

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.
- High Input Impedance (HA-2600/883) 100M Ω Min
500M Ω Typ
- High Slew Rate 4V/ μ s Min
7V/ μ s Typ
- Low Input Bias Current (HA-2600/883) 10nA Max
1nA Typ
- Low Input Offset Voltage (HA-2600/883) .. 4mV Max
- Wide Unity Gain Bandwidth 12MHz Typ
- Output Short Circuit Protection

Applications

- Video Amplifier
- Pulse Amplifier
- High-Q Active Filters
- High Speed Comparators
- Low Distortion Oscillators

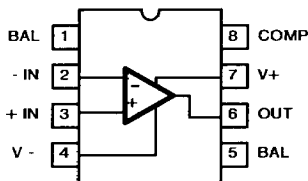
Description

HA-2600/883 and HA-2602/883 are internally compensated bipolar operational amplifiers that feature very high input impedance coupled with wideband AC performance. The high resistance of the input stage is complemented by low offset voltage (4mV_{max} @ +25°C for HA-2600/883) and low bias and offset current (10nA max @ +25°C for HA-2600/883) to facilitate accurate signal processing. Offset voltage can be reduced further by means of an external nulling potentiometer. The 4V/ μ s minimum slew rate @ +25°C and the minimum open loop gain of 100kV/V @ +25°C enables the HA-2600/883 to perform high gain amplification of fast, wideband signals. These dynamic characteristics, coupled with fast settling times, make these amplifiers ideally suited to pulse amplification designs as well as high frequency or video applications. The frequency response of the amplifier can be tailored to exact design requirements by means of an external bandwidth control capacitor. Other high performance designs such as high gain, low distortion audio amplifiers, high-Q and wideband active filters and high speed comparators, are excellent uses of this part.

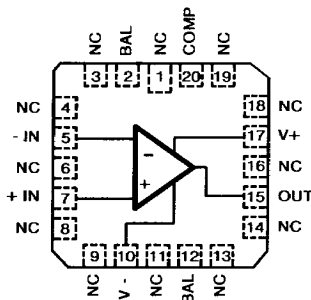
The HA-2600/883 and the HA-2602/883 are available as MIL-STD-883 compliant devices screened to class B level. These devices are sensitive to electrostatic discharge and are in microcircuit group number 49 (see MIL-M-38510, Appendix E). The HA-2600/883 and the HA-2602/883 have guaranteed operation over the military temperature range from -55°C to +125°C and are available in 8 pin Metal Can and Ceramic Mini-DIP packages. The HA-2602/883 is also available in a 20 pin Ceramic LCC package.

Pinouts

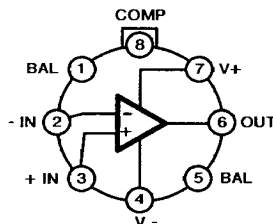
HA7-2600/883 (CERAMIC MINI-DIP)
HA7-2602/883 (CERAMIC MINI-DIP)
TOP VIEW



HA4-2602/883 (CERAMIC LCC)
TOP VIEW



HA2-2600/883 (METAL CAN)
HA2-2602/883 (METAL CAN)
TOP VIEW



Absolute Maximum Ratings

Voltage Between V+ and V- Terminals	40V
Differential Input Voltage	12V
Voltage at Either Input Terminal	V+ to V-
Peak Output Current	Full Short Circuit Protection
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	136°C/W	58°C/W
Ceramic LCC Package	98°C/W	41°C/W
Metal Can Package	136°C/W	41°C/W
Package Power Dissipation Limit at +75°C for T _J ≤ +175°C		
Ceramic DIP Package	740mW	
Ceramic LCC Package	1.02W	
Metal Can Package	740mW	
Package Power Dissipation Derating Factor Above +75°C		
Ceramic DIP Package	7.4mW/°C	
Ceramic LCC Package	10.2mW/°C	
Metal Can Package	7.4mW/°C	

Recommended Operating Conditions

Operating Temperature Range	-55°C to +125°C	$V_{INcm} \leq 1/2 (V+ - V-)$
Operating Supply Voltage	±15V	$R_L \geq 2k\Omega$

