

## Dual, Low Noise, Wideband, Precision Operational Amplifier

January 1996

### Features

- This Circuit is Processed in Accordance to MIL-STD-883 and is Fully Conformant Under the Provisions of Paragraph 1.2.1.
- Gain Bandwidth Product . . . . . 100MHz (Min)
- Unity Gain Bandwidth . . . . . 30MHz (Min)  
40MHz (Typ)
- High Slew Rate . . . . . 25V/μs (Min)  
37V/μs (Typ)
- Low Offset Voltage . . . . . 0.75mV (Max)  
0.30mV (Typ)
- High Open Loop Gain . . . . . 106dB (Min)  
128dB (Typ)
- Channel Separation (at 10kHz) . . . . . 110dB (Typ)
- Low Voltage Noise (at 1kHz) . . . . . 5.9nV/√Hz (Max)  
3.3nV/√Hz (Typ)
- Low Current Noise (at 1kHz) . . . . . 2.7pA/√Hz (Max)  
1.3pA/√Hz (Typ)
- High Output Current . . . . . ±30mA (Min)  
±56mA (Typ)
- Low Supply Current (per Op Amp.) . . . . . 10mA (Max)  
8mA (Typ)

### Applications

- Precision Test Systems
- Active Filtering
- Small Signal Video
- Accurate Signal Processing
- RF Signal Conditioning

### Description

The HA-5222/883 is a dual, high performance, dielectrically isolated, monolithic op amp, featuring precision DC characteristics while providing excellent AC characteristics. Designed for audio, video, and other demanding applications, noise (3.3nV/√Hz at 1kHz typ), total harmonic distortion (<0.005% typ), and DC errors are kept to a minimum.

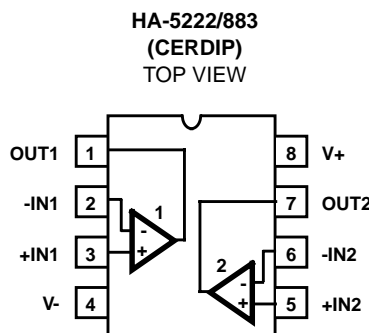
The precision performance is shown by low offset voltage (0.3mV typ), low bias currents (40nA typ), low offset currents (15nA typ), and high open loop gain (128dB typ). The combination of these excellent DC characteristics with fast settling time (0.4μs typ) make the HA-5222/883 ideally suited for precision signal conditioning.

The unique design of the HA-5222/883 gives this device outstanding AC characteristics, including high unity gain bandwidth (40MHz typ) and high slew rate (37V/μs typ), not normally associated with precision op amps. Other key specifications include high CMRR (95dB typ) and high PSRR (100dB typ). The combination of these specifications will allow the HA-5222/883 to be used in RF signal conditioning as well as video amplifiers.

### Ordering Information

PART NUMBER	TEMPERATURE RANGE	PACKAGE
HA7-5222/883	-55°C to +125°C	8 Lead CerDIP

### Pinout



# Specifications HA-5222/883

## Absolute Maximum Ratings

Voltage Between V+ and V- Terminals . . . . .	36V
Differential Input Voltage . . . . .	5V
Voltage at Either Input Terminal . . . . .	V+ to V-
Peak Output Current (Pulsed at 1ms, 10% Duty Cycle) . . . . .	100mA
Continuous Output Current . . . . .	Short Circuit Protected
Junction Temperature . . . . .	+175°C
Storage Temperature Range . . . . .	-65°C to +150°C
ESD Rating . . . . .	<2000V
Lead Temperature (Soldering 10s) . . . . .	+300°C

## Thermal Information (Typical)

Thermal Resistance	$\theta_{JA}$	$\theta_{JC}$
CerDIP Package . . . . .	96°C/W	16°C/W
Package Power Dissipation Limit at +75°C		
CerDIP Package . . . . .	1.04W	
Package Power Dissipation Derating Factor Above +75°C		
CerDIP Package . . . . .	10.4mW/°C	

