

July 1994

Ultra Low Offset Voltage 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 Voltage **60 μ V (Max)**
10 μ V (Typ)
- Low Offset Voltage Drift **0.6 μ V/ $^{\circ}$ C (Max)**
0.1 μ V/ $^{\circ}$ C (Typ)
- High Voltage Gain **126dB (Min)**
150dB (Typ)
- High CMRR **110dB (Min)**
140dB (Typ)
- High PSRR **110dB (Min)**
135dB (Typ)
- Low Noise **11nV/ $\sqrt{\text{Hz}}$ (Max)**
9nV/ $\sqrt{\text{Hz}}$ (Typ)
- Low Power Consumption **51mW (Max)**
- Wide Gain Bandwidth Product **2MHz (Min)**
- Unity Gain Stable

Applications

- High Gain Instrumentation Amplifiers
- Precision Control Systems
- Precision Integrators
- High Resolution Data Converters
- Precision Threshold Detectors
- Low Level Transducer Amplifiers

Description

The HA-5177/883 is a monolithic, all bipolar, precision operational amplifier, utilizing Intersil Dielectric Isolation and advance processing techniques. This design features a combination of precision input characteristics, wide gain bandwidth (2MHz) and high speed (0.5V/ μ s min) and is an improved version of the HA-5135/883.

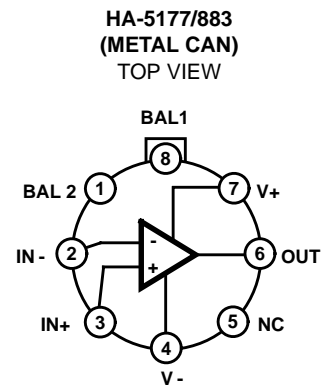
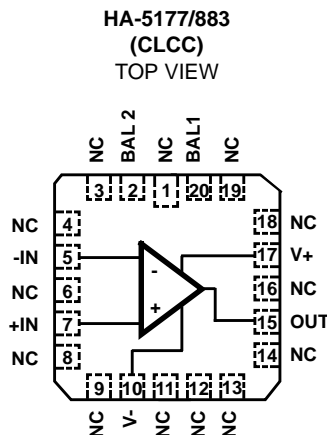
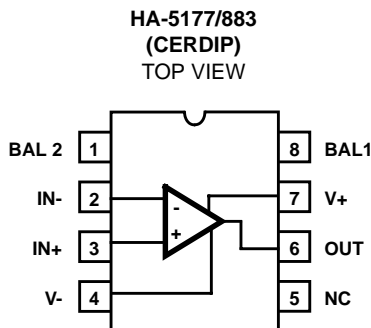
The HA-5177/883 uses advanced matching techniques and laser trimming to produce low offset voltage (10 μ V typ, 60 μ V max) and low offset voltage drift (0.1 μ V/ $^{\circ}$ C typ, 0.6 μ V/ $^{\circ}$ C max). This design also features low voltage noise (9nV/ $\sqrt{\text{Hz}}$ typ), Low current noise (0.32pA/ $\sqrt{\text{Hz}}$ typ), nanoamp input currents, and 126dB minimum gain.

These outstanding features along with high CMRR (140dB typ, 110dB min) and high PSRR (135dB typ, 110dB min) make this unity gain stable amplifier ideal for high resolution data acquisition systems, precision integrators, and low level transducer amplifiers.

Ordering Information

| PART NUMBER | TEMPERATURE RANGE | PACKAGE |
|--------------|---------------------------------------|---------------------|
| HA2-5177/883 | -55 $^{\circ}$ C to +125 $^{\circ}$ C | 8 Pin Can |
| HA7-5177/883 | -55 $^{\circ}$ C to +125 $^{\circ}$ C | 8 Lead CerDIP |
| HA4-5177/883 | -55 $^{\circ}$ C to +125 $^{\circ}$ C | 20 Lead Ceramic LCC |

Pinouts



Specifications HA-5177/883

Absolute Maximum Ratings

| | |
|----------------------------------------|-------------------------------|
| Voltage Between V+ and V- Terminals | 44V |
| Differential Input Voltage (Note 1) | 7V |
| Voltage at Either Input Terminal | V+ to V- |
| Input Current | 25mA |
| 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 10s) | +300°C |

Thermal Information

| | | |
|----------------------------------------------------------------------|---------------|---------------|
| Thermal Resistance | θ_{JA} | θ_{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 _J ≤ +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} ≤ 1/2 (V+ - V-) |
| Operating Supply Voltage | ±15V | R _L ≥ 600Ω |