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	HA-2600/883		HA-2602/883		UNITS
					MIN	MAX	MIN	MAX	
Input Offset Voltage	V _{IO}	V _{CM} = 0V	1	+25°C	-4	4	-5	5	mV
			2, 3	+125°C, -55°C	-6	6	-7	7	mV
Input Bias Current	+I _B	V _{CM} = 0V +R _S = 100kΩ -R _S = 100Ω	1	+25°C	-10	10	-25	25	nA
			2, 3	+125°C, -55°C	-30	30	-60	60	nA
	-I _B	V _{CM} = 0V +R _S = 100Ω -R _S = 100kΩ	1	+25°C	-30	10	-25	25	nA
			2, 3	+125°C, -55°C	-30	30	-60	60	nA
Input Offset Current	I _{IO}	V _{CM} = 0V +R _S = 100kΩ -R _S = 100kΩ	1	+25°C	-10	10	-25	25	nA
			2, 3	+125°C, -55°C	-30	30	-60	60	nA
	+CMR	V+ = 4V V- = -26V	1	+25°C	11	-	11	-	V
			2, 3	+125°C, -55°C	11	-	11	-	V
Common Mode Range	-CMR	V+ = 26V V- = -4V	1	+25°C	-	-11	-	-11	V
			2, 3	+125°C, -55°C	-	-11	-	-11	V
Large Signal Voltage Gain	+A _{VOL}	V _{OUT} = 0V and +10V R _L = 2kΩ	4	+25°C	100	-	80	-	kV/V
			5, 6	+125°C, -55°C	70	-	60	-	kV/V
	-A _{VOL}	V _{OUT} = 0V and -10V R _L = 2kΩ	4	+25°C	100	-	80	-	kV/V
			5, 6	+125°C, -55°C	70	-	60	-	kV/V
Common Mode Rejection Ratio	+CMRR	ΔV _{CM} = +10V +V = +5V -V = -25V V _{OUT} = -10V	1	+25°C	80	-	74	-	dB
			2, 3	+125°C, -55°C	80	-	74	-	dB
	-CMRR	ΔV _{CM} = -10V +V = +25V -V = -5V V _{OUT} = +10V	1	+25°C	80	-	74	-	dB
			2, 3	+125°C, -55°C	80	-	74	-	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 = $\pm 15V$, $R_{SOURCE} = 100\Omega$, $R_{LOAD} = 500k\Omega$, $V_{OUT} = 0V$, Unless Otherwise Specified.

D.C. PARAMETERS	SYMBOL	CONDITIONS	GROUP A SUBGROUP	TEMPERATURE	HA-2600/883		HA-2602/883		UNITS
					MIN	MAX	MIN	MAX	
Output Voltage Swing	+V _{OUT}	R _L = 2k Ω	4	+25°C	10	-	10	-	V
			5, 6	+125°C, -55°C	10	-	10	-	V
	-V _{OUT}	R _L = 2k Ω	4	+25°C	-	-10	-	-10	V
			5, 6	+125°C, -55°C	-	-10	-	-10	V
Output Current	+I _{OUT}	V _{OUT} = -10V	4	+25°C	15	-	10	-	mA
			5, 6	+125°C, -55°C	10	-	7.5	-	mA
	-I _{OUT}	V _{OUT} = +10V	4	+25°C	-	-15	-	-10	mA
			5, 6	+125°C, -55°C	-	-10	-	-7.5	mA
Quiescent Power Supply Current	+I _{CC}	V _{OUT} = 0V I _{OUT} = 0mA	1	+25°C	-	3.7	-	3.7	mA
			2, 3	+125°C, -55°C	-	4.0	-	4.0	mA
	-I _{CC}	V _{OUT} = 0V I _{OUT} = 0mA	1	+25°C	-3.7	-	-3.7	-	mA
			2, 3	+125°C, -55°C	-4.0	-	-4.0	-	mA
Power Supply Rejection Ratio	+PSRR	$\Delta V_{SUP} = \pm 5$ +V = +10V, -V = -15V +V = +20V, -V = -15V	1	+25°C	80	-	74	-	dB
			2, 3	+125°C, -55°C	80	-	74	-	dB
	-PSRR	$\Delta V_{SUP} = \pm 5V$ +V = +15V, -V = -10V +V = +15V, -V = -20V	1	+25°C	80	-	74	-	dB
			2, 3	+125°C, -55°C	80	-	74	-	dB
Offset Voltage Adjustment	+V _{IOAdj}	Note 4	1	+25°C	V _{IO-1}	-	V _{IO-1}	-	mV
			2, 3	+125°C, -55°C	V _{IO-1}	-	V _{IO-1}	-	mV
	-V _{IOAdj}	Note 4	1	+25°C	V _{IO+1}	-	V _{IO+1}	-	mV
			2, 3	+125°C, -55°C	V _{IO+1}	-	V _{IO+1}	-	mV

