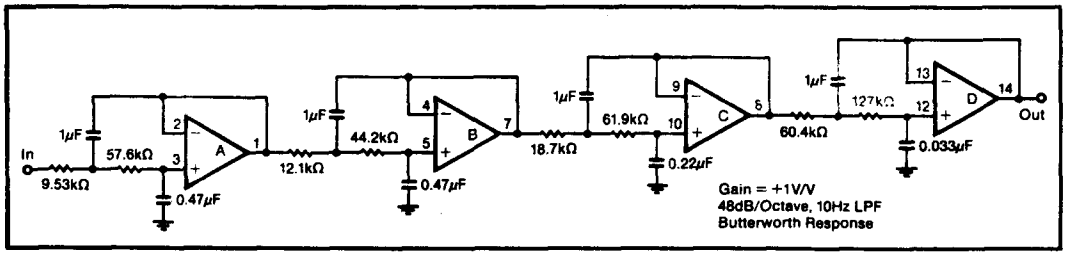


FIGURE 10. 8-Pole 10Hz Low-Pass Filter.

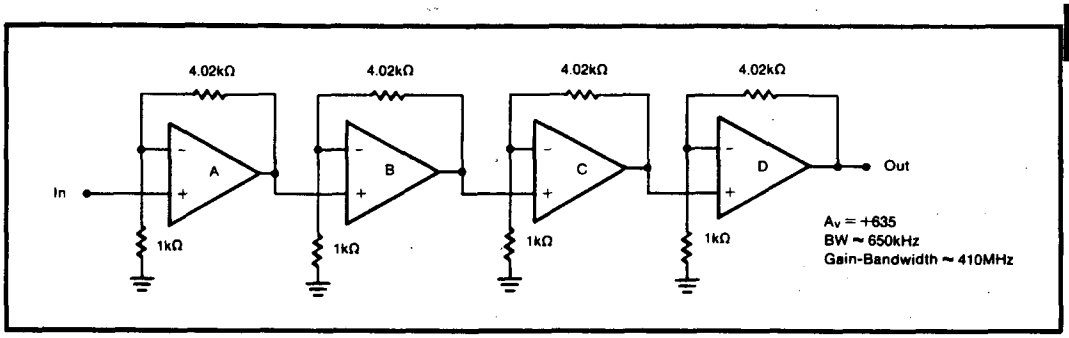


FIGURE 11. Wide-Band Amplifier