HARRIS

HA-5114/883

Low Noise, High Performance Operational Amplifier

January 1989

Features

- This Circuit Is Processed In Accordance to Mil-Std-883 and Is Fully Conformant Under the Provisions of Paragraph 1.2.1.
- Low Input Noise Voltage Density @ 1kHz.. 6nV/$\sqrt{Hz}$ Max, 4.3nV/$\sqrt{Hz}$ Typ
- High Slew Rate .... 12V/µs Min, 20V/µs Typ
- Wide Gain Bandwidth Product ($A_{VCL} \geq 10$) .. 60MHz Typ
- High Open Loop Gain (Full Temp) ...... 100kV/V Min, 250kV/V Typ
- High CMRR, PSRR (Full Temp)............. 86dB Min, 100dB Typ
- Low Offset Voltage Drift ....3µV/°C Typ
- No Crossover Distortion
- Standard Quad Pinout

Applications

- High Quality Audio Preamplifiers
- High Q Active Filters
- Low Noise Function Generators
- Low Distortion Oscillators
- Low Noise Comparators

Description

Low noise and high performance are key words describing the quad, uncompensated HA-5114/883. This general purpose amplifier offers an array of dynamic specifications including 12V/µs slew rate (min), and 60MHz gain-bandwidth-product for $A_{VCL} \geq 10$. Complementing these outstanding parameters is a very low noise specification of 6nV/$\sqrt{Hz}$ at 1kHz (max).

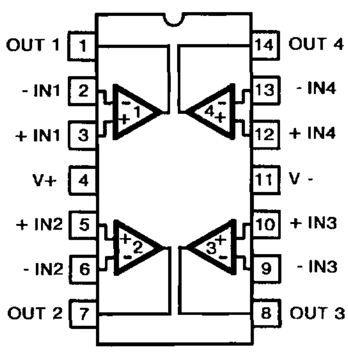
Fabricated using the Harris standard high frequency D.I. process, these operational amplifiers also offer excellent input specifications such as 2.5mV (max) offset voltage and 75nA (max) offset current. Complementing these specifications are 100dB (min) open loop gain and 100 dB channel separation (typ). Economically, HA-5114/883 also consumes a very modest amount of power (225mW/package), while also saving board space and cost.

This impressive combination of features make this amplifier ideally suited for designs ranging from audio amplifiers and active filters to the most demanding signal conditioning and instrumentation circuits.

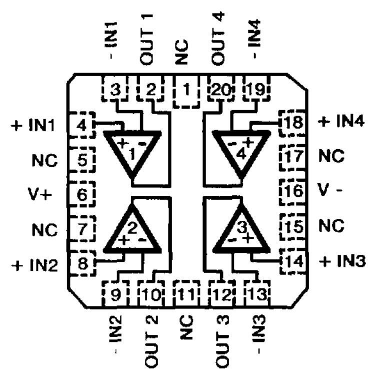
This quad operational amplifier is available with industry standard pinouts allowing for immediate interchangeability with most other quad operational amplifiers. The HA-5114/883 is available in a 14 pin Ceramic DIP and a 20 pin Ceramic LCC package.

Pinouts

HA1-5114/883 (CERAMIC DIP)
TOP VIEW



HA4-5114/883 (METAL CAN)
TOP VIEW



Absolute Maximum Ratings

Voltage Between V+ and V- Terminals 40V
Differential Input Voltage 7V
Voltage at Either Input Terminal .... V+ to V-
Peak Output Current .... Indefinite
(One Amplifier Shorted to Ground)
Junction Temperature (T_J) .... +175°C
Storage Temperature Range .... -65°C to +150°C
ESD Rating .... <2000V
Lead Temperature (Soldering 10 sec) .... +275°C

CAUTION: Absolute maximum ratings are limiting values, applied individually beyond which the serviceability of the circuit may be impaired. Functional operability under any of these conditions is not necessarily implied.

Thermal Information

Thermal Resistance	θ_{ja}	θ_{jc}
Ceramic DIP Package	78°C/W	18°C/W
Ceramic LCC Package	76°C/W	19°C/W

Package Power Dissipation Limit at +75°C for $T_J \le$ +175°C
Ceramic DIP Package 1.29mW
Ceramic LCC Package 1.32W
Package Power Dissipation Derating Factor Above +75°C
Ceramic DIP Package .... 12.9mW/°C
Ceramic LCC Package .... 13.1mW/°C

Recommended Operating Conditions

Operating Temperature Range .... -55°C to +125°C
Operating Supply Voltage .... ±5V to ±15V
$V_{INcm} \le$ 1/2 (V+ - V-)
$R_L \ge$ 2kΩ

TABLE 1. D.C. ELECTRICAL PERFORMANCE CHARACTERISTICS

Device Tested at: Supply Voltage = ±15V, R_{SOURCE} = 100Ω, R_{LOAD} = 500kΩ, V_{OUT} = 0V, Unless Otherwise Specified.