TABLE 2. A.C. ELECTRICAL PERFORMANCE CHARACTERISTICS

Device Tested at: Supply Voltage = $\pm 15V$, $R_{SOURCE} = 50\Omega$, $R_{LOAD} = 2k\Omega$, $C_{LOAD} = 50pF$, $A_{VCL} = +1V/V$, Unless Otherwise Specified.

PARAMETERS	SYMBOL	CONDITIONS	GROUP A SUBGROUP	TEMPERATURE	HA-2600/883		HA-2602/883		UNITS
					MIN	MAX	MIN	MAX	
Slew Rate	+SR	V _{OUT} = -5V to +5V	7	+25°C	4	-	4	-	V/ μ s
			8A, 8B	+125°C, -55°C	3	-	3	-	V/ μ s
	-SR	V _{OUT} = +5V to -5V	7	+25°C	4	-	4	-	V/ μ s
			8A, 8B	+125°C, -55°C	3	-	3	-	V/ μ s
Rise & Fall Time	T _R	V _{OUT} = 0 to +200mV 10% $\leq$ T _R $\leq$ 90%	7	+25°C	-	60	-	60	ns
			8A, 8B	+125°C, -55°C	-	70	-	70	ns
	T _F	V _{OUT} = 0 to -200mV 10% $\leq$ T _F $\leq$ 90%	7	+25°C	-	60	-	60	ns
			8A, 8B	+125°C, -55°C	-	70	-	70	ns
Overshoot	+OS	V _{OUT} = 0 to +200mV	7	+25°C	-	40	-	40	%
			8A, 8B	+125°C, -55°C	-	50	-	50	%
	-OS	V _{OUT} = 0 to -200mV	7	+25°C	-	40	-	40	%
			8A, 8B	+125°C, -55°C	-	50	-	50	%

TABLE 3. ELECTRICAL PERFORMANCE CHARACTERISTICS

Device Characterized at: Supply Voltage = $\pm 15\text{V}$, $R_{\text{LOAD}} = 2\text{k}\Omega$, $C_{\text{LOAD}} = 50\text{pF}$, $A_V = +1$, Unless Otherwise Specified.

PARAMETERS	SYMBOL	CONDITIONS	NOTES	TEMPERATURE	HA-2600/883		HA-2602/883		UNITS
					MIN	MAX	MIN	MAX	
Differential Input Resistance	R_{IN}	$V_{\text{CM}} = 0\text{V}$	1	$+25^\circ\text{C}$	100	-	40	-	$\text{M}\Omega$
Full Power Bandwidth	FPBW	$V_{\text{PEAK}} = 10\text{V}$	1, 2	$+25^\circ\text{C}$	50	-	50	-	kHz
Minimum Closed Loop Stable Gain	CLSG	$R_{\text{L}} = 2\text{k}\Omega$, $C_{\text{L}} = 50\text{pF}$	1	-55°C to $+125^\circ\text{C}$	1	-	1	-	V/V
Output Short Circuit Current	$+I_{\text{SC}}$	$V_{\text{OUT}} = 1\text{V}$, $R_{\text{L}} = 10\Omega$	1	$+25^\circ\text{C}$	-	50	-	50	mA
			1	$+125^\circ\text{C}$	-	45	-	45	mA
			1	-55°C	-	60	-	60	mA
	$-I_{\text{SC}}$	$V_{\text{OUT}} = -1\text{V}$, $R_{\text{L}} = 10\Omega$	1	$+25^\circ\text{C}$	-50	-	-50	-	mA
			1	$+125^\circ\text{C}$	-45	-	-45	-	mA
			1	-55°C	-60	-	-60	-	mA
Quiescent Power Consumption	PC	$V_{\text{OUT}} = 0\text{V}$, $I_{\text{OUT}} = 0\text{mA}$	1, 3	-55°C to $+125^\circ\text{C}$	-	120	-	120	mW

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.

