

July 1994

## Precision 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 Offset Drift .....  $0.4\mu\text{V}/^\circ\text{C}$  (Max)
- Low Offset Voltage.....  $75\mu\text{V}$  (Max)
- High Gain .....  $120\text{dB}(1\text{MV}/\text{V})$  (Min)
- High CMRR.....  $106\text{dB}$  (Min)
- High PSRR .....  $94\text{dB}$  (Min)
- Low Supply Current.....  $1.7\text{mA}$  (Max)
- Low Noise Voltage Density at  $1\text{kHz}$  .....  $9\text{nV}/\sqrt{\text{Hz}}$  (Max)
- Low Noise Current Density at  $1\text{kHz}$  ....  $0.4\text{pA}/\sqrt{\text{Hz}}$  (Max)

### Applications

- High Gain Instrumentation
- Precision Data Acquisition
- Precision Integrators
- Biomedical Amplifiers
- Precision Threshold Detectors

### Description

The HA-5135/883 is a precision operational amplifier manufactured using a combination of key technological advancements to provide outstanding input characteristics.

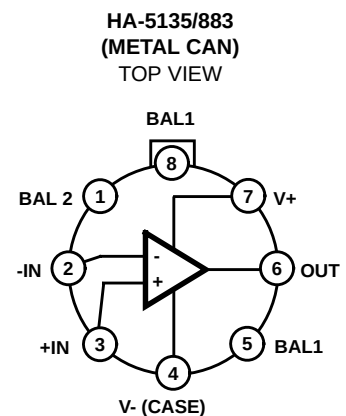
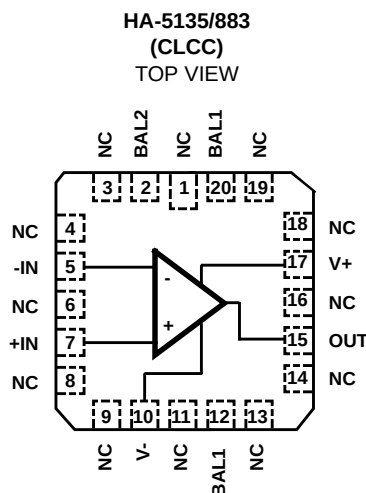
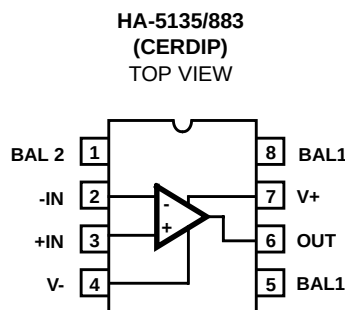
A high Beta input stage is combined with laser trimming, dielectric isolation, and matching techniques to produce  $75\mu\text{V}$  (max) input offset voltage and  $0.4\mu\text{V}/^\circ\text{C}$  (max) input offset voltage average drift. Other features enhanced by this process include  $9\text{nV}/\sqrt{\text{Hz}}$  (typ) Input Noise Voltage,  $4\text{nA}$  Input Bias Current (max) and  $120\text{dB}$  Open Loop Gain (min).

These features coupled with  $106\text{dB}$  CMRR and  $94\text{dB}$  PSRR make HA-5135/883 an ideal device for precision D.C. instrumentation amplifiers. Excellent input characteristics in conjunction with  $0.6\text{MHz}$  (min) bandwidth and  $0.5\text{V}/\mu\text{s}$  (min) slew rate, makes this amplifier extremely useful for precision integrator and biomedical amplifier designs. These amplifiers are also well suited for precision data acquisition and for accurate threshold detector applications.

