HARRIS

HA-5112/883

January 1989

Dual, Low Noise, High Performance Uncompensated Operational Amplifier

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**
- **Low Offset Voltage Drift .... 3μV/°C 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 Dual 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 dual, uncompensated HA-5112/883. This general purpose amplifier offers an array of dynamic specifications including 12V/μs slew rate (min), and 60MHz gain-band-width-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 100dB channel separation (typ). The HA-5112/883 also consumes a very modest amount of supply power (180mW/package).

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 dual operational amplifier is available with industry standard pinouts allowing for immediate interchangeability with most other dual operational amplifiers. HA-5112/883 is available in an 8 pin Ceramic Mini-DIP, 20 pin LCC and an 8 pin Metal Can (TO-99).

Pinouts

HA7-5112/883 (CERAMIC MINI-DIP)
TOP VIEW
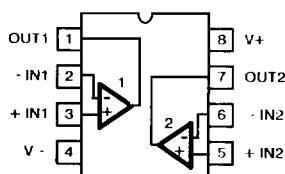
HA4-5112/883 (CERAMIC LCC)
TOP VIEW
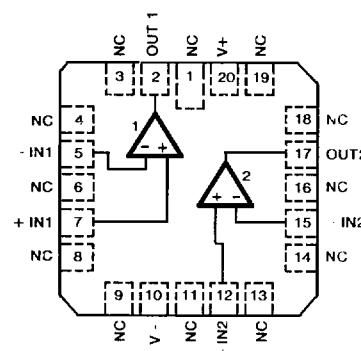
HA2-5112/883 (METAL CAN)
TOP VIEW
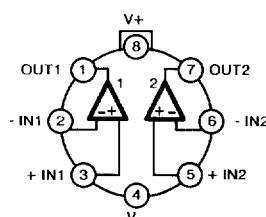
Absolute Maximum Ratings

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	121°C/W	39°C/W
Ceramic LCC Package	74°C/W	20°C/W
Metal Can Package	101°C/W	30°C/W

Package Power Dissipation at +75°C for T_J ≤ +175°C
Ceramic DIP Package 820mW
Ceramic LCC Package 1.36W
Metal Can Package 1W
Package Power Dissipation Derating Factor Above +75°C
Ceramic DIP Package . . . . 8.2mW/^{o}C
Ceramic LCC Package . . . . 13.6mW/^{o}C
Metal Can Package . . . . 10mW/^{o}C

Recommended Operating Conditions

Operating Temperature Range . . . . –55°C to +125°C
Operating Supply Voltage . . . . ±5V to ±15V

$V_{INcm} \leq 1/2$ (V+ – V–)
$R_L \geq 2k\Omega$

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	–2.0	2.0	mV
			2, 3	+125°C, –55°C	–2.5	2.5	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

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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	$+V_{OUT1}$	$R_L = 2k\Omega$	1	+25°C	10	–	V
			2, 3	+125°C, –55°C	10	–	V
	$-V_{OUT1}$	$R_L = 2k\Omega$	1	+25°C	–	–10	V
			2, 3	+125°C, –55°C	–	–10	V
	$+V_{OUT2}$	$R_L = 10k\Omega$	1	+25°C	12	–	V
			2, 3	+125°C, –55°C	12	–	V
	$-V_{OUT2}$	$R_L = 10k\Omega$	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	$+I_{CC}$	$V_{OUT} = 0V$	1	+25°C	–	5	mA
		$I_{OUT} = 0mA$	2, 3	+125°C, –55°C	–	6	mA
	$-I_{CC}$	$V_{OUT} = 0V$ $I_{OUT} = 0mA$	1	+25°C	–5	–	mA
			2, 3	+125°C, –55°C	–6	–	mA
Power Supply Rejection Ratio	+PSRR	$\Delta V_{SUP} = 10V$ +V = +10V, –V = –15V	1	+25°C	86	–	dB
		+V = +20V, –V = –15V	2, 3	+125°C, –55°C	86	–	dB
	–PSRR	$\Delta V_{SUP} = 10V$ +V = +15V, –V = –10V	1	+25°C	86	–	dB
		+V = +15V, –V = –20V	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	–	180	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/(2πV_{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.