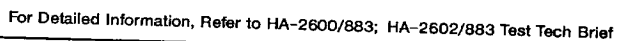
2. Full Power Bandwidth guarantee based on Slew Rate measurement using $\text{FPBW} = \text{Slew Rate} / (2\pi V_{\text{PEAK}})$.
3. Quiescent Power Consumption based upon Quiescent Supply Current test maximum. (No load on outputs.)
4. Offset adjustment range is $|V_{\text{IO}}(\text{Measured})| \pm 1\text{mV}$ minimum referred to output. This test is for functionality only to assure adjustment through 0V.

TABLE 4. ELECTRICAL TEST REQUIREMENTS

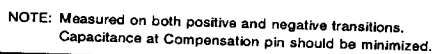
MIL-STD-883 TEST REQUIREMENTS	SUBGROUPS (SEE TABLES 1 & 2)
Interim Electrical Parameters (Pre Burn-In)	1
Final Electrical Test Parameters	1*, 2, 3, 4, 5, 6, 7, 8A, 8B
Group A Test Requirements	1, 2, 3, 4, 5, 6, 7, 8A, 8B
Groups C & D Endpoints	1

* PDA applies to Subgroup 1 only.

The Subgroup assignments of the parameters in these tables were patterned after Mil-M-38510/122, device type 02.

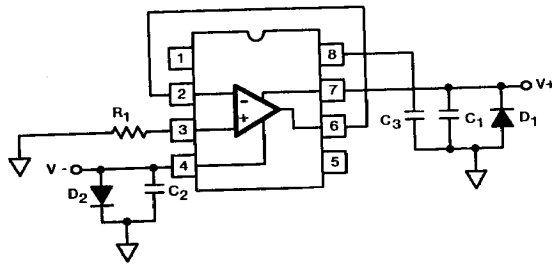


SIMPLIFIED TEST CIRCUIT (Applies to Table 2)

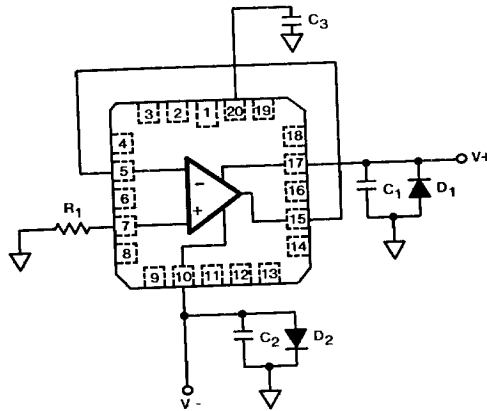


Burn-In Circuits

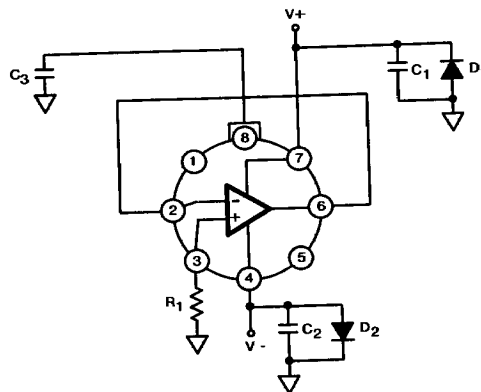
HA7-2600/883 CERAMIC MINI-DIP
HA7-2602/883 CERAMIC MINI-DIP