TABLE 1. DC ELECTRICAL PERFORMANCE CHARACTERISTICS

Device Tested at: V_{SUPPLY} = ±15V, R_{SOURCE} = 50Ω, R_{LOAD} = 100kΩ, 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 | -60 | 60 | μV |
| | | | 2, 3 | +125°C, -55°C | -100 | 100 | μV |
| Input Bias Current | I _B | V _{CM} = 0V, R _S = 10kΩ, 50Ω $\left(\frac{ I_{B+} + I_{B-} }{2} \right)$ | 1 | +25°C | -6 | 6 | nA |
| | | | 2, 3 | +125°C, -55°C | -8 | 8 | nA |
| Input Offset Current | I _{IO} | V _{CM} = 0V, +R _S = 10kΩ, -R _S = 10kΩ | 1 | +25°C | -6 | 6 | nA |
| | | | 2, 3 | +125°C, -55°C | -8 | 8 | 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 | 126 | - | dB |
| | | | 5, 6 | +125°C, -55°C | 120 | - | dB |
| | -A _{VOL} | V _{OUT} = 0V and -10V, R _L = 2kΩ | 4 | +25°C | 126 | - | dB |
| | | | 5, 6 | +125°C, -55°C | 120 | - | dB |
| Common Mode Rejection Ratio | +CMRR | ΔV _{CM} = 10V, V+ = +5V, V- = -25V, V _{OUT} = -10 | 1 | +25°C | 116 | - | dB |
| | | | 2, 3 | +125°C, -55°C | 110 | - | dB |
| | -CMRR | ΔV _{CM} = 10V, V+ = +25V, V- = -5V, V _{OUT} = +10 | 1 | +25°C | 116 | - | dB |
| | | | 2, 3 | +125°C, -55°C | 110 | - | dB |
| Output Voltage Swing | +V _{OUT1} | R _L = 2kΩ | 4 | +25°C | 12 | - | V |
| | | | 5, 6 | +125°C, -55°C | 12 | - | V |
| | -V _{OUT1} | R _L = 2kΩ | 4 | +25°C | - | -12 | V |
| | | | 5, 6 | +125°C, -55°C | - | -12 | V |
| | +V _{OUT2} | R _L = 600Ω | 4 | +25°C | 10 | - | V |
| | | | 4 | +25°C | - | -10 | V |

Specifications HA-5177/883

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 SUBGROUPS | TEMPERATURE | LIMITS | | UNITS |
|--------------------------------|---------------------|--------------------------------------------------------------------------------------------------------------------------|-------------------|---------------|--------|------|-------|
| | | | | | MIN | MAX | |
| Output Current | +I _{OUT} | V _{OUT} = -10V | 4 | +25°C | 15 | - | mA |
| | | | 5, 6 | +125°C, -55°C | 15 | - | mA |
| | -I _{OUT} | V _{OUT} = +10V | 4 | +25°C | - | -15 | mA |
| | | | 5, 6 | +125°C, -55°C | - | -15 | mA |
| Quiescent Power Supply Current | +I _{CC} | V _{OUT} = 0V, I _{OUT} = 0mA | 1 | +25°C | - | 1.7 | mA |
| | | | 2, 3 | +125°C, -55°C | - | 1.7 | mA |
| | -I _{CC} | 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 | $\Delta V_{SUP} = 15V$, V ₊ = +5V, V ₋ = -15V, V ₊ = +20V, V ₋ = -15V | 1 | +25°C | 110 | - | dB |
| | | | 2, 3 | +125°C, -55°C | 110 | - | dB |
| | -PSRR | $\Delta V_{SUP} = 15V$, V ₊ = +15V, V ₋ = -5V, V ₊ = +15V, V ₋ = -20V | 1 | +25°C | 110 | - | dB |
| | | | 2, 3 | +125°C, -55°C | 110 | - | dB |
| Offset Voltage Adjustment | +V _{IOAdj} | Note 2 | 1 | +25°C | 0.3 | - | mV |
| | | | 2, 3 | +125°C, -55°C | 0.3 | - | mV |
| | -V _{IOAdj} | Note 2 | 1 | +25°C | - | -0.3 | mV |
| | | | 2, 3 | +125°C, -55°C | - | -0.3 | mV |

NOTES:

1. The input stage has series 500Ω resistors along with back to back diodes. This provides large differential input voltage protection for a slight increase in noise voltage.
2. This test is for functionality only to assure adjustment through 0V.

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 SUBGROUPS | TEMPERATURE | LIMITS | | UNITS |
|--------------------|----------------|-----------------------------------------------------------------|-------------------|-------------|--------|-----|-------|
| | | | | | MIN | MAX | |
| Slew Rate | +SR | V _{OUT} = -3V to +3V, V _{IN} S.R. ≤ 25V/μs | 7 | +25°C | 0.5 | - | V/μs |
| | -SR | V _{OUT} = +3V to -3V, V _{IN} S.R. ≤ 25V/μs | 7 | +25°C | 0.5 | - | V/μs |
| Rise and Fall Time | t _R | V _{OUT} = 0 to +200mV 10% ≤ T _R ≤ 90% | 7 | +25°C | - | 420 | ns |
| | t _F | V _{OUT} = 0 to -200mV 10% ≤ T _F ≤ 90% | 7 | +25°C | - | 420 | ns |
| Overshoot | +OS | V _{OUT} = 0 to +200mV | 7 | +25°C | - | 40 | % |
| | -OS | V _{OUT} = 0 to -200mV | 7 | +25°C | - | 40 | % |

