HARRIS

HA-5190/883

Wideband, Fast Settling Operational Amplifier

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.**
- **Very High Slew Rate .... 160V/µs (Min)**
- **Fast Settling Time .... 100ns (Typ)**
- **Wide Gain Bandwidth .... 150MHz (Min)**
- **Power Bandwidth .... 5MHz (Min)**
- **Low Offset Voltage .... 5mV (Max)**
- **Input Voltage Noise @ 1kHz.......... 6nV/$\sqrt{Hz}$ (Typ)**
- **Monolithic Bipolar Construction**

Applications

- **Fast, Precise D/A Converters**
- **High Speed Sample and Hold Circuits**
- **Pulse and Video Amplifiers**
- **WideBand Amplifiers**
- **Replace Costly Hybrids**

Description

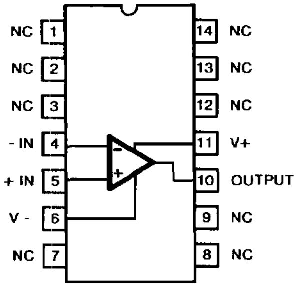
The HA-5190/883 is a monolithic operational amplifier featuring an ultimate combination of speed, precision, and bandwidth. Employing monolithic bipolar construction coupled with Dielectric Isolation, this device is capable of delivering an unparalleled 160V/µs slew rate (min) with a settling time of 100ns (typ). This truly differential amplifier is designed to operate at a gain of 5 without the need for external compensation. Other oustanding HA-5190/883 features are 150MHz (min) gain-bandwidth-product and 5MHz full power bandwidth. In addition to these dynamic characteristics, this amplifier also has excellent input characteristics such as 5mV offset voltage (max) and 6.0nV (typ) input voltage noise density at 1kHz.

With such dynamic A.C. performance, the HA-5190/883 makes an ideal output amplifier for accurate, high speed D/A converters or the main component in high speed sample and hold circuits. The HA-5190/883 is also ideally suited for a variety of pulse and wideband video amplifier applications.

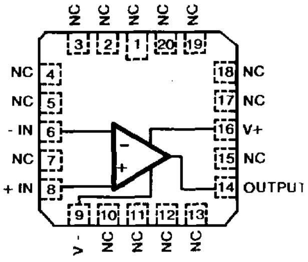
The HA-5190/883 is available in Metal Can (TO-8), 20 pin Ceramic LCC, and 14 pin Ceramic DIP packages and is specified over the -55°C to +125°C temperature range.

Pinouts

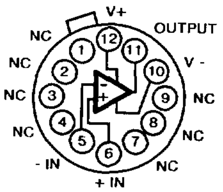
HA1-5190/883 (CERAMIC DIP)
TOP VIEW



HA4-5190/883 (CERAMIC LCC)
TOP VIEW



HA2-5190/883 (TO-8 METAL CAN)
TOP VIEW



Case Tied To V-

Absolute Maximum Ratings

Voltage Between V+ and V- Terminals	35V
Differential Input Voltage (Note 8)	6V
Voltage at Either Input Terminal	V+ to V-
Peak Output Current (< 10% Duty Cycle)	50mA
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	98°C/W	30°C/W
Ceramic LCC Package	95°C/W	35°C/W
Metal Can Package	69°C/W	31°C/W

Package Power Dissipation Limit at +75°C For $T_J \leq 175°C$	
Ceramic DIP Package	1.02mW
Ceramic LCC Package	1.06W
Metal Can Package	1.45W

Package Power Dissipation Derating Factor Above +75°C	
Ceramic DIP Package	10.2mW/°C
Ceramic LCC Package	10.6mW/°C
Metal Can Package	14.5mW/°C

Recommended Operating Conditions

Operating Temperature Range	-55°C to +125°C
Operating Supply Voltage	±12V to ±15V