## Test Circuit (Applies To Table 1)

ONE OF TWO TEST LOOPS FOR THE HA - 5112/ 883 DUT

ALL RESISTORS = ± 1% (Ω)
ALL CAPACITORS = ± 10% (µF)
DUT = 1/2 OF HA - 5112/ 883
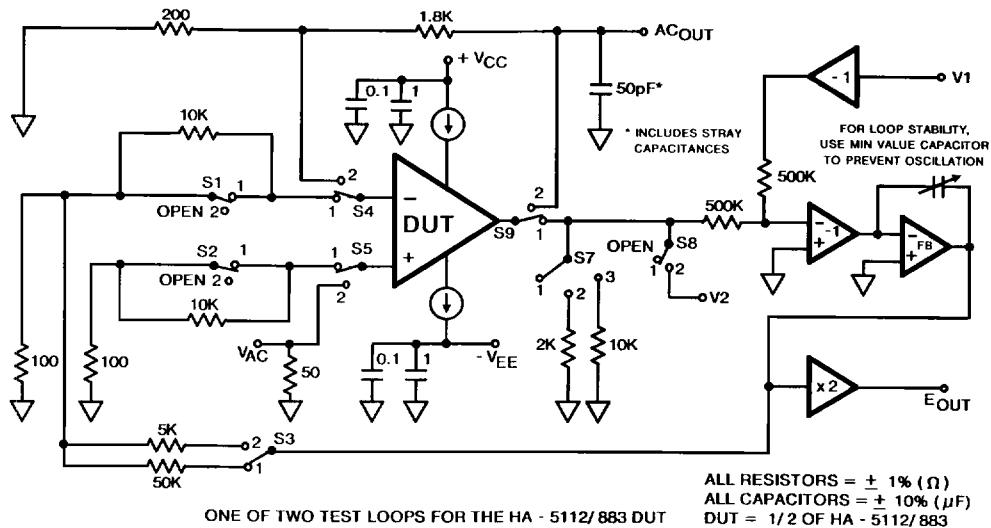
Test Waveforms

SIMPLIFIED TEST CIRCUIT (Applies To Table 3)
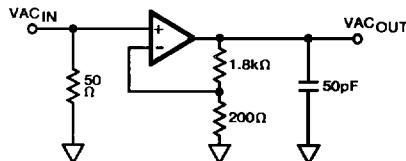
SLEW RATE WAVEFORM

$$\pm \text{ S.R.} = \frac{\Delta v}{\Delta t}$$
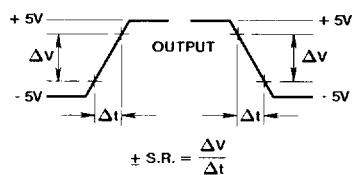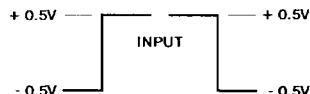
TRANSIENT RESPONSE WAVEFORM
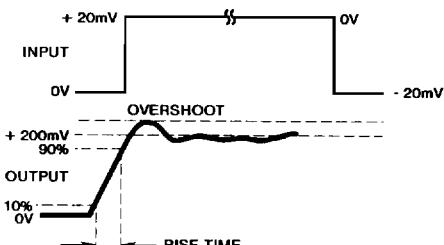
NOTE: Measured on both positive and negative transitions.

HA-5112/883

Burn-In Circuits

HA7-5112/883 CERAMIC DIP
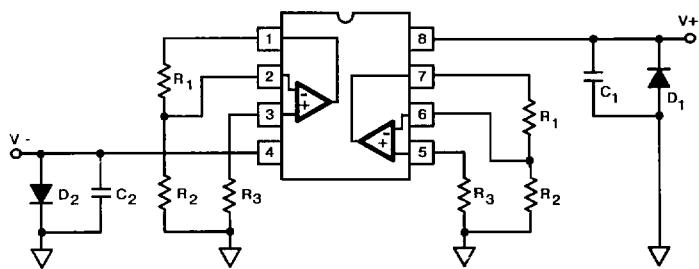
HA4-5112/883 CERAMIC LCC
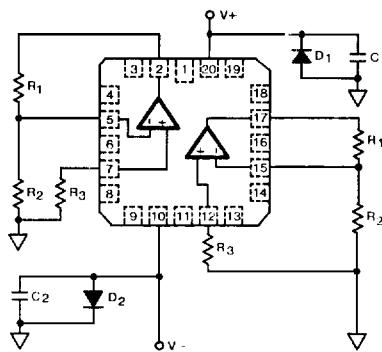
HA2-5112/883 (TO-99) METAL CAN
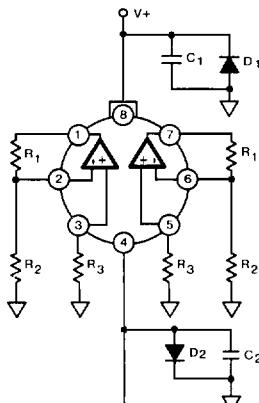
NOTES:
R_1 = 10kΩ, ±5%, 1/4W (Min)
R_2 = R_3 = 1kΩ, ±5%, 1/4W (Min)
C_1 = C_2 = 0.01μF/Socket (Min) or 0.1μF/Row, (Min)
D_1 = D_2 = IN4002 or Equivalent/Board
$|(V+) - (V-)|$ = 30V