HA4-2602/883 CERAMIC LCC



HA2-2600/883 (TO-99) METAL CAN
HA2-2602/883 (TO-99) METAL CAN

**NOTES:**

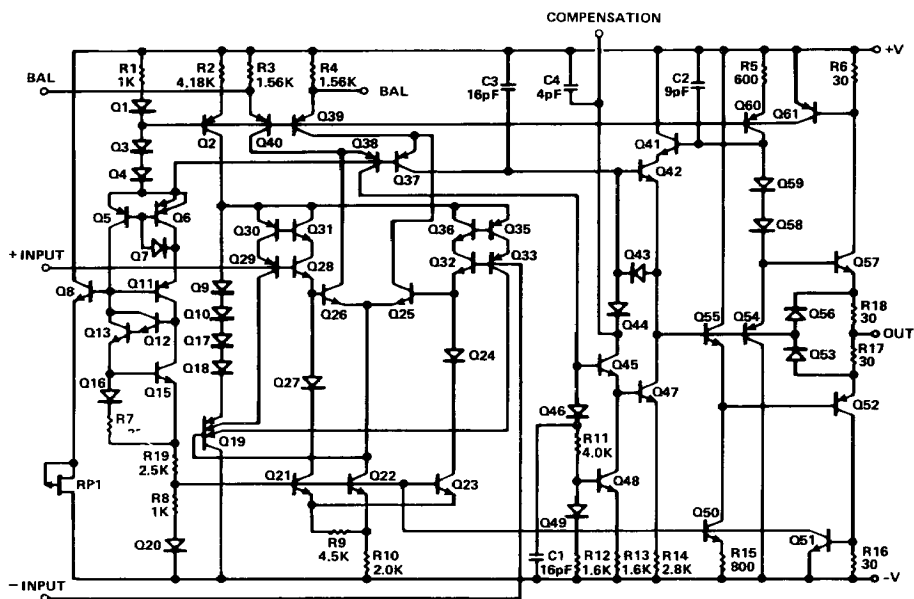
$R_1 = 1M\Omega, \pm 5\%, 1/4W$ (Min)

$C_1 = C_2 = 0.01\mu F/\text{Socket}$ (Min) or $0.1\mu F/\text{Row}$ (Min)

$C_3 = 0.01\mu F/\text{Socket}$ (10%)

$D_1 = D_2 = \text{IN4002 or Equivalent/Board}$

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

Schematic Diagram

Die Characteristics**DIE DIMENSIONS:**

73 x 52 x 19 mils
(1860 x 1320 x 483 μm)

METALLIZATION:

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

WORST CASE CURRENT DENSITY:

$1.5 \times 10^5 \text{A/cm}^2$ @ 19mA

SUBSTRATE POTENTIAL (Powered Up):

Unbiased

GLASSIVATION:

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

TRANSISTOR COUNT:

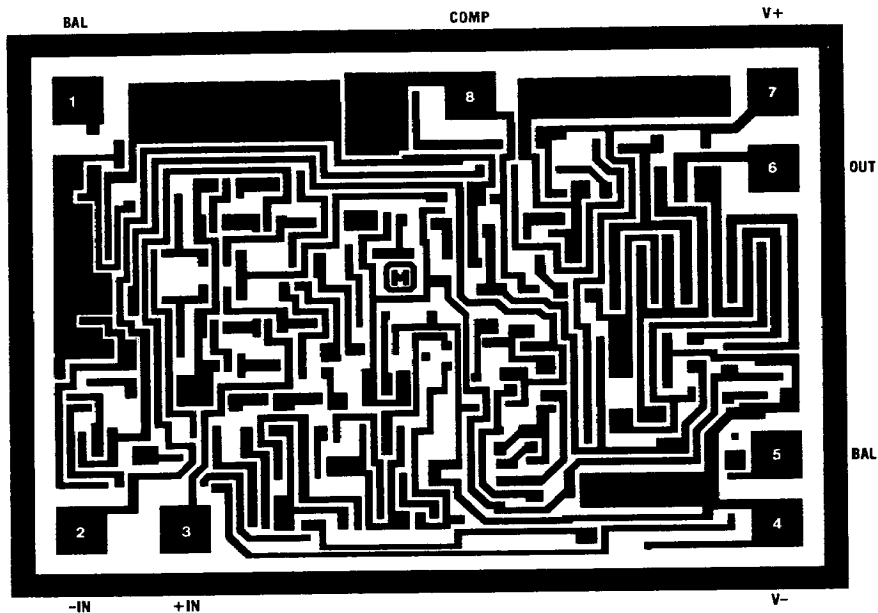
HA-2600/883: 140
HA-2602/883: 140

PROCESS: Std. Linear Bipolar Dielectric Isolation**DIE ATTACH:**

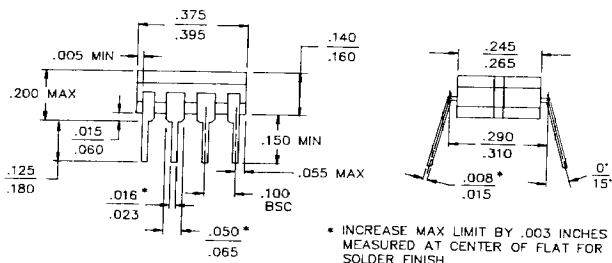
Material: Gold/Silicon Eutectic Alloy
Temperature: Ceramic DIP — 460°C (Max)
Ceramic LCC — 420°C (Max)
Metal Can — 420°C (Max)