$V_{INcm} \leq 1/2\ (V+ - V-)$

$R_L \geq 200\Omega$

TABLE 1. D.C. ELECTRICAL PERFORMANCE CHARACTERISTICS

Device Tested at: Supply Voltage = ±15V, $R_{SOURCE} = 100\Omega$, $R_{LOAD} = 500k\Omega$, $V_{OUT} = 0V$, 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	-5	5	mV
			2, 3	+125°C, -55°C	-10	10	mV
Input Bias Current	$+I_B$	$V_{CM} = 0V$ $+R_S = 1.1k\Omega$ $-R_S = 100\Omega$	1	+25°C	-15	15	μA
			2, 3	+125°C, -55°C	-20	20	μA
	$-I_B$	$V_{CM} = 0V$ $+R_S = 100\Omega$ $-R_S = 1.1k\Omega$	1	+25°C	-15	15	μA
			2, 3	+125°C, -55°C	-20	20	μA
Input Offset Current	I_{IO}	$V_{CM} = 0V$ $+R_S = 1.1k\Omega$ $-R_S = 1.1k\Omega$	1	+25°C	-4	4	μA
			2, 3	+125°C, -55°C	-6	6	μA
Common Mode Range	+CMR	V+ = 10V V- = -20V	1	+25°C	5	-	V
			2, 3	+125°C, -55°C	5	-	V
	-CMR	V+ = 20V V- = -10V	1	+25°C	-	-5	V
			2, 3	+125°C, -55°C	-	-5	V
Large Signal Voltage Gain	$+A_{VOL}$	$V_{OUT} = 0V$ and $+5V$ $R_L = 200\Omega$	4	+25°C	15	-	kV/V
			5, 6	+125°C, -55°C	5	-	kV/V
	$-A_{VOL}$	$V_{OUT} = 0V$ and $-5V$ $R_L = 200\Omega$	4	+25°C	15	-	kV/V
			5, 6	+125°C, -55°C	5	-	kV/V
Common Mode Rejection Ratio	+CMRR	$\Delta V_{CM} = +5V$ $+V = +10V$ $-V = -20V$ $V_{OUT} = -5V$	1	+25°C	74	-	dB
			2, 3	+125°C, -55°C	74	-	dB
	-CMRR	$\Delta V_{CM} = -5V$ $+V = +20V$ $-V = -10V$ $V_{OUT} = +5V$	1	+25°C	74	-	dB
			2, 3	+125°C, -55°C	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 = ±15V, R_{SOURCE} = 10Ω, R_{LOAD} = 500kΩ, V_{OUT} = 0V,
Unless Otherwise Specified.

D.C. PARAMETERS	SYMBOL	CONDITIONS	GROUP A SUBGROUP	TEMPERATURE	LIMITS		UNITS
					MIN	MAX	
Output Voltage Swing	$+V_{OUT}$	R_L = 200Ω	1	+25°C	5	-	V
			2, 3	+125°C, -55°C	5	-	V
	$-V_{OUT}$	R_L = 200Ω	1	+25°C	-	-5	V
			2, 3	+125°C, -55°C	-	-5	V
Output Current	$+I_{OUT}$	$V_{OUT} \geq -5V$	1	+25°C	25	-	mA
	$-I_{OUT}$	$V_{OUT} \leq +5V$	1	+25°C	-	-25	mA
Quiescent Power Supply Current	$+I_{CC}$	V_{OUT} = 0V I_{OUT} = 0mA	1	+25°C	-	24	mA
			2, 3	+125°C, -55°C	-	24	mA
	$-I_{CC}$	V_{OUT} = 0V I_{OUT} = 0mA	1	+25°C	-24	-	mA
			2, 3	+125°C, -55°C	-24	-	mA
Power Supply Rejection Ratio	+PSRR	ΔV_{SUP} = 10V +V = +10V, -V = -15V +V = +20V, -V = -15V	1	+25°C	70	-	dB
			2, 3	+125°C, -55°C	70	-	dB
	-PSRR	ΔV_{SUP} = 10V +V = +15V, -V = -10V +V = +15V, -V = -20V	1	+25°C	70	-	dB
			2, 3	+125°C, -55°C	70	-	dB

TABLE 2. A.C. ELECTRICAL PERFORMANCE CHARACTERISTICS

Device Tested at: Supply Voltage = ±15V, R_{SOURCE} = 100Ω, R_{LOAD} = 200Ω, $C_{LOAD} \leq$ 10pF, A_{VCL} = 5V/V,
Unless Otherwise Specified.