Schematic Diagram (½ HA-5112/883)

ONE OF TWO AMPLIFIERS
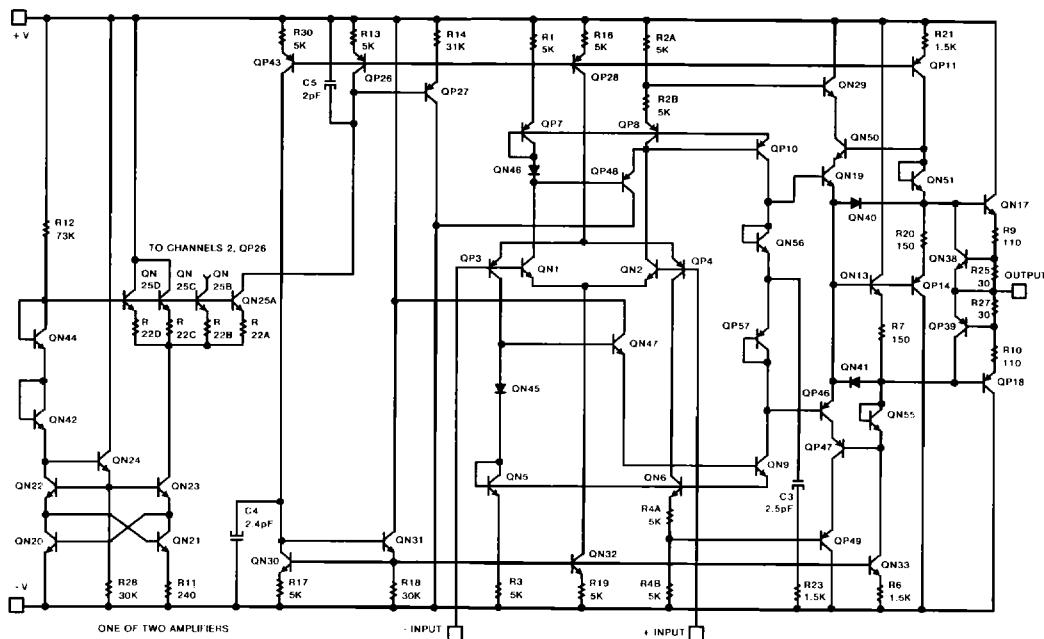
Die Characteristics

DIE DIMENSIONS:
98.4 x 67.3 x 19 mils
(2500 x 1710 x 483 µm)