*CAUTION: Stresses above those listed in "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress only rating and operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied.*

## Operating Conditions

Operating Temperature Range . . . . .	-55°C to +125°C	$V_{INCM} \leq 1/2 (V+ - V-)$
Operating Supply Voltage . . . . .	$\pm 5V$ to $\pm 15V$	$R_L \geq 1k\Omega$

**TABLE 1. DC ELECTRICAL PERFORMANCE CHARACTERISTICS**

Device Tested at:  $V_{SUPPLY} = \pm 15V$ ,  $R_{LOAD} = 1k\Omega$ ,  $V_{OUT} = 0V$ , Unless Otherwise Specified.

PARAMETERS	SYMBOL	CONDITIONS	GROUP A SUBGROUPS	TEMPERATURE	LIMITS		UNITS
					MIN	MAX	
Input Offset Voltage	$V_{IO}$	$V_{CM} = 0V$	1	+25°C	-0.75	0.75	mV
			2, 3	+125°C, -55°C	-1.5	1.5	mV
Input Bias Current	+ $I_B$	$V_{CM} = 0V$ , + $R_S = 100.1k\Omega$ , - $R_S = 100\Omega$	1	+25°C	-80	80	nA
			2, 3	+125°C, -55°C	-200	200	nA
	- $I_B$	$V_{CM} = 0V$ , + $R_S = 100\Omega$ , - $R_S = 100.1k\Omega$	1	+25°C	-80	80	nA
			2, 3	+125°C, -55°C	-200	200	nA
Input Offset Current	$I_{IO}$	$V_{CM} = 0V$ , + $R_S = 100.1k\Omega$ , - $R_S = 100.1k\Omega$	1	+25°C	-50	50	nA
			2, 3	+125°C, -55°C	-150	150	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	4	+25°C	106	-	dB
			5, 6	+125°C, -55°C	100	-	dB
	- $A_{VOL}$	$V_{OUT} = 0V$ and -10V	4	+25°C	106	-	dB
			5, 6	+125°C, -55°C	100	-	dB
Common Mode Rejection Ratio	+CMRR	$\Delta V_{CM} = +10V$ , $V+ = +5V$ , $V- = -25V$ , $V_{OUT} = -10V$	1	+25°C	88	-	dB
			2, 3	+125°C, -55°C	86	-	dB
	-CMRR	$\Delta V_{CM} = -10V$ , $V+ = +25V$ , $V- = -5V$ , $V_{OUT} = +10V$	1	+25°C	88	-	dB
			2, 3	+125°C, -55°C	86	-	dB
Output Voltage Swing	+ $V_{OUT}$	$R_L = 1k\Omega$	4	+25°C	12.0	-	V
			5, 6	+125°C, -55°C	11.5	-	V
	- $V_{OUT}$	$R_L = 1k\Omega$	4	+25°C	-	-12.0	V
			5, 6	+125°C, -55°C	-	-11.5	V

## Specifications HA-5222/883

**TABLE 1. DC ELECTRICAL PERFORMANCE CHARACTERISTICS (Continued)**

Device Tested at:  $V_{SUPPLY} = \pm 15V$ ,  $R_{LOAD} = 1k\Omega$ ,  $V_{OUT} = 0V$ , Unless Otherwise Specified.