D.C. PARAMETERS	SYMBOL	CONDITIONS	GROUP A SUBGROUP	TEMPERATURE	LIMITS MIN	LIMITS MAX	UNITS
Input Offset Voltage	V_{IO}	V_{CM} = 0V	1	+25°C	-2.5	2.5	mV
			2, 3	+125°C, -55°C	-3.0	3.0	mV
Input Bias Current	$+I_B$	V_{CM} = 0V $+R_S$ = 10kΩ $-R_S$ = 100Ω	1	+25°C	-200	200	nA
			2, 3	+125°C, -55°C	-325	325	nA
	$-I_B$	V_{CM} = 0V $+R_S$ = 100Ω $-R_S$ = 10kΩ	1	+25°C	-200	200	nA
			2, 3	+125°C, -55°C	-325	325	nA
Input Offset Current	I_{IO}	V_{CM} = 0V $+R_S$ = 10kΩ $-R_S$ = 10kΩ	1	+25°C	-75	75	nA
			2, 3	+125°C, -55°C	-125	125	nA
Common Mode Range	+CMR	V+ = 3V V- = -27V	1	+25°C	+12	-	V
			2, 3	+125°C, -55°C	+12	-	V
	-CMR	V+ = 27V V- = -3V	1	+25°C	-	-12	V
			2, 3	+125°C, -55°C	-	-12	V
Large Signal Voltage Gain	$+A_{VOL}$	V_{OUT} = 0V and +10V R_L = 2kΩ	4	+25°C	100	-	kV/V
			5, 6	+125°C, -55°C	100	-	kV/V
	$-A_{VOL}$	V_{OUT} = 0V and -10V R_L = 2kΩ	4	+25°C	100	-	kV/V
			5, 6	+125°C, -55°C	100	-	kV/V
Common Mode Rejection Ratio	+CMRR	ΔV_{CM} = +5V +V = +10V -V = -20V V_{OUT} = -5V	1	+25°C	86	-	dB
			2, 3	+125°C, -55°C	86	-	dB
	-CMRR	ΔV_{CM} = -5V +V = +20V -V = -10V V_{OUT} = +5V	1	+25°C	86	-	dB
			2, 3	+125°C, -55°C	86	-	dB

CAUTION: This device is sensitive to electrostatic discharge. Proper I.C. handling procedures should be followed.

TABLE 1. D.C. ELECTRICAL PERFORMANCE CHARACTERISTICS (Continued)

Device Tested at: Supply Voltage = ±15V, R_{SOURCE} = 100Ω, R_{LOAD} = 500kΩ, V_{OUT} = 0V, Unless Otherwise Specified.

D.C. PARAMETERS	SYMBOL	CONDITIONS	GROUP A SUBGROUP	TEMPERATURE	LIMITS MIN	LIMITS MAX	UNITS
Output Voltage Swing	$+V_{OUT1}$	R_L = 2kΩ	1	+25°C	10	-	V
			2, 3	+125°C, -55°C	10	-	V
	$-V_{OUT1}$	R_L = 2kΩ	1	+25°C	-	-10	V
			2, 3	+125°C, -55°C	-	-10	V
	$+V_{OUT2}$	R_L = 10kΩ	1	+25°C	12	-	V
			2, 3	+125°C, -55°C	12	-	V
	$-V_{OUT2}$	R_L = 10kΩ	1	+25°C	-	-12	V
			2, 3	+125°C, -55°C	-	-12	V
Output Current	$+I_{OUT}$	V_{OUT} = -5V	1	+25°C	10	-	mA
			2, 3	+125°C, -55°C	10	-	mA
	$-I_{OUT}$	V_{OUT} = +5V	1	+25°C	-	-10	mA
			2, 3	+125°C, -55°C	-	-10	mA
Quiescent Power Supply Current	$+I_{CC}$	V_{OUT} = 0V I_{OUT} = 0mA	1	+25°C	-	6.5	mA
			2, 3	+125°C, -55°C	-	7.5	mA
	$-I_{CC}$	V_{OUT} = 0V I_{OUT} = 0mA	1	+25°C	-6.5	-	mA
			2, 3	+125°C, -55°C	-7.5	-	mA
Power Supply Rejection Ratio	+PSRR	ΔV_{SUP} = 10V +V = +10V, -V = -15V +V = +20V, -V = -15V	1	+25°C	86	-	dB
			2, 3	+125°C, -55°C	86	-	dB
	-PSRR	ΔV_{SUP} = 10V +V = +15V, -V = -10V +V = +15V, -V = -20V	1	+25°C	86	-	dB
			2, 3	+125°C, -55°C	86	-	dB

TABLE 2. A.C. ELECTRICAL PERFORMANCE CHARACTERISTICS

This Table Intentionally Left Blank. See A.C. Parameters on Table 3.

TABLE 3. ELECTRICAL PERFORMANCE CHARACTERISTICS

Device Characterized at: Supply Voltage = ±15V, R_{LOAD} = 2kΩ, C_{LOAD} = 50pF, A_{VCL} = 10V/V Unless Otherwise Specified.

PARAMETERS	SYMBOL	CONDITIONS	NOTES	TEMPERATURE	LIMITS MIN	LIMITS MAX	UNITS
Differential Input Resistance	R_{IN}	V_{CM} = 0V	1	+25°C	250	-	kΩ
Input Noise Voltage	E_n	R_S = 20Ω, f_O = 1000Hz	1	+25°C	-	6	$nV/\sqrt{Hz}$
Input Noise Current	I_n	R_S = 2MΩ, f_O = 1000Hz	1	+25°C	-	3	$pA/\sqrt{Hz}$
Gain Bandwidth Product	GBWP	V_O = 200mV, f_O = 10kHz	1	+25°C	40	-	MHz
		V_O = 200mV, f_O = 1MHz	1	+25°C	60	-	MHz
Slew Rate	+SR	V_{OUT} = -5V to +5V	1	+25°C	12	-	V/µs
	-SR	V_{OUT} = +5V to -5V	1	+25°C	12	-	V/µs
Full Power Bandwidth	FPBW	V_{PEAK} = 10V	1, 2	+25°C	191	-	kHz
Minimum Closed Loop Stable Gain	CLSG	R_L = 2kΩ, C_L = 50pF	1	-55°C to +125°C	10	-	V/V
Rise & Fall Time	T_R	V_{OUT} = 0V to +200mV	1, 4	+25°C	-	100	ns
	T_F	V_{OUT} = 0V to -200mV	1, 4	+25°C	-	100	ns
Overshoot	+OS	V_{OUT} = 0V to +200mV	1	+25°C	-	40	%
	-OS	V_{OUT} = 0V to -200mV	1	+25°C	-	40	%
Output Resistance	R_{OUT}	Open Loop	1	+25°C	-	150	Ω
Quiescent Power Consumption	PC	V_{OUT} = 0V, I_{OUT} = 0mA	1, 3	-55°C to +125°C	-	225	mW
Channel Separation	CS	R_S = 1kΩ, A_{VCL} = 100V/V, V_{IN} = 100mV_{RMS} @ 10kHz Referred to Input	1	+25°C	90	-	dB