METALLIZATION:
Type: Aluminum
Thickness: $16k\text{Å} \pm 2k\text{Å}$

WORST CASE CURRENT DENSITY:
$1.43 \times 10^5 \text{A/cm}^2$ at 10mA

SUBSTRATE POTENTIAL (POWERED UP):
Unbiased

GLASSIVATION:
Type: Nitride
Thickness: $7k\text{Å} \pm 0.7k\text{Å}$

TRANSISTOR COUNT: 93

PROCESS: HFSB Linear Dielectric Isolation

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

Metallization Mask Layout

HA-5112/883
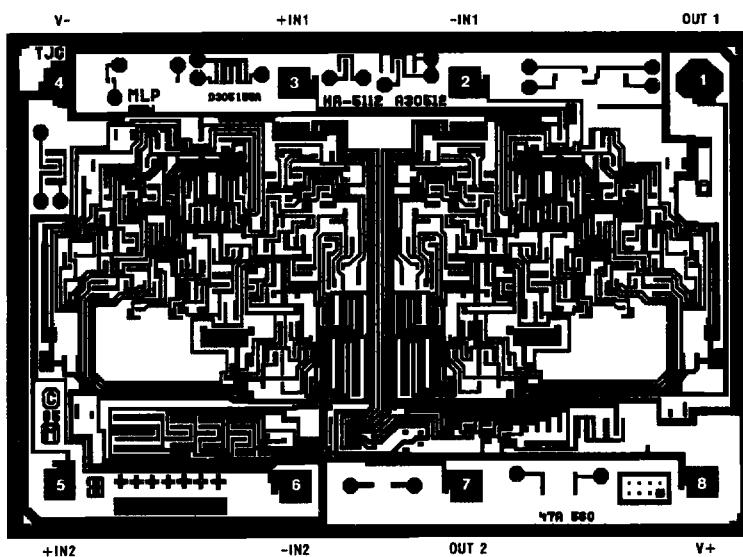
NOTE: Pin Numbers Correspond to Mini-DIP and Metal Can Packages Only.

Packaging †

8 PIN CERAMIC DIP
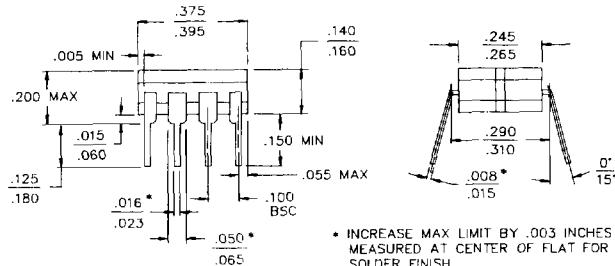
LEAD MATERIAL: Type B
LEAD FINISH: Type A
PACKAGE MATERIAL: Ceramic, 90% Alumina
PACKAGE SEAL:
    Material: Glass Frit
    Temperature: 450°C ± 10°C
    Method: Furnace Seal
INTERNAL LEAD WIRE:
    Material: Aluminum
    Diameter: 1.25 Mil
    Bonding Method: Ultrasonic
COMPLIANT OUTLINE: 38510 D-4

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

20 PAD CERAMIC LCC
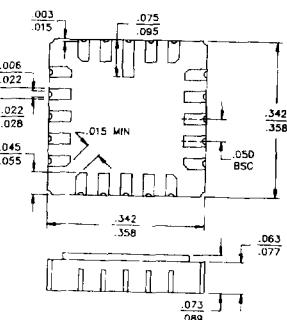
PAD MATERIAL: Type C
PAD FINISH: Type A
FINISH DIMENSION: Type A
PACKAGE MATERIAL: Ceramic, 90% Al_2O_3
PACKAGE SEAL:
    Material: Gold/Tin (80/20)
    Temperature: 320°C ± 10°C
    Method: Furnace Braze
INTERNAL LEAD WIRE:
    Material: Aluminum
    Diameter: 1.25 Mil
    Bonding Method: Ultrasonic
COMPLIANT OUTLINE: 38510 C-2

8 PIN TO-99 METAL CAN
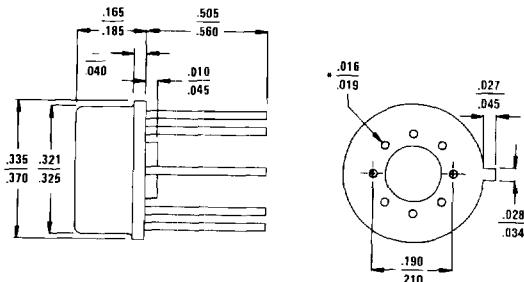
LEAD MATERIAL: Type A
LEAD FINISH: Type C
PACKAGE MATERIAL: Kovar Header with
                      Nickel Can
PACKAGE SEAL:
    Material: No Seal Material
    Temperature: Room Temperature
    Method: Resistance Weld
INTERNAL LEAD WIRE:
    Material: Aluminum
    Diameter: 1.25 Mil
    Bonding Method: Ultrasonic Bonded
COMPLIANT OUTLINE: 38510 A-1

*Dimension Maximum Limits Are Increased by 0.003 inches for Solder Dip Finish

NOTE: All Dimensions are $\frac{Min}{Max}$, Dimensions are in inches.