Metallization Mask Layout

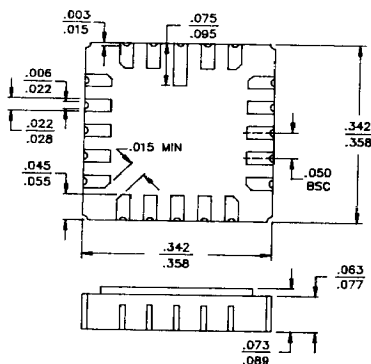
HA-2600/883 HA-2602/883



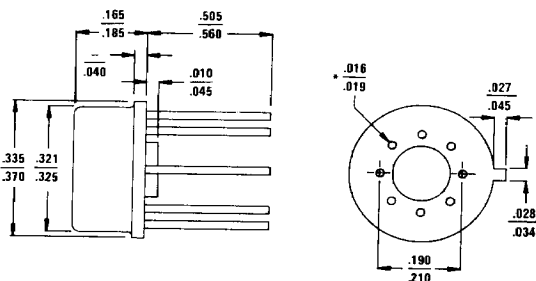
NOTE: Pad Numbers Correspond to Metal Can and Mini-DIP Packages Only.

Packaging †**8 PIN CERAMIC DIP**

LEAD MATERIAL: Type B
LEAD FINISH: Type A
PACKAGE MATERIAL: Ceramic, 90% Alumina
PACKAGE SEAL:
 Material: Glass Frit
 Temperature: $450^{\circ}\text{C} \pm 10^{\circ}\text{C}$
 Method: Furnace Seal
INTERNAL LEAD WIRE:
 Material: Aluminum
 Diameter: 1.25 Mil
 Bonding Method: Ultrasonic
COMPLIANT OUTLINE: 38510 D-4

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: $320^{\circ}\text{C} \pm 10^{\circ}\text{C}$
 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 $\frac{\text{Min}}{\text{Max}}$, Dimensions are in inches.

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

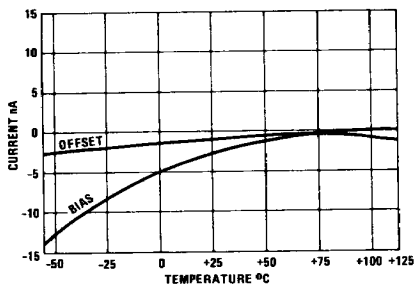
DESIGN INFORMATION

Wideband, High Impedance Operational Amplifiers

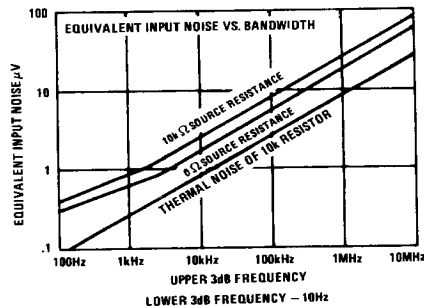
The information contained in this section has been developed through characterization by Harris Semiconductor and is for use as application and design aid only. These characteristics are not 100% tested and no product guarantee is implied.

Typical Performance Curves Unless Otherwise Specified: $T_A = +25^\circ\text{C}$, $V_{\text{SUPPLY}} = \pm 15\text{V}$

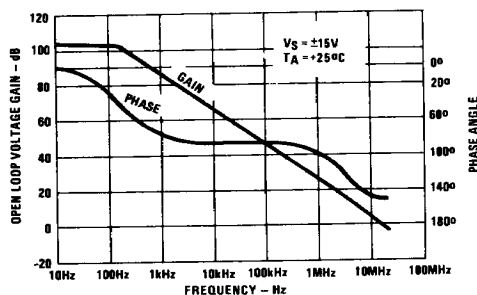
INPUT BIAS CURRENT AND OFFSET CURRENT AS A FUNCTION OF TEMPERATURE



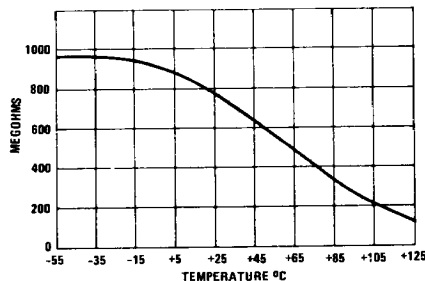
LOWER 3dB FREQUENCY-10Hz BROADBAND NOISE CHARACTERISTICS