NOTES: 1. Parameters listed in Table 3 are controlled via design or process parameters and are not directly tested at final production. These parameters are lab characterized upon initial design release, or upon design changes. These parameters are guaranteed by characterization based upon data from multiple production runs which reflect lot to lot and within lot variation.

2. Full Power Bandwidth guarantee based on Slew Rate measurement using FPBW = Slew Rate/($2\pi V_{PEAK}$).

3. Quiescent Power Consumption based upon Quiescent Supply Current test maximum. (No load on outputs.)

4. Measured between 10% and 90% points.

TABLE 4. ELECTRICAL TEST REQUIREMENTS

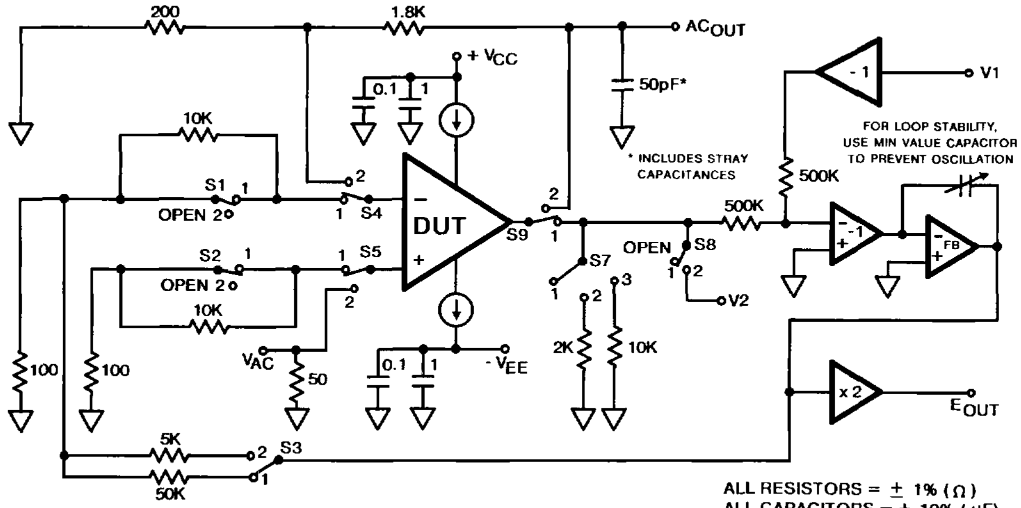
MIL-STD-883 TEST REQUIREMENTS	SUBGROUPS (SEE TABLES 1 & 2)
Interim Electrical Parameters (Pre Burn-in)	1
Final Electrical Test Parameters	1*, 2, 3, 4, 5, 6
Group A Test Requirements	1, 2, 3, 4, 5, 6
Groups C & D Endpoints	1

* PDA applies to Subgroup 1 only.

3

OP AMPs & COMPARATORS

Test Circuit

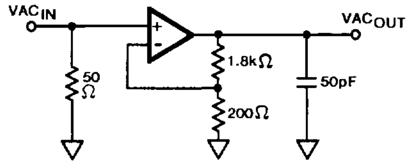


ALL RESISTORS = ± 1% (Ω)
ALL CAPACITORS = ± 10% (μF)
DUT = 1/4 OF HA - 5114/883

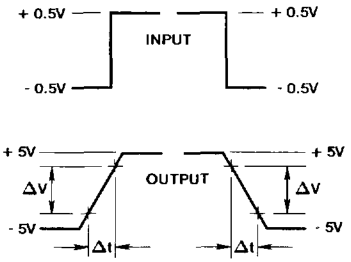
ONE OF FOUR TEST LOOPS FOR THE HA - 5114/883

Test Waveforms

SIMPLIFIED TEST CIRCUIT (Applies To Table 3)