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

HARRIS

HA-5112

DESIGN INFORMATION

Dual, Low Noise, High Performance
## Uncompensated Operational Amplifier

The information contained in this section has been developed through characterization by Harris Semiconductor and is for use as application and design aid only. These characteristics are not 100% tested and no product guarantee is implied.

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

INPUT NOISE VOLTAGE DENSITY
V_{CC} = ±15V, T_A = +25°C

INPUT NOISE CURRENT DENSITY
V_{CC} = ±15V, T_A = +25°C
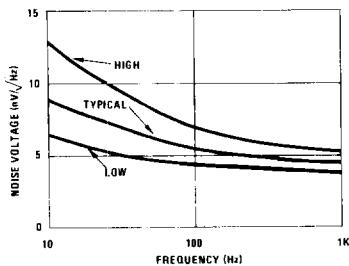
0.1Hz TO 10Hz NOISE
V_{CC} = ±15V, T_A = +25°C
50µV/Div., 1s/Div., A_V = 1000V/V
Input Noise = 0.232V_{p-p}
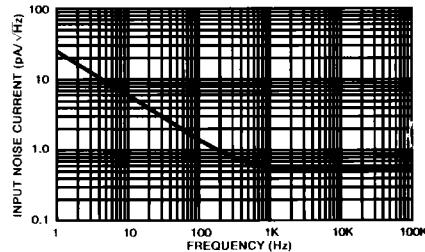
0.1Hz TO 1MHz NOISE
V_{CC} = ±15V, T_A = +25°C
500µV/Div., 1s/Div., A_V = 1000V/V
Total Output Noise = 2.075µV_{p-p}
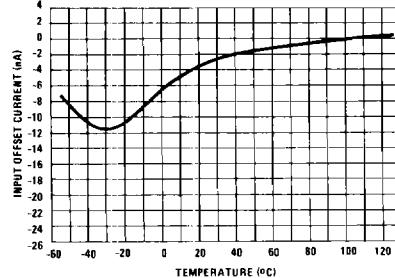
V_{IO} vs. TEMPERATURE
V_{CC} = ±15V

I_{IO} vs. TEMPERATURE
V_{CC} = ±15V


3

OP AMPs &
COMPARATORS

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
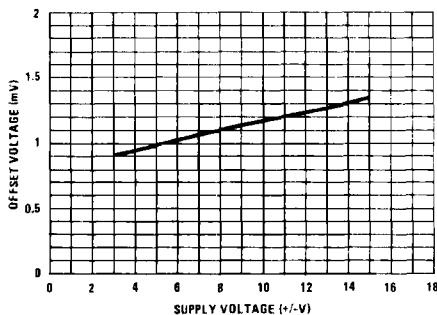
I_{BIAS} vs. TEMPERATURE
V_{CC} = ±15V
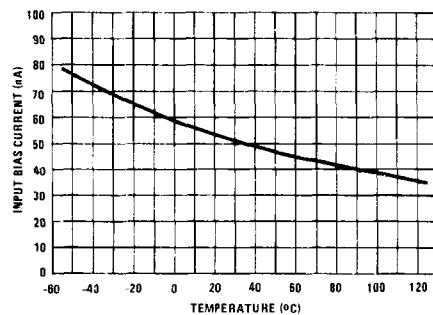
A_{VOL} vs. TEMPERATURE
VCC = ±15V, ΔV_O = ±10V, R_L = 2K
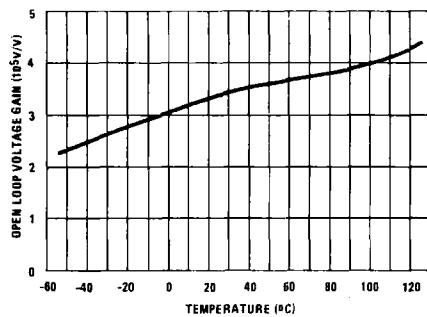
A_{VOL} vs. LOAD RESISTANCE
V_O = ±10V, V_{CC} = ±15V, T_A = +25°C
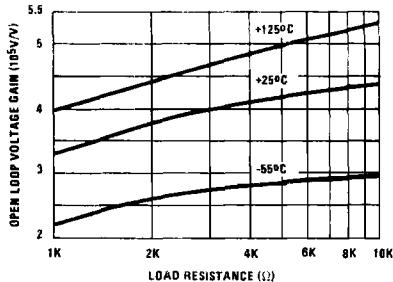
A_{VOL} vs. V_{CC}
T_A = +25°C, R_L = 2K
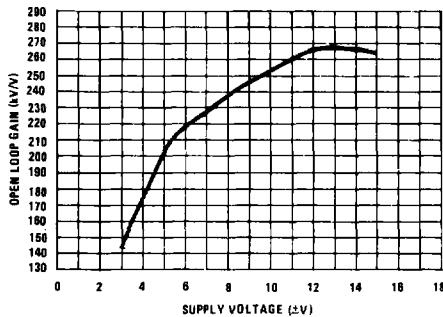
V_{OUT} vs. V_{CC}
T_A = +25°C, R_L = 2K
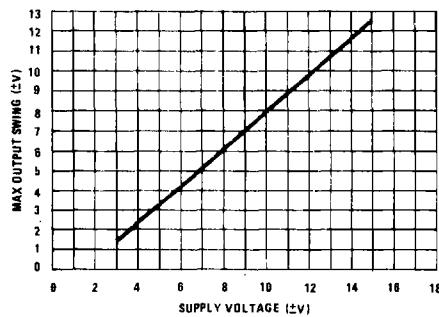
DESIGN INFORMATION (Continued)