### Ordering Information

| PART NUMBER  | TEMPERATURE RANGE                           | PACKAGE             |
|--------------|---------------------------------------------|---------------------|
| HA2-5135/883 | $-55^\circ\text{C}$ to $+125^\circ\text{C}$ | 8 Pin Can           |
| HA7-5135/883 | $-55^\circ\text{C}$ to $+125^\circ\text{C}$ | 8 Lead CerDIP       |
| HA4-5135/883 | $-55^\circ\text{C}$ to $+125^\circ\text{C}$ | 20 Lead Ceramic LCC |

### Pinouts



# Specifications HA-5135/883

## Absolute Maximum Ratings

Voltage Between V+ and V- Terminals . . . . . 40V  
Differential Input Voltage (Note 2) . . . . . 7V  
Voltage at Either Input Terminal . . . . . V+ to V-  
Input Current . . . . . 25mA  
Output Current . . . . . Full Short Circuit Protection  
Junction Temperature (T<sub>J</sub>) . . . . . +175°C  
Storage Temperature Range . . . . . -65°C to +150°C  
ESD Rating . . . . . <2000V  
Lead Temperature (Soldering 10s) . . . . . +300°C

## Thermal Information

Thermal Resistance  $\theta_{JA}$   $\theta_{JC}$   
CerDIP Package . . . . . 115°C/W 28°C/W  
Ceramic LCC Package . . . . . 65°C/W 15°C/W  
Metal Can Package . . . . . 155°C/W 67°C/W  
Package Power Dissipation Limit at +75°C for T<sub>J</sub> ≤ +175°C  
CerDIP Package . . . . . 870mW  
Ceramic LCC Package . . . . . 1.54W  
Metal Can Package . . . . . 645mW  
Package Power Dissipation Derating Factor Above +75°C  
CerDIP Package . . . . . 8.7mW/°C  
Ceramic LCC Package . . . . . 15.4mW/°C  
Metal Can Package . . . . . 6.5mW/°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 . . . . . ±15V  $R_L \geq 600\Omega$

**TABLE 1. DC ELECTRICAL PERFORMANCE CHARACTERISTICS**

Device Tested at: V<sub>SUPPLY</sub> = ±15V, R<sub>SOURCE</sub> = 50Ω, R<sub>LOAD</sub> = 100kΩ, V<sub>OUT</sub> = 0V, Unless Otherwise Specified.

| PARAMETERS                  | SYMBOL            | CONDITIONS                                                                                            | GROUP A<br>SUBGROUPS | TEMPERATURE   | LIMITS |     | UNITS |
|-----------------------------|-------------------|-------------------------------------------------------------------------------------------------------|----------------------|---------------|--------|-----|-------|
|                             |                   |                                                                                                       |                      |               | MIN    | MAX |       |
| Input Offset Voltage        | V <sub>IO</sub>   | V <sub>CM</sub> = 0V                                                                                  | 1                    | +25°C         | -75    | 75  | μV    |
|                             |                   |                                                                                                       | 2, 3                 | +125°C, -55°C | -130   | 130 | μV    |
| Input Bias Current          | I <sub>B</sub>    | V <sub>CM</sub> = 0V,<br>R <sub>S</sub> = 10kΩ, 50Ω<br>$\left( \frac{ I_{B1}  +  I_{B2} }{2} \right)$ | 1                    | +25°C         | -4     | 4   | nA    |
|                             |                   |                                                                                                       | 2, 3                 | +125°C, -55°C | -6     | 6   | nA    |
| Input Offset Current        | I <sub>IO</sub>   | V <sub>CM</sub> = 0V,<br>+R <sub>S</sub> = 10kΩ,<br>-R <sub>S</sub> = 10kΩ                            | 1                    | +25°C         | -4     | 4   | nA    |
|                             |                   |                                                                                                       | 2, 3                 | +125°C, -55°C | -5.5   | 5.5 | nA    |
| Common Mode Range           | +CMR              | V+ = +3V,<br>V- = -27V                                                                                | 1                    | +25°C         | 12     | -   | V     |
|                             |                   |                                                                                                       | 2, 3                 | +125°C, -55°C | 12     | -   | V     |
|                             | -CMR              | V+ = +27V,<br>V- = -3V                                                                                | 1                    | +25°C         | -      | -12 | V     |
|                             |                   |                                                                                                       | 2, 3                 | +125°C, -55°C | -      | -12 | V     |
| Large Signal Voltage Gain   | +A <sub>VOL</sub> | V <sub>OUT</sub> = 0V and +10V,<br>R <sub>L</sub> = 2kΩ                                               | 4                    | +25°C         | 120    | -   | kV/V  |
|                             |                   |                                                                                                       | 5, 6                 | +125°C, -55°C | 120    | -   | kV/V  |
|                             | -A <sub>VOL</sub> | V <sub>OUT</sub> = 0V and -10V,<br>R <sub>L</sub> = 2kΩ                                               | 4                    | +25°C         | 120    | -   | kV/V  |
|                             |                   |                                                                                                       | 5, 6                 | +125°C, -55°C | 120    | -   | kV/V  |
| Common Mode Rejection Ratio | +CMRR             | ΔV <sub>CM</sub> = +10V,<br>V+ = +5V, V- = -25V,<br>V <sub>OUT</sub> = -10V                           | 1                    | +25°C         | 106    | -   | dB    |
|                             |                   |                                                                                                       | 2, 3                 | +125°C, -55°C | 106    | -   | dB    |
|                             | -CMRR             | ΔV <sub>CM</sub> = -10V,<br>V+ = +25V, V- = -5V,<br>V <sub>OUT</sub> = +10V                           | 1                    | +25°C         | 106    | -   | dB    |
|                             |                   |                                                                                                       | 2, 3                 | +125°C, -55°C | 106    | -   | dB    |
| Output Voltage Swing        | +V <sub>OUT</sub> | R <sub>L</sub> = 600Ω                                                                                 | 4                    | +25°C         | 10     | -   | V     |
|                             |                   |                                                                                                       | 5, 6                 | +125°C, -55°C | 10     | -   | V     |
|                             | -V <sub>OUT</sub> | R <sub>L</sub> = 600Ω                                                                                 | 4                    | +25°C         | -      | -10 | V     |
|                             |                   |                                                                                                       | 5, 6                 | +125°C, -55°C | -      | -10 | V     |
| Output Current              | +I <sub>OUT</sub> | V <sub>OUT</sub> = -10V                                                                               | 4                    | +25°C         | 15     | -   | mA    |
|                             | -I <sub>OUT</sub> | V <sub>OUT</sub> = +10V                                                                               | 4                    | +25°C         | -      | -15 | mA    |