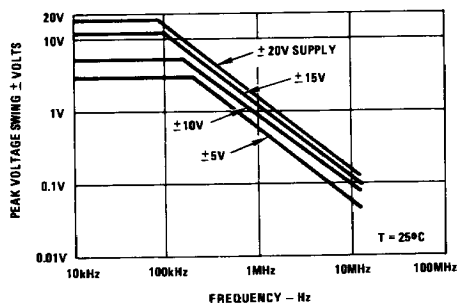
OPEN LOOP FREQUENCY AND PHASE RESPONSE



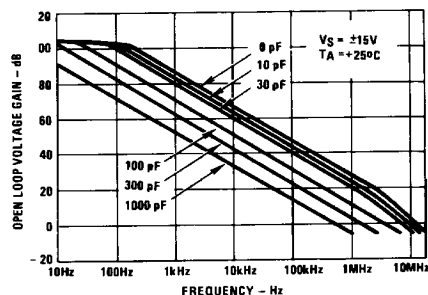
INPUT IMPEDANCE vs. TEMPERATURES, 100Hz



OUTPUT VOLTAGE SWING vs. FREQUENCY



OPEN LOOP FREQUENCY RESPONSE FOR VARIOUS VALUES OF CAPACITORS FROM COMPENSATION PIN TO GROUND



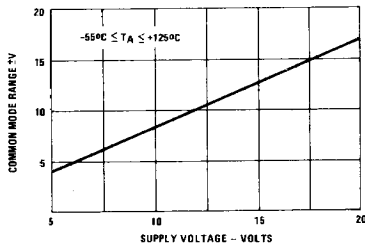
NOTE: External compensation components are not required for stability. But may be added to reduce bandwidth if desired. If external compensation is used, also connect 100pF Capacitor from output to ground.

DESIGN INFORMATION (Continued)

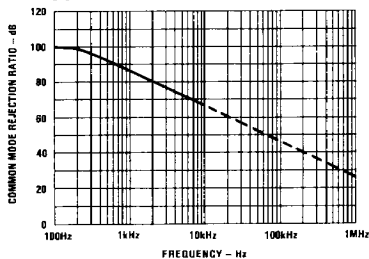
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Typical Performance Curves Unless Otherwise Specified: $T_A = +25^\circ\text{C}$, $V_{\text{SUPPLY}} = \pm 15\text{V}$

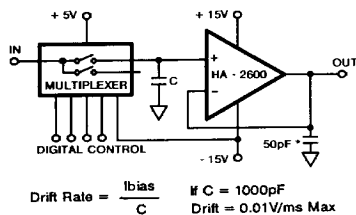
COMMON MODE VOLTAGE RANGE AS A FUNCTION OF SUPPLY VOLTAGE



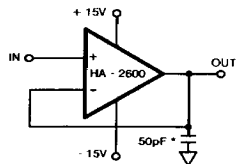
COMMON MODE REJECTION RATIO



SAMPLE-AND-HOLD



VOLTAGE FOLLOWER



1.000 Gain 0.999
 $Z_{\text{IN}} = 10^{12} \Omega \text{ Min}$
 $Z_{\text{OUT}} = 0.01 \Omega \text{ Max}$
 Slew Rate = $4\text{V}/\mu\text{s Min}$
 B.W. = 12MHz Typ
 Output Swing = $\pm 10\text{V Min to } 50\text{kHz}$

* A small load capacitance is recommended in all applications where practical to prevent possible high frequency oscillations resulting from external wiring parasitics. Capacitance up to 100pF has negligible effect on the bandwidth or slew rate.