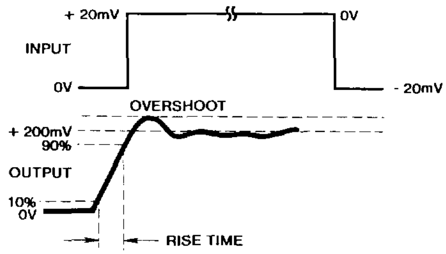


SLEW RATE WAVEFORM



$\pm$ S.R. $= \frac{\Delta V}{\Delta t}$

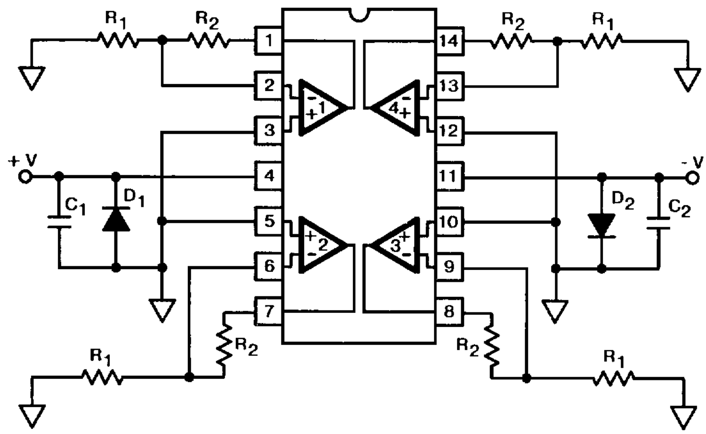
TRANSIENT RESPONSE WAVEFORM



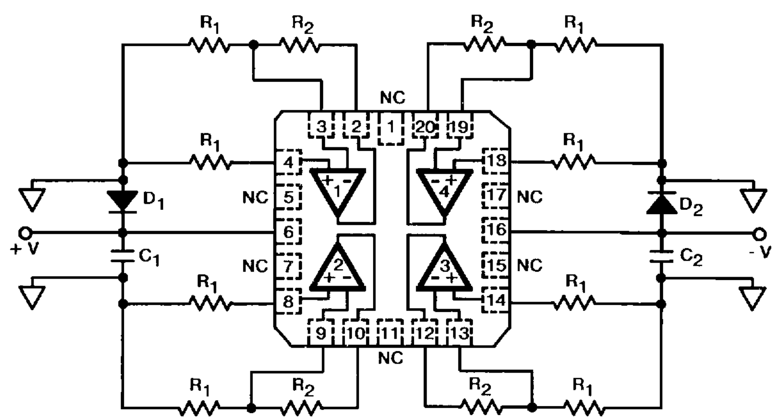
NOTE: Measured on both positive and negative transitions.

Burn-In Circuits

HA7-5114/883 CERAMIC DIP



HA4-5114/883 CERAMIC LCC



NOTES:

R_1 = 1kΩ, 5%, 1/4W (Per Socket) (Min)

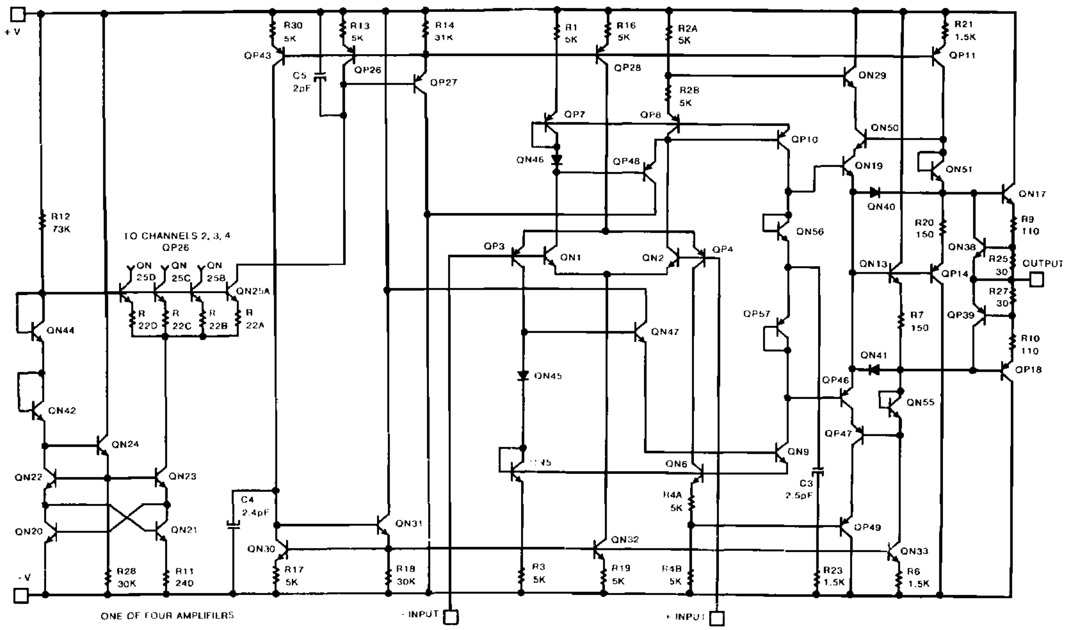
R_2 = 10kΩ, 5%, 1/4W/Socket (Min)

$C_1 = C_2$ = 0.01μF/Socket (Min) or 0.1μF/Row (Min)

$D_1 = D_2$ = IN4002 or Equivalent (Per Board)

$|(V+) - (V-)| = 30V$

Schematic Diagram (¼ HA-5114/883)



Die Characteristics

DIE DIMENSIONS:
99.6 x 95.3 x 19 mils
(2530 x 2420 x 483 μm)