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

OUTPUT SHORT-CIRCUIT CURRENT vs. TIME
$V_{CC} = \pm15V$, $T_A = +25^oC$
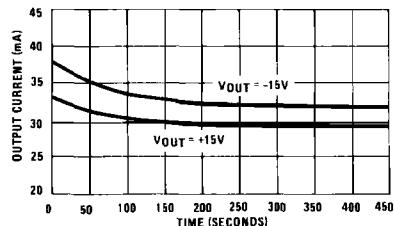
CMRR vs. FREQUENCY
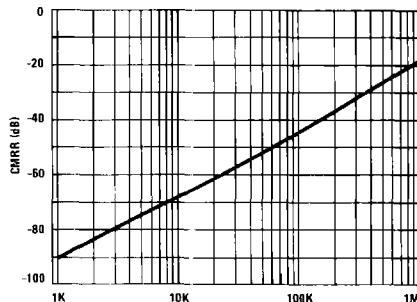
PSRR vs. FREQUENCY
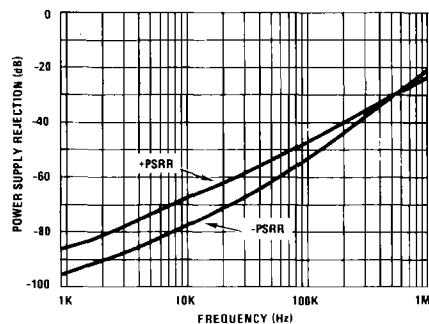
CHANNEL SEPARATION vs. FREQUENCY
$10Hz \le f \le 10MHz$
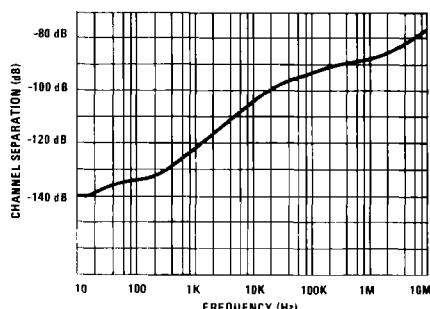
HA-5112 FREQUENCY RESPONSE
$A_{VCL} = 10$, $T_A = +25^oC$, $R_L = 2K$, $C_L = 50pF$
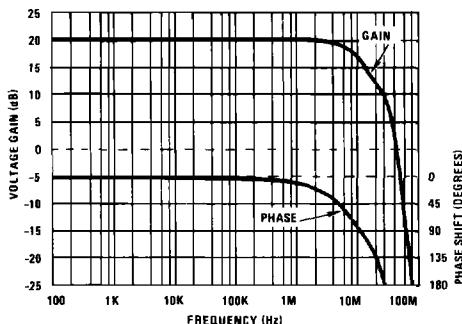
OPEN-LOOP GAIN vs. FREQUENCY
$V_{CC} = \pm15V$, $R_L = 2K$, $C_L = 50pF$, $T_A = +25^oC$
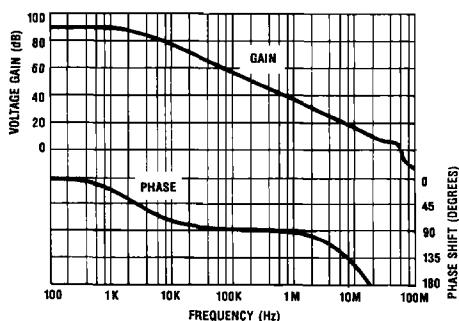
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OP AMPs &
COMPARATORS