## Specifications HA-5135/883

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

Device Tested at:  $V_{SUPPLY} = \pm 15V$ ,  $R_{SOURCE} = 50\Omega$ ,  $R_{LOAD} = 100k\Omega$ ,  $V_{OUT} = 0V$ , Unless Otherwise Specified.

| PARAMETERS                     | SYMBOL               | CONDITIONS                                                                              | GROUP A<br>SUBGROUPS | TEMPERATURE   | LIMITS             |     | UNITS |
|--------------------------------|----------------------|-----------------------------------------------------------------------------------------|----------------------|---------------|--------------------|-----|-------|
|                                |                      |                                                                                         |                      |               | MIN                | MAX |       |
| Quiescent Power Supply Current | +I <sub>CC</sub>     | $V_{OUT} = 0V$ , $I_{OUT} = 0mA$                                                        | 1                    | +25°C         | -                  | 1.7 | mA    |
|                                |                      |                                                                                         | 2, 3                 | +125°C, -55°C | -                  | 1.7 | mA    |
|                                | -I <sub>CC</sub>     | $V_{OUT} = 0V$ , $I_{OUT} = 0mA$                                                        | 1                    | +25°C         | -1.7               | -   | mA    |
|                                |                      |                                                                                         | 2, 3                 | +125°C, -55°C | -1.7               | -   | mA    |
| Power Supply Rejection Ratio   | +PSRR                | $\Delta V_{SUP} = 10V$ ,<br>$V_+ = +5V$ , $V_- = -15V$ ,<br>$V_+ = +15V$ , $V_- = -15V$ | 1                    | +25°C         | 94                 | -   | dB    |
|                                |                      |                                                                                         | 2, 3                 | +125°C, -55°C | 94                 | -   | dB    |
|                                | -PSRR                | $\Delta V_{SUP} = 10V$ ,<br>$V_+ = +15V$ , $V_- = -5V$ ,<br>$V_+ = +15V$ , $V_- = -15V$ | 1                    | +25°C         | 94                 | -   | dB    |
|                                |                      |                                                                                         | 2, 3                 | +125°C, -55°C | 94                 | -   | dB    |
| Offset Voltage Adjustment      | +V <sub>IO</sub> Adj | Note 1                                                                                  | 1                    | +25°C         | V <sub>IO</sub> -1 | -   | mV    |
|                                |                      |                                                                                         | 2, 3                 | +125°C, -55°C | V <sub>IO</sub> -1 | -   | mV    |
|                                | -V <sub>IO</sub> Adj | Note 1                                                                                  | 1                    | +25°C         | V <sub>IO</sub> +1 | -   | mV    |
|                                |                      |                                                                                         | 2, 3                 | +125°C, -55°C | V <sub>IO</sub> +1 | -   | mV    |