METALLIZATION:
Type: Aluminum
Thickness: 16kÅ ± 2kÅ

WORST CASE CURRENT DENSITY:
1.43 x 10^5A/cm^2 at 10mA

SUBSTRATE POTENTIAL (POWERED UP):
Unbiased

GLASSIVATION:
Type: Nitride
Thickness: 7kÅ ± 0.7kÅ

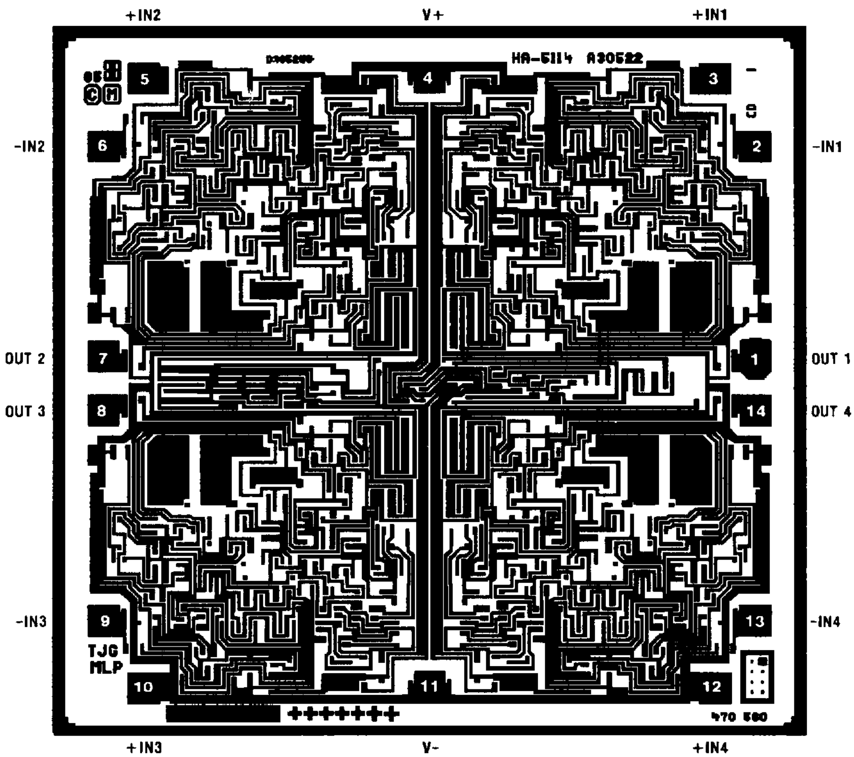
TRANSISTOR COUNT: 175

PROCESS: HFSB Linear Dielectric Isolation

DIE ATTACH:
Material: Gold/Silicon Eutectic Alloy
Temperature: Ceramic DIP — 460°C (Max)
Ceramic LCC — 420°C (Max)

Metallization Mask Layout

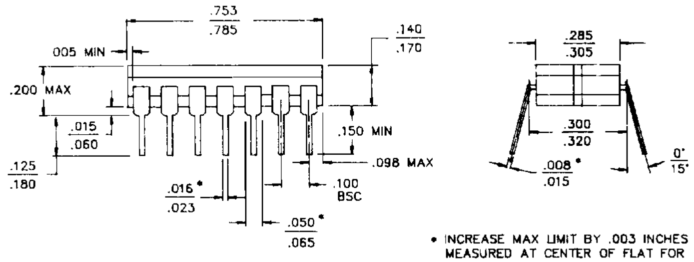
HA-5114/883



NOTE: Pad Numbers Correspond to 14 Lead Ceramic DIIP Package Only.

Packaging†

14 PIN CERAMIC DIP

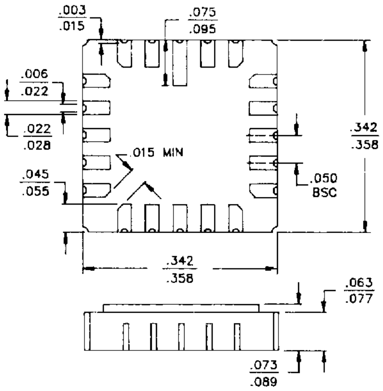


• INCREASE MAX LIMIT BY .003 INCHES MEASURED AT CENTER OF FLAT FOR SOLDER FINISH

LEAD MATERIAL: Type B
LEAD FINISH: Type A
PACKAGE MATERIAL: Ceramic, 90% Alumina
PACKAGE SEAL:
Material: Glass Frit
Temperature: 450°C ± 10°C
Method: Furnace Seal

INTERNAL LEAD WIRE:
Material: Aluminum
Diameter: 1.25 Mil
Bonding Method: Ultrasonic
COMPLIANT OUTLINE: 38510 D-1

20 PAD CERAMIC LCC



PAD MATERIAL: Type C
PAD FINISH: Type A
FINISH DIMENSION: Type A
PACKAGE MATERIAL: Multilayer Ceramic, 90% Alumina
PACKAGE SEAL:
Material: Gold/Tin (80/20)
Temperature: 320°C ± 10°C
Method: Furnace Braze

INTERNAL LEAD WIRE:
Material: Aluminum
Diameter: 1.25 Mil
Bonding Method: Ultrasonic
COMPLIANT OUTLINE: 38510 C-2

NOTE: All Dimensions are Min/Max, Dimensions are in inches.

† Mil-M-38510 Compliant Materials, Finishes, and Dimensions.

HA-5114

DESIGN INFORMATION

Low Noise, High Performance Operational Amplifier

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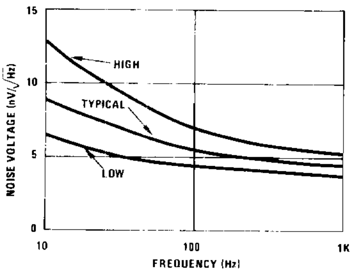
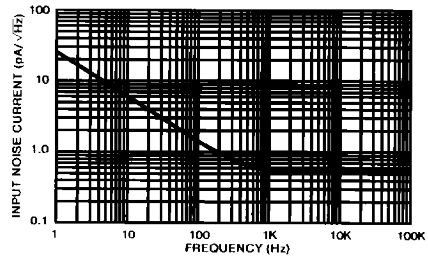
Typical Performance Curves Unless Otherwise Specified: $T_A = +25^oC$, $V_{SUPPLY} = \pm15V$