PARAMETERS	SYMBOL	CONDITIONS	GROUP A SUBGROUPS	TEMPERATURE	LIMITS		UNITS
					MIN	MAX	
Output Current	+I <sub>OUT</sub>	V <sub>OUT</sub> = +10V, R <sub>L</sub> = 1kΩ	4	+25°C	30	-	mA
			5, 6	+125°C, -55°C	30	-	mA
	-I <sub>OUT</sub>	V <sub>OUT</sub> = -10V, R <sub>L</sub> = 1kΩ	4	+25°C	-	-30	mA
			5, 6	+125°C, -55°C	-	-30	mA
Quiescent Power Supply Current	+I <sub>CC</sub>	V <sub>OUT</sub> = 0V, I <sub>OUT</sub> = 0mA	1	+25°C	-	20	mA
			2, 3	+125°C, -55°C	-	22	mA
	-I <sub>CC</sub>	V <sub>OUT</sub> = 0V, I <sub>OUT</sub> = 0mA	1	+25°C	-20	-	mA
			2, 3	+125°C, -55°C	-22	-	mA
Power Supply Rejection Ratio	+PSRR	ΔV <sub>SUP</sub> = 10V, V <sub>+</sub> = +20V, V <sub>-</sub> = -15V, V <sub>+</sub> = +10V, V <sub>-</sub> = -15V	1	+25°C	90	-	dB
			2, 3	+125°C, -55°C	86	-	dB
	-PSRR	ΔV <sub>SUP</sub> = 10V, V <sub>+</sub> = +15V, V <sub>-</sub> = -20V, V <sub>+</sub> = +15V, V <sub>-</sub> = -10V	1	+25°C	90	-	dB
			2, 3	+125°C, -55°C	86	-	dB

**TABLE 2. AC ELECTRICAL PERFORMANCE CHARACTERISTICS**

Table 2 Intentionally Left Blank. See AC Specifications in Table 3.

**TABLE 3. ELECTRICAL PERFORMANCE CHARACTERISTIC**

Device Characterized at:  $V_{SUPPLY} = \pm 15V$ ,  $R_{LOAD} = 1k\Omega$ , Unless Otherwise Specified.

PARAMETERS	SYMBOL	CONDITIONS	NOTES	TEMPERATURE	LIMITS		UNITS
					MIN	MAX	
Input Noise Voltage Density	E <sub>N</sub>	R <sub>S</sub> = 0Ω, f <sub>O</sub> = 10Hz	1, 5	+25°C	-	16.0	nV/√Hz
		R <sub>S</sub> = 0Ω, f <sub>O</sub> = 100Hz	1, 5	+25°C	-	6.6	nV/√Hz
		R <sub>S</sub> = 0Ω, f <sub>O</sub> = 1kHz	1, 5	+25°C	-	5.9	nV/√Hz
Input Noise Current Density	I <sub>N</sub>	R <sub>S</sub> = 500kΩ, f <sub>O</sub> = 10Hz	1, 5	+25°C	-	24.0	pA/√Hz
		R <sub>S</sub> = 500kΩ, f <sub>O</sub> = 100Hz	1, 5	+25°C	-	6.6	pA/√Hz
		R <sub>S</sub> = 500kΩ, f <sub>O</sub> = 1kHz	1, 5	+25°C	-	2.7	pA/√Hz
Gain Bandwidth Product	GBWP	V <sub>OUT</sub> = 200mV <sub>P-P</sub> , f <sub>O</sub> = 100kHz	1	+25°C	100	-	MHz
				-55°C to +125°C	88	-	MHz
Unity Gain Bandwidth	UGBW	V <sub>OUT</sub> = 200mV	1	+25°C	30	-	MHz
				-55°C to +125°C	25	-	MHz
Slew Rate	±SR	V <sub>OUT</sub> = ±2.5V, C <sub>L</sub> = 50pF	1	-55°C to +125°C	25	-	V/μs
Full Power Bandwidth	FPBW	V <sub>PEAK</sub> = 10V	1, 2	-55°C to +125°C	398	-	kHz

## Specifications HA-5222/883

**TABLE 3. ELECTRICAL PERFORMANCE CHARACTERISTIC (Continued)**

Device Characterized at:  $V_{SUPPLY} = \pm 15V$ ,  $R_{LOAD} = 1k\Omega$ , Unless Otherwise Specified.