D.C. PARAMETERS	SYMBOL	CONDITIONS	GROUP A SUBGROUP	TEMPERATURE	LIMITS		UNITS
					MIN	MAX	
Slew Rate	+SR	V_{OUT} = -5V to +5V	7	+25°C	160	-	V/μs
	-SR	V_{OUT} = +5V to -5V	7	+25°C	160	-	V/μs
Rise & Fall Time	T_R	V_{OUT} = 0 to +200mV $10\% \leq T_R \leq 90\%$	7	+25°C	-	18	ns
	T_F	V_{OUT} = 0 to -200mV $10\% \leq T_F \leq 90\%$	7	+25°C	-	18	ns

TABLE 3. ELECTRICAL PERFORMANCE CHARACTERISTICS

Device Characterized at: Supply Voltage = ±15V, R_{LOAD} = 1kΩ, $C_{LOAD} \leq$ 10pF, A_V = 5V/V, Unless Otherwise Specified.

PARAMETERS	SYMBOL	CONDITIONS	NOTES	TEMPERATURE	LIMITS MIN	LIMITS MAX	UNITS
Gain Bandwidth Product	GBWP	$V_O \leq$ 200mV, f_O = 10kHz	1	+25°C	150	-	MHz
		$V_O \leq$ 200mV, f_O = 1MHz	1	+25°C	150	-	MHz
Full Power Bandwidth	FPBW	V_{PEAK} = 5V	1, 2	+25°C	5	-	MHz
Minimum Closed Loop Stable Gain	CLSG	R_L = 200Ω, $C_L \leq$ 10pF	1	-55°C to +125°C	5	-	V/V
Overshoot	+OS	V_{OUT} = 0V to +200mV	1	+25°C	-	45	%
	-OS	V_{OUT} = 0V to -200mV	1	+25°C	-	45	%
Output Resistance	R_{OUT}	Open Loop	1	+25°C	-	60	Ω
Quiescent Power Consumption	PC	V_{OUT} = 0V, I_{OUT} = 0mA	1, 3	-55°C to +125°C	-	720	mW

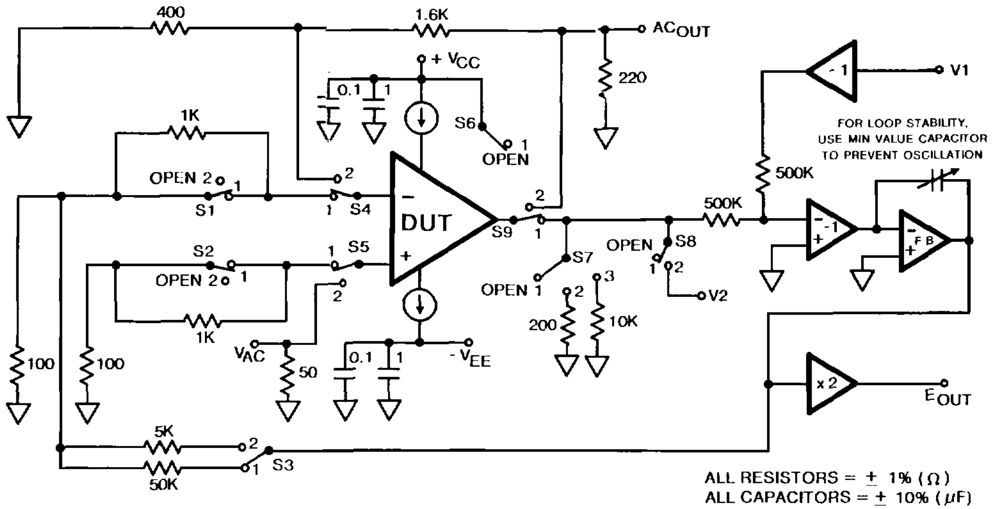
NOTES:
1. Parameters listed in Table 3 are controlled via design or process parameters and are not directly tested at final production. These parameters are lab characterized upon initial design release, or upon design changes. These parameters are guaranteed by characterization based upon data from multiple production runs which reflect lot to lot and within lot variation.
2. Full Power Bandwidth guarantee based on Slew Rate measurement using FPBW = Slew Rate/($2\pi V_{PEAK}$).
3. Quiescent 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 & 2)
Interim Electrical Parameters (Pre Burn-in)	1
Final Electrical Test Parameters	1*, 2, 3, 4, 5, 6, 7
Group A Test Requirements	1, 2, 3, 4, 5, 6, 7
Groups C & D Endpoints	1

* PDA applies to Subgroup 1 only.