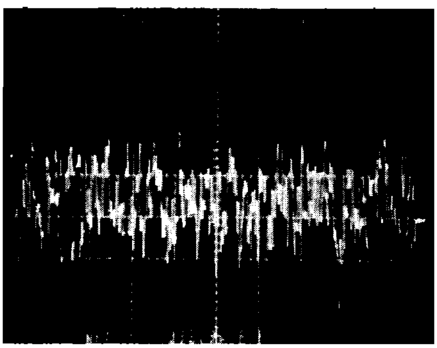
INPUT NOISE VOLTAGE DENSITY
$V_{CC} = \pm15V$, $T_A = +25^oC$



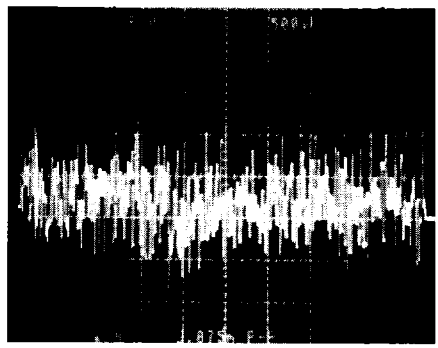
INPUT NOISE CURRENT DENSITY
$V_{CC} = \pm15V$, $T_A = +25^oC$



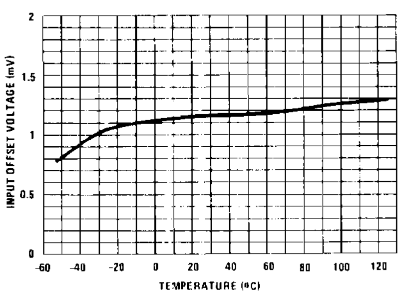
0.1Hz TO 10Hz NOISE
$V_{CC} = \pm15V$, $T_A = +25^oC$
50µV/Div., 1s/Div., A_V = 1000V/V
Input Noise = 0.232μV_{p-p}



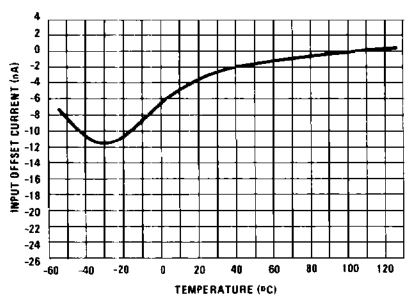
0.1Hz TO 1MHz NOISE
$V_{CC} = \pm15V$, $T_A = +25^oC$
500µV/Div., 1s/Div., A_V = 1000V/V
Total Output Noise = 2.075μV_{p-p}



V_{IO} vs. TEMPERATURE
$V_{CC} = \pm15V$



I_{IO} vs. TEMPERATURE
$V_{CC} = \pm15V$



DESIGN INFORMATION (Continued)

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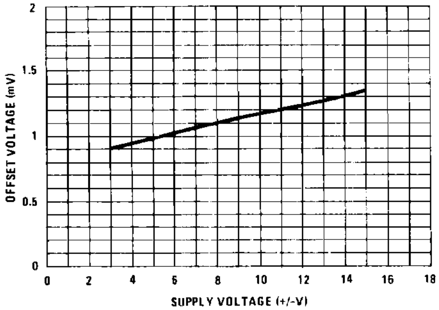
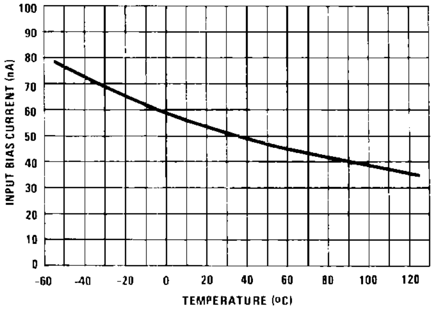
Typical Performance Curves Unless Otherwise Specified: T_A = +25°C, V_{SUPPLY} = ±15V

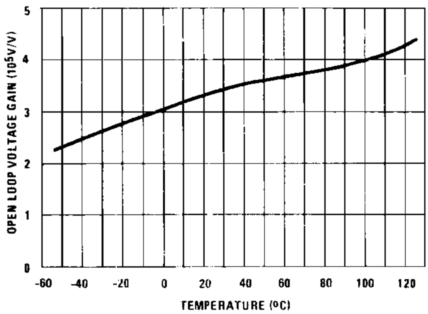
V_{IO} vs. V_{CC}
T_A = +25°C



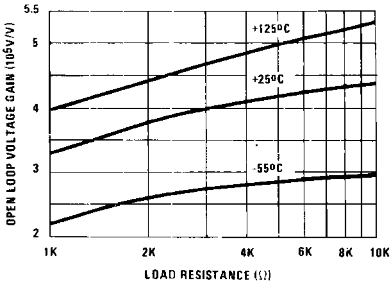
I_{BIAS} vs. TEMPERATURE
V_{CC} = ±15V



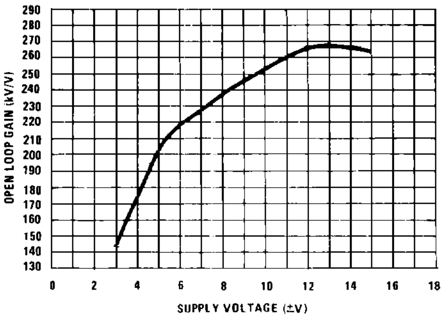
A_{VOL} vs. TEMPERATURE
VCC = ±15V, ΔV_O = ±10V, R_L = 2kΩ