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. V_{CC}
T_A = +25°C, I_{OUT} = 0mA
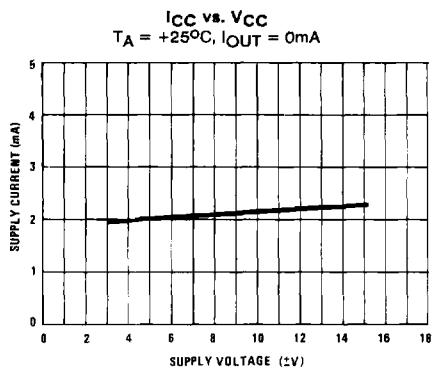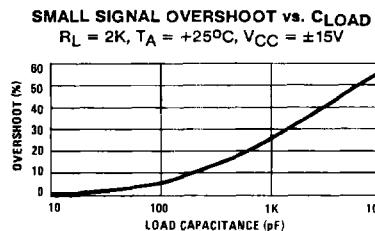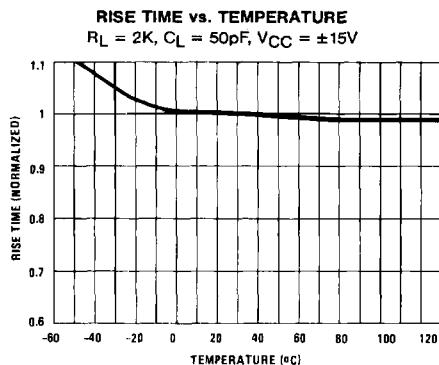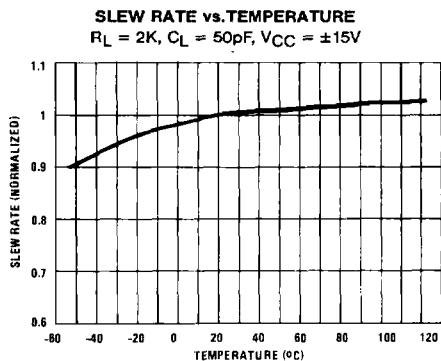
LARGE SIGNAL RESPONSE
V_{OUT} = ±3V, A_V = 10, R_L = 2K, C_L = 50pF
Input = 500mV/Div., Output = 2V/Div., Timescale = 200ns/Div.

SMALL SIGNAL RESPONSE
V_{OUT} = 0V to –200mV for Fall Time & –Overshoot
A_V = 10, R_L = 2K, C_L = 50pF, Timescale = 50ns/Div.
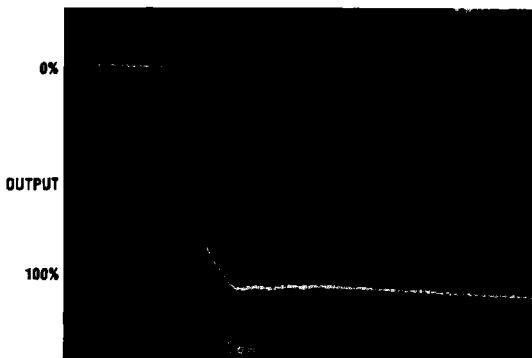
DESIGN INFORMATION (Continued)

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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/$\sqrt{Hz}$
	f_o = 100Hz	+25°C	5.6	8	nV/$\sqrt{Hz}$
	f_o = 1kHz	+25°C	4.3	Table 3	nV/$\sqrt{Hz}$
Input Noise Current Density	f_o = 10Hz	+25°C	6	15	pA/$\sqrt{Hz}$
	f_o = 100Hz	+25°C	1.5	5	pA/$\sqrt{Hz}$
	f_o = 1kHz	+25°C	0.52	Table 3	pA/$\sqrt{Hz}$
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	2.4	Table 1	mA
Minimum Supply Voltage	Functional Operation Only, Other Parameters Will Vary	+25°C	±4	±5	V