Test Circuit (Applies to Table 1)

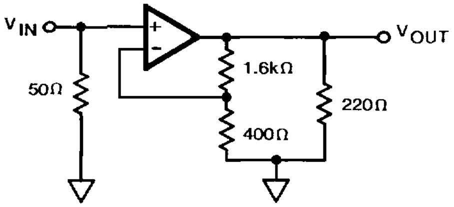


ALL RESISTORS = ± 1% (Ω)
ALL CAPACITORS = ± 10% (μF)

For Detailed Information, Refer to HA-5190/883 Test Tech Brief

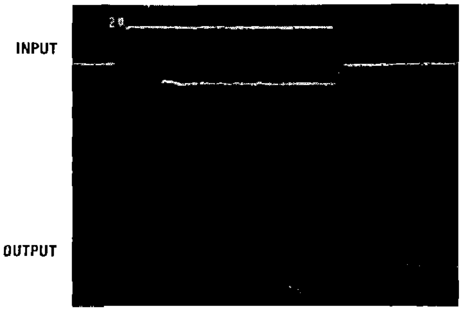
Test Waveforms

SIMPLIFIED TEST CIRCUIT FOR LARGE AND SMALL SIGNAL RESPONSE (Applies to Tables 2 and 3)

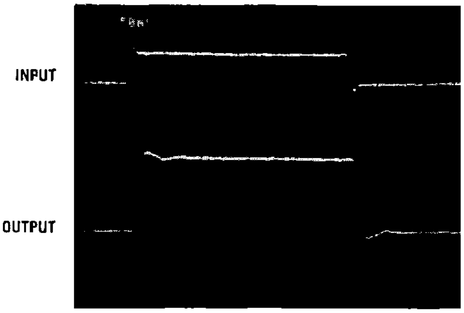


$A_V = +5$
$C_L \leq 10pF$

MEASURED LARGE SIGNAL RESPONSE
Vertical Scale: Input = 2V/Div., Output = 2V/Div.
Horizontal Scale: Time: 50ns/Div.

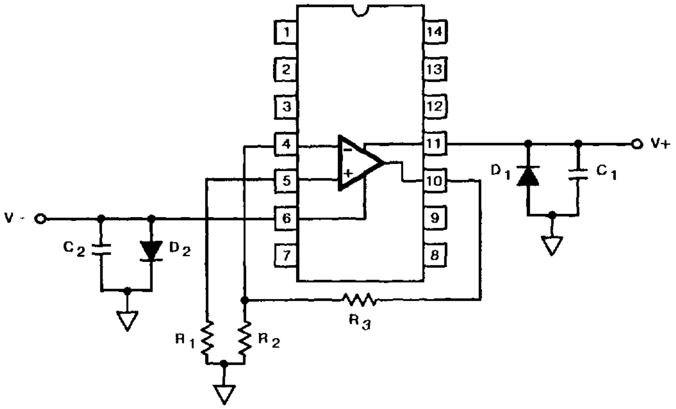


MEASURED SMALL SIGNAL RESPONSE
Vertical Scale: Input = 50mV/Div., Output = 100mV/Div.
Horizontal Scale: 50ns/Div.

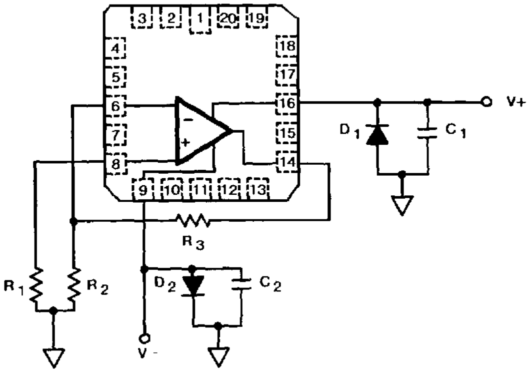


Burn-In Circuits

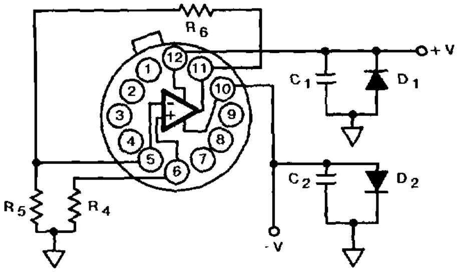
HA1-5190/883 CERAMIC DIP



HA4-5190/883 CERAMIC LCC