PARAMETERS	SYMBOL	CONDITIONS	NOTES	TEMPERATURE	LIMITS		UNITS
					MIN	MAX	
Minimum Closed Loop Stable Gain	CLSG	$R_L = 1k\Omega$ , $C_L = 50pF$	1	-55°C to +125°C	1	-	V/V
Rise and Fall Time	$t_R, t_F$	$V_{OUT} = \pm 100mV$	1, 4	+25°C	-	20	ns
				-55°C to +125°C	-	35	ns
Overshoot	$\pm OS$	$V_{OUT} = \pm 100mV$	1	+25°C	-	25	%
				-55°C to +125°C	-	30	%
Power Consumption	PC	$V_{OUT} = 0V$ , $I_{OUT} = 0mA$	1, 3	-55°C to +125°C	-	660	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  $FPBW = \text{Slew Rate}/(2\pi V_{PEAK})$ .
3. Power Consumption based upon Quiescent Supply Current test maximum. (No load on outputs.)
4. Measured between 10% and 90% points.
5. Input Noise Voltage Density and Input Noise Current Density limits are based on characterization data.

**TABLE 4. ELECTRICAL TEST REQUIREMENTS**

MIL-STD-883 TEST REQUIREMENTS	SUBGROUPS (SEE TABLE 1)
Interim Electrical Parameters (Pre Burn-In)	1
Final Electrical Test Parameters	1 (Note 1), 2, 3, 4, 5, 6
Group A Test Requirements	1, 2, 3, 4, 5, 6
Groups C and D Endpoints	1

**NOTE:**

1. PDA applies to Subgroup 1 only.

**Die Characteristics**

**DIE DIMENSIONS:**

78 x 185 x 19 mils ± 1 mils  
 1980 x 4690 x 483µm ± 25.4µm

**METALLIZATION:**

Type: Al, 1% Cu  
 Thickness: 16kÅ ± 2kÅ

**GLASSIVATION:**

Type: Nitride (Si3N4) over Silox (SiO2 5% Phos.)  
 Silox Thickness: 12kÅ ± 2kÅ  
 Nitride Thickness: 3.5kÅ ± 1.5kÅ