Specifications HA-5177/883

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 | $V_{IO TC}$ | $V_{CM} = 0V$ | 1 | -55°C to +125°C | - | 0.6 | $\mu V/^\circ C$ |
| Average Offset Current Drift | $I_{IO TC}$ | Versus Temperature | 1 | -55°C to +125°C | - | 40 | $pA/^\circ C$ |
| Average Bias Current Drift | $I_{R TC}$ | Versus Temperature | 1 | -55°C to +125°C | - | 40 | $pA/^\circ C$ |
| Differential Input Resistance | R_{IN} | $V_{CM} = 0V$ | 1 | +25°C | 20 | - | $M\Omega$ |
| Low Frequency Peak-to-Peak Noise Voltage | E_{NP-P} | 0.1Hz to 10Hz | 1 | +25°C | - | 0.6 | μV_{P-P} |
| Low Frequency Peak-to-Peak Noise Current | I_{NP-P} | 0.1Hz to 10Hz | 1 | +25°C | - | 45 | pA_{P-P} |
| Input Noise Voltage Density | E_N | $R_S = 20\Omega$, $f_O = 10Hz$ | 1 | +25°C | - | 18 | nV/\sqrt{Hz} |
| | | $R_S = 20\Omega$, $f_O = 100Hz$ | 1 | +25°C | - | 13 | nV/\sqrt{Hz} |
| | | $R_S = 20\Omega$, $f_O = 1kHz$ | 1 | +25°C | - | 11 | nV/\sqrt{Hz} |
| Input Noise Current Density | I_N | $R_S = 2M\Omega$, $f_O = 10Hz$ | 1 | +25°C | - | 4 | pA/\sqrt{Hz} |
| | | $R_S = 2M\Omega$, $f_O = 100Hz$ | 1 | +25°C | - | 2.3 | pA/\sqrt{Hz} |
| | | $R_S = 2M\Omega$, $f_O = 1kHz$ | 1 | +25°C | - | 1 | pA/\sqrt{Hz} |
| Gain Bandwidth Product | GBWP | $V_O = 100mV$, $1Hz \leq f_O \leq 100kHz$ | 1 | +25°C | 2 | - | MHz |
| 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 |
| Settling Time | t_S | To 0.1% for a 10V Step | 1 | +25°C | - | 15 | μs |
| Output Resistance | R_{OUT} | Open Loop | 1 | +25°C | - | 70 | Ω |
| 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 ± 1 mils
 1840 x 2620 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:

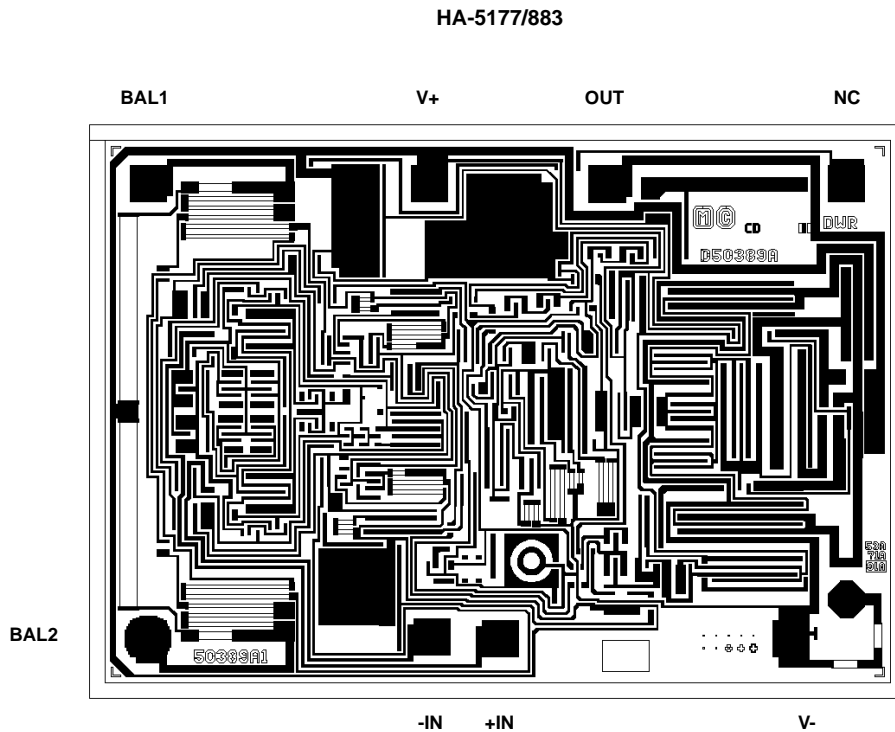
6.0 x 10⁴ A/cm²

SUBSTRATE POTENTIAL (Powered Up): V-

TRANSISTOR COUNT: 71

PROCESS: Bipolar Dielectric Isolation

Metallization Mask Layout



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