**NOTES:**

- Offset adjustment range is [V<sub>IO</sub> (Measured  $\pm 1mV$ ) minimum referred to output. This test is for functionality only to assure adjustment through 0V.
- The input stage has series 500 $\Omega$  resistors along with back to back diodes. This provides large differential input voltage protection for a slight increase in noise voltage.

**TABLE 2. AC ELECTRICAL PERFORMANCE CHARACTERISTICS**

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

| PARAMETERS | SYMBOL | CONDITIONS                                                   | GROUP A<br>SUBGROUPS | TEMPERATURE | LIMITS |     | UNITS      |
|------------|--------|--------------------------------------------------------------|----------------------|-------------|--------|-----|------------|
|            |        |                                                              |                      |             | MIN    | MAX |            |
| Slew Rate  | +SR    | $V_{OUT} = -3V$ to $+3V$ ,<br>$V_{IN}$ S.R. $\leq 25V/\mu s$ | 7                    | +25°C       | 0.5    | -   | V/ $\mu s$ |
|            | -SR    | $V_{OUT} = +3V$ to $-3V$ ,<br>$V_{IN}$ S.R. $\leq 25V/\mu s$ | 7                    | +25°C       | 0.5    | -   | V/ $\mu s$ |

**TABLE 3. ELECTRICAL PERFORMANCE CHARACTERISTICS**

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

| PARAMETERS                    | SYMBOL             | CONDITIONS                                           | NOTES | TEMPERATURE     | LIMITS |     | UNITS            |
|-------------------------------|--------------------|------------------------------------------------------|-------|-----------------|--------|-----|------------------|
|                               |                    |                                                      |       |                 | MIN    | MAX |                  |
| Average Offset Voltage Drift  | V <sub>IO</sub> TC | V <sub>CM</sub> = 0V                                 | 1     | -55°C to +125°C | -      | 1.3 | $\mu V/^\circ C$ |
| Differential Input Resistance | R <sub>IN</sub>    | V <sub>CM</sub> = 0V                                 | 1     | +25°C           | 20     | -   | M $\Omega$       |
| Average Offset Current Drift  | I <sub>IO</sub> TC | Versus Temperature<br>V <sub>CM</sub> = 0V           | 1     | -55°C to +125°C | -      | 40  | pA/ $^\circ C$   |
| Average Bias Current Drift    | I <sub>B</sub> TC  | Versus Temperature<br>V <sub>CM</sub> = 0V           | 1     | -55°C to +125°C | -      | 40  | pA/ $^\circ C$   |
| Input Noise Voltage Density   | E <sub>N</sub>     | R <sub>S</sub> = 20 $\Omega$ , f <sub>0</sub> = 1kHz | 1     | +25°C           | -      | 11  | nV/ $\sqrt{Hz}$  |

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

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

| PARAMETERS                      | SYMBOL    | CONDITIONS                               | NOTES | TEMPERATURE     | LIMITS |     | UNITS           |
|---------------------------------|-----------|------------------------------------------|-------|-----------------|--------|-----|-----------------|
|                                 |           |                                          |       |                 | MIN    | MAX |                 |
| Input Noise Current Density     | $I_N$     | $R_S = 2M\Omega$ , $f_O = 1kHz$          | 1     | +25°C           | -      | 0.4 | pA/ $\sqrt{Hz}$ |
| Unity Gain Bandwidth            | UGBW      | $V_{OUT} = \pm 100mV$ ,<br>$f_O$ at -3dB | 1     | +25°C           | 600    | -   | kHz             |
| Full Power Bandwidth            | FPBW      | $V_{PEAK} = 10V$                         | 1, 2  | +25°C           | 8      | -   | kHz             |
| Minimum Closed Loop Stable Gain | CLSG      | $R_L = 2k\Omega$ , $C_L = 50pF$          | 1     | -55°C to +125°C | +1     | -   | V/V             |
| Output Resistance               | $R_{OUT}$ | Open Loop                                | 1     | +25°C           | -      | 80  | $\Omega$        |
| Power Consumption               | PC        | $V_{OUT} = 0V$ , $I_{OUT} = 0mA$         | 1, 3  | -55°C to +125°C | -      | 51  | mW              |