**WORST CASE CURRENT DENSITY:**

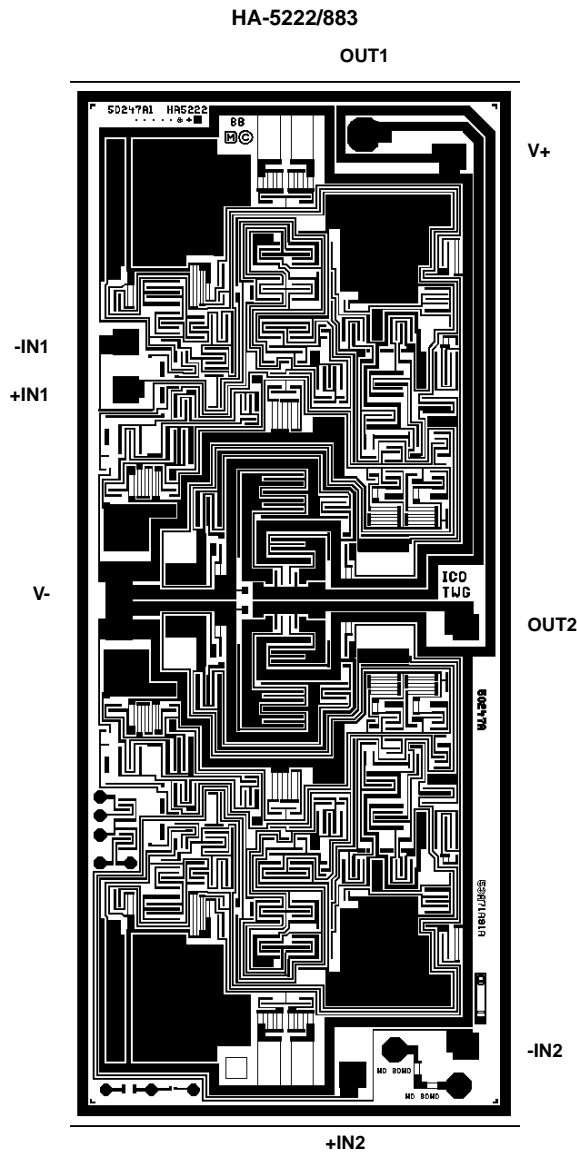
4.2 x 10<sup>4</sup> A/cm<sup>2</sup>

**SUBSTRATE POTENTIAL (Powered Up): V-**

**TRANSISTOR COUNT: 128**

**PROCESS: Bipolar Dielectric Isolation**

**Metallization Mask Layout**



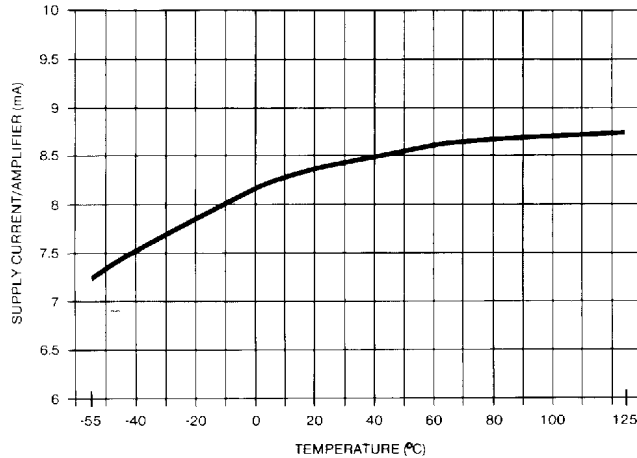
## DESIGN INFORMATION (Continued)

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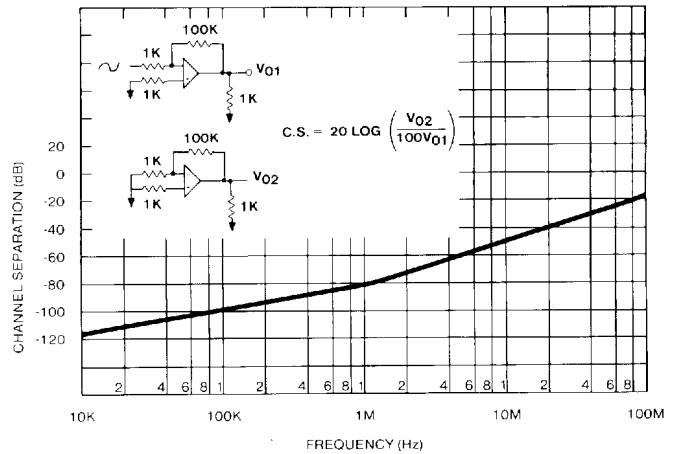
### Typical Performance Curves

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

**SUPPLY CURRENT/AMPLIFIER vs TEMPERATURE**



**CHANNEL SEPARATION vs FREQUENCY**



### TYPICAL PERFORMANCE CHARACTERISTICS

Device Characterized at: Supply Voltage =  $\pm 15\text{V}$ ,  $R_L = 1\text{k}\Omega$ ,  $C_L = 50\text{pF}$ , Unless Otherwise Specified