OPEN LOOP VOLTAGE GAIN vs. TEMPERATURE

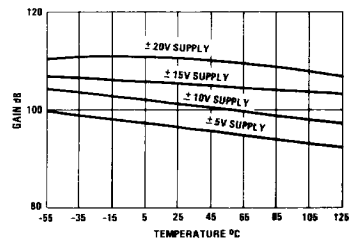
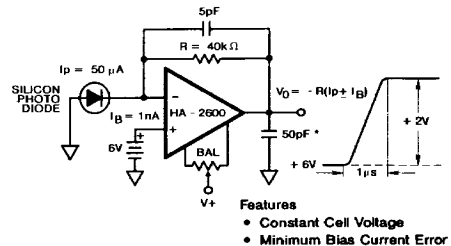
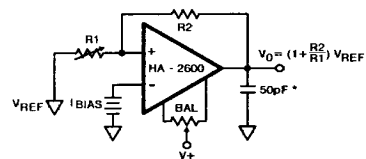


PHOTO CURRENT TO VOLTAGE CONVERTER



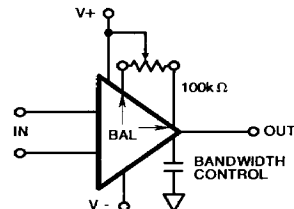
REFERENCE VOLTAGE AMPLIFIER



Features

- Minimum Bias Current in Reference Cell
- Short Circuit Protection

SUGGESTED V_{OS} ADJUSTMENT AND COMPENSATION HOOK-UP



Typical Range is $\pm 10\text{mV}$ with $R_T = 100\text{k}\Omega$

DESIGN INFORMATION (Continued)

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 CHARACTERISTICS

Device Characterized at: $V_S = \pm 15V$, $R_L = 2K$, $C_L = 50pF$, $A_V = +1$, Unless Otherwise Specified.

PARAMETERS	CONDITIONS	TEMP	HA-2600	HA-2602	DESIGN LIMIT	UNITS
			TYPICAL	TYPICAL		
Offset Voltage	$V_{CM} = 0V$	+25°C	0.5	3	Table 1	mV
		Full	2	4	Table 1	mV
Offset Voltage Average Drift	Versus Temperature	Full	5	5	15	$\mu V/^\circ C$
Offset Current Average Drift	Versus Temperature	Full	100	100	200	$pA/^\circ C$
Differential Input Resistance		+25°C	500	300	Table 3	$M\Omega$
Input Noise Voltage Density	$f_o = 10Hz$	+25°C	45	45	60	$nV/\sqrt{Hz}$
	$f_o = 100Hz$	+25°C	25	25	40	$nV/\sqrt{Hz}$
	$f_o = 1kHz$ to 100kHz	+25°C	15	15	Table 3	$nV/\sqrt{Hz}$
Input Noise Current Density	$f_o = 10Hz$	+25°C	1	1	2	$pA/\sqrt{Hz}$
	$f_o = 100Hz$	+25°C	0.25	0.25	0.5	$pA/\sqrt{Hz}$
	$f_o = 1kHz$ to 100kHz	+25°C	0.16	0.16	0.3	$pA/\sqrt{Hz}$
Output Voltage Swing	$R_L = 2k\Omega$	Full	± 12	± 12	Table 1	V
Large Signal Voltage Gain	$V_{OUT} = \pm 10V$	+25°C	150	150	Table 1	kV/V
CMRR	$V_{CM} = \pm 10V$	Full	100	100	Table 1	dB
PSRR	$\Delta V_{Supply} = \pm 10V$	Full	90	90	Table 1	dB
Gain Bandwidth Product (Small Signal)	$f_o = 10kHz$, $C_{COMP} = 0pF$	+25°C	15	15	10	MHz
	$f_o = 1MHz$, $C_{COMP} = 0pF$	+25°C	15	15	10	MHz
Unity Gain Bandwidth	$A_V = +1$, $C_{COMP} = 0pF$	+25°C	12	12	8	MHz
Rise/Fall Time	$V_{OUT} = \pm 200mV$	+25°C	30	30	Table 2	ns
Overshoot	$V_{OUT} = \pm 200mV$	+25°C	25	25	Table 2	%
Slew Rate	$V_{OUT} = \pm 10V$	+25°C	7	7	Table 2	V/ μs
Full Power Bandwidth	$V_{PEAK} = 10V$, (Note 2)	+25°C	75	75	Table 3	kHz
Settling Time	10V Step to 0.1%	+25°C	1.5	1.5	4	μs
Output Resistance	Open Loop	+25°C	30	30	65	Ω
Minimum Supply Voltage	Functional Operation Only. Other Parameters Will Vary.	+25°C	± 7	± 7	$\pm 8V$	V