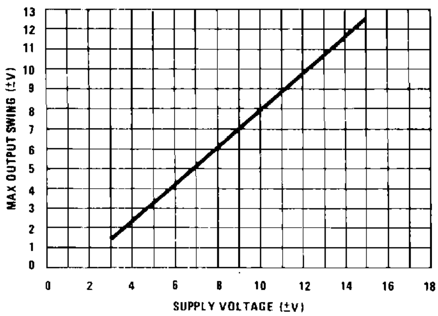
A_{VOL} vs. LOAD RESISTANCE
V_O = ±10V, V_{CC} = ±15V, T_A = +25°C



A_{VOL} vs. V_{CC}
T_A = +25°C, R_L = 2kΩ



V_{OUT} vs. V_{CC}
T_A = +25°C, R_L = 2kΩ



DESIGN INFORMATION (Continued)

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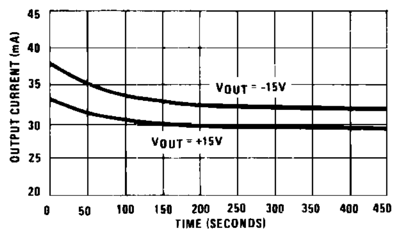
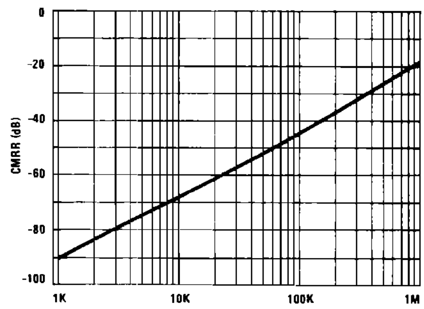
Typical Performance Curves Unless Otherwise Specified: $T_A = +25^oC$, $V_{SUPPLY} = \pm15V$

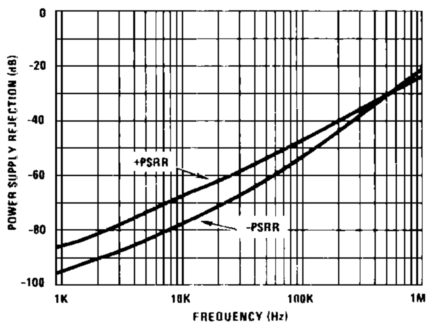
OUTPUT SHORT-CIRCUIT CURRENT vs. TIME
$V_{CC} = \pm15V$, $T_A = +25^oC$



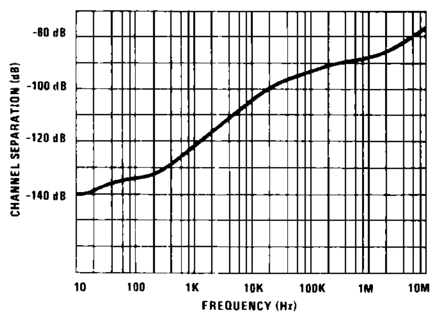
CMRR vs. FREQUENCY



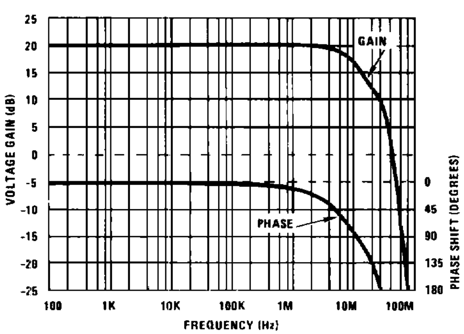
PSRR vs. FREQUENCY



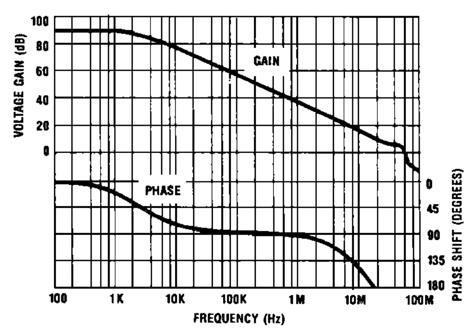
CHANNEL SEPARATION vs. FREQUENCY
$10Hz \leq f \leq 10MHz$



HA-5114 FREQUENCY RESPONSE
$A_{VCL} = 10$, $T_A = +25^oC$, $R_L = 2k\Omega$, $C_L = 50pF$



OPEN-LOOP GAIN vs. FREQUENCY
$V_{CC} = \pm15V$, $R_L = 2k\Omega$, $C_L = 50pF$, $T_A = +25^oC$



DESIGN INFORMATION (Continued)

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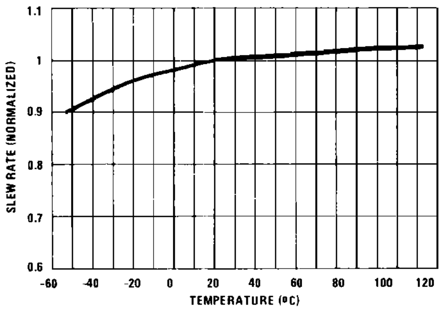
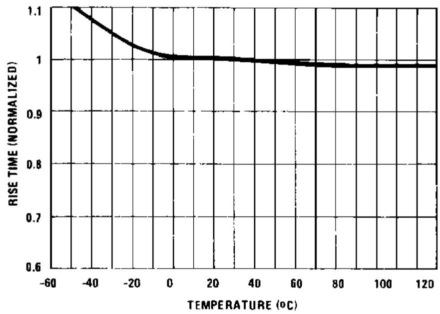
Typical Performance Curves Unless Otherwise Specified: T_A = +25°C, V_{SUPPLY} = ±15V