PARAMETERS	CONDITIONS	TEMPERATURE	TYPICAL	UNITS
Input Offset Voltage	See Table 1	+25°C	0.30	mV
		Full	0.35	mV
Average Offset Voltage Drift	See Table 1	Full	0.50	$\mu\text{V}/^\circ\text{C}$
Input Bias Current	See Table 1	+25°C	40	nA
		Full	70	nA
Input Offset Current	See Table 1	+25°C	15	nA
		Full	30	nA
Differential Input Resistance	See Table 1	+25°C	70	k $\Omega$
Input Noise Voltage	$f_O = 0.1\text{Hz}$ to $10\text{Hz}$	+25°C	0.33	$\mu\text{V}_{\text{P-P}}$
Input Noise Voltage Density	$f_O = 10\text{Hz}$	+25°C	6.4	$\text{nV}/\sqrt{\text{Hz}}$
	$f_O = 100\text{Hz}$	+25°C	3.7	$\text{nV}/\sqrt{\text{Hz}}$
	$f_O = 1\text{kHz}$	+25°C	3.3	$\text{nV}/\sqrt{\text{Hz}}$
Input Noise Current Density	$f_O = 10\text{Hz}$	+25°C	8	$\text{pA}/\sqrt{\text{Hz}}$
	$f_O = 100\text{Hz}$	+25°C	2.7	$\text{pA}/\sqrt{\text{Hz}}$
	$f_O = 1\text{kHz}$	+25°C	1.3	$\text{pA}/\sqrt{\text{Hz}}$
THD & N	See Note 1	+25°C	0.005	%
Large Signal Voltage Gain	$V_{\text{OUT}} = 0\text{V}$ to $\pm 10\text{V}$	+25°C	128	dB
		Full	120	dB

**DESIGN INFORMATION** (Continued)

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**TYPICAL PERFORMANCE CHARACTERISTICS** (Continued)

Device Characterized at: Supply Voltage =  $\pm 15V$ ,  $R_L = 1k\Omega$ ,  $C_L = 50pF$ , Unless Otherwise Specified

PARAMETERS	CONDITIONS	TEMPERATURE	TYPICAL	UNITS	
Common Mode Rejection Ratio	$\Delta V_{CM} = \pm 10V$	Full	95	dB	
Unity Gain Bandwidth	-3dB	+25°C	40	MHz	
		+125°C	33	MHz	
		-55°C	50	MHz	
Gain Bandwidth Product	1kHz to 400kHz	+25°C	140	MHz	
		+125°C	115	MHz	
		-55°C	160	MHz	
Minimum Gain Stability		Full	1	V/V	
Output Voltage Swing	$R_L = 333\Omega$	Full	110	V	
	$R_L = 1K$	+25°C	112.5	V	
		Full	112.1	V	
Output Current	$V_{OUT} = \pm 10V$	Full	156	mA	
Output Resistance		+25°C	10	V	
Full Power Bandwidth	FPBW = $SR/2\pi V_{PEAK}$ , $V_{PEAK} = 10V$	+25°C	398	kHz	
Channel Separation	$f_O = 10kHz$	+25°C	110	dB	
Slew Rate	$V_{OUT} = \pm 2.5V$	+25°C	37	V/ $\mu s$	
		+125°C	39	V/ $\mu s$	
		-55°C	36	V/ $\mu s$	
Rise Time	$V_{OUT} = \pm 100mV$	+25°C	16	ns	
		+125°C	17	ns	
		-55°C	17	ns	
Overshoot	$V_{OUT} = \pm 100mV$	+25°C	12	%	
		+125°C	11	%	
		-55°C	12	%	
Settling Time	$10V_{STEP}$ $A_V = -1$	0.1%	+25°C	0.4	$\mu s$
		0.01%	+25°C	1.5	$\mu s$
Power Supply Rejection Ratio	$\Delta V_S = \pm 10V$ to $\pm 20V$	Full	100	dB	
Supply Current	Quiescent, $V_{OUT} = 0V$ , $I_{OUT} = 0mA$	Full	8	mA/Op Amp	
Minimum Supply Voltage	Functional Operation Only. Other Parameters May Vary.	+25°C	15	V	

## NOTE:

- $A_{VCL} = 10$ ,  $f_O = 1kHz$ ,  $V_{OUT} = 5V_{rms}$ ,  $R_L = 600\Omega$ , 10Hz to 100kHz, Minimum resolution of test equipment is 0.005%.

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