NOTES:

- 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.
- Full Power Bandwidth guarantee based on Slew Rate measurement using  $FPBW = \text{Slew Rate} / (2\pi V_{PEAK})$ .
- Power Consumption based upon Quiescent Supply Current test maximum. (No load on outputs.)

**TABLE 4. ELECTRICAL TEST REQUIREMENTS**

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

NOTE:

- PDA applies to Subgroup 1 only.

## Die Characteristics

### DIE DIMENSIONS:

72 x 103 x 19 mils  $\pm$  1 mils  
1840 x 2620 x 483 $\mu$ m  $\pm$  25.4 $\mu$ m

**METALLIZATION:**

Type: Al, 1% Cu  
Thickness:  $16\text{k}\text{\AA} \pm 2\text{k}\text{\AA}$

**GLASSIVATION:**

Type: Nitride (Si<sub>3</sub>N<sub>4</sub>) over Silox (SiO<sub>2</sub>, 5% Phos.)  
 Silox Thickness: 12kÅ ± 2kÅ  
 Nitride Thickness: 3.5kÅ ± 1.5kÅ

**WORST CASE CURRENT DENSITY:**

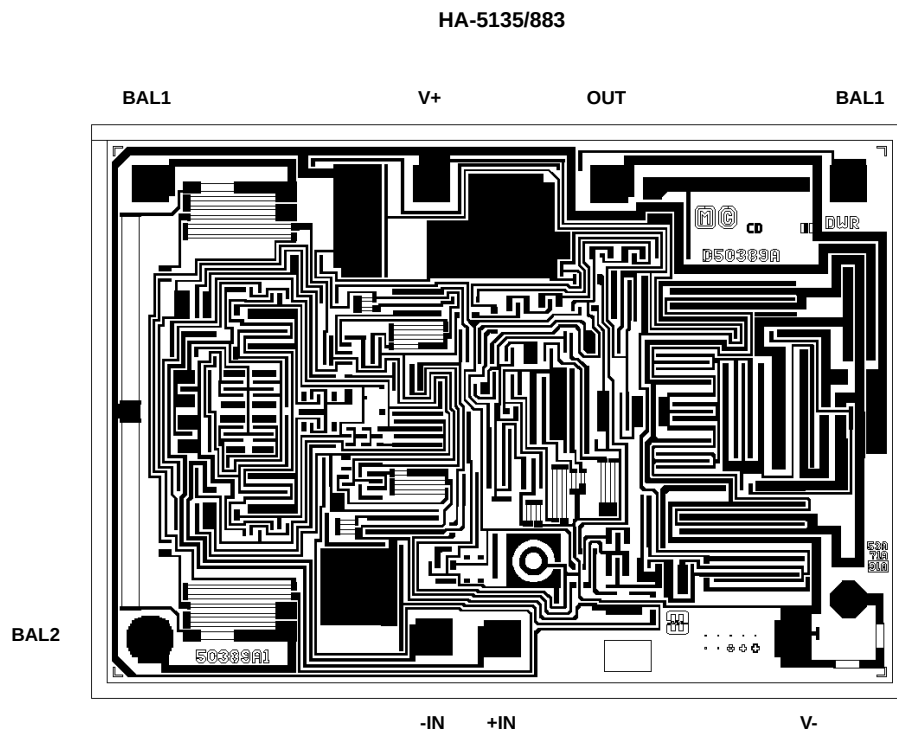
 $6.0 \times 10^4 \text{ A/cm}^2$ 

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

**TRANSISTOR COUNT: 71**

**PROCESS:** Bipolar Dielectric Isolation

## Metallization Mask Layout



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