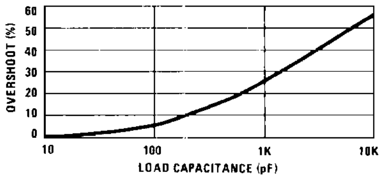
SLEW RATE vs.TEMPERATURE
R_L = 2K, C_L = 50pF, V_{CC} = ±15V



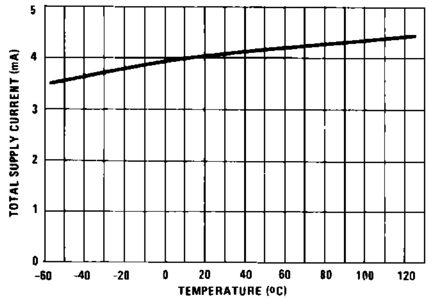
RISE TIME vs. TEMPERATURE
R_L = 2K, C_L = 50pF, V_{CC} = ±15V



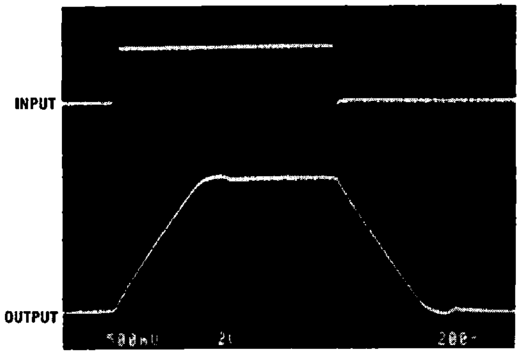
SMALL SIGNAL OVERSHOOT vs. C_{LOAD}
R_L = 2K, T_A = +25°C, V_{CC} = ±15V



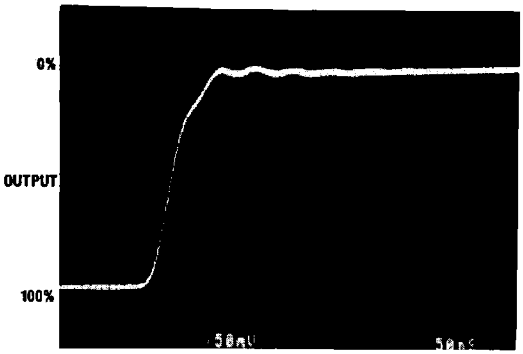
I_{CC} vs. TEMPERATURE
T_A = +25°C, V_{CC} = ±15V, I_{OUT} = 0mA



LARGE SIGNAL RESPONSE
V_{OUT} = ±3V, A_V = +10, R_L = 2kΩ, C_L = 50pF
Input = 500mV/Div., Output = 2V/Div., Timescale = 200ns/Div.



SMALL SIGNAL RESPONSE
V_{OUT} = 0V to +200mV for Rise Time & +Overshoot
A_V = +10, R_L = 2kΩ, C_L = 50pF, Timescale = 50ns/Div.



DESIGN INFORMATION (Continued)

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TYPICAL PERFORMANCE CHARACTERISTICS

Device Characterized at: Supply Voltage = ±15V, R_L = 2kΩ, C_L = 50pF, A_{VCL} = 10V/V Unless Otherwise Specified.

PARAMETERS	CONDITIONS	TEMP	TYPICAL	DESIGN LIMITS	UNITS
Offset Voltage	V_{CM} = 0V	+25°C	0.8	Table 1	mV
Offset Voltage Average Drift	Versus Temperature	-55°C to +125°C	3	7	µV/°C
Offset Current Average Drift	Versus Temperature	-55°C to +125°C	100	250	pA/°C
Input Bias Current	V_{CM} = 0V	+25°C	50	Table 1	nA
Input Offset Current	V_{CM} = 0V	+25°C	25	Table 1	nA
Differential Input Resistance	V_{CM} = 0V	+25°C	500	Table 3	kΩ
Input Noise Voltage Density	f_O = 10Hz	+25°C	10.3	14	nV/√Hz
	f_O = 100Hz	+25°C	5.6	8	nV/√Hz
	f_O = 1kHz	+25°C	4.3	Table 3	nV/√Hz
Input Noise Current Density	f_O = 10Hz	+25°C	6	15	pA/√Hz
	f_O = 100Hz	+25°C	1.5	5	pA/√Hz
	f_O = 1kHz	+25°C	0.52	Table 3	pA/√Hz
Large Signal Voltage Gain	V_{OUT} = ±10V	-55°C	200	Table 1	kV/V
		+25°C	300	Table 1	kV/V
		+125°C	400	Table 1	kV/V
Slew Rate	V_{OUT} = ±5V	-55°C to +125°C	±20	±10	V/µs
Full Power Bandwidth	Note 2, V_{peak} = 10V	-55°C to +125°C	318	159	kHz
Rise and Fall Times	V_{OUT} = ±200mV	-55°C to +125°C	48	130	ns
Overshoot	V_{OUT} = ±200mV	-55°C to +125°C	30	50	%
Settling Time	To 0.1% for 10V Step	+25°C	0.6	1	µs
	To 0.01% for 10V Step	+25°C	1.2	2	µs
Output Short Circuit Current	To <10 Seconds, V_{OUT} = ±15V	+25°C	±35	±50	mA
Output Resistance	Open Loop	+25°C	110	Table 3	Ω
Channel Separation	f = 10kHz	+25°C	108	Table 3	dB
Supply Current	No Load	+25°C	4.2	Table 1	mA
Minimum Supply Voltage	Functional Operation Only, Other Parameters Will Vary	+25°C	±4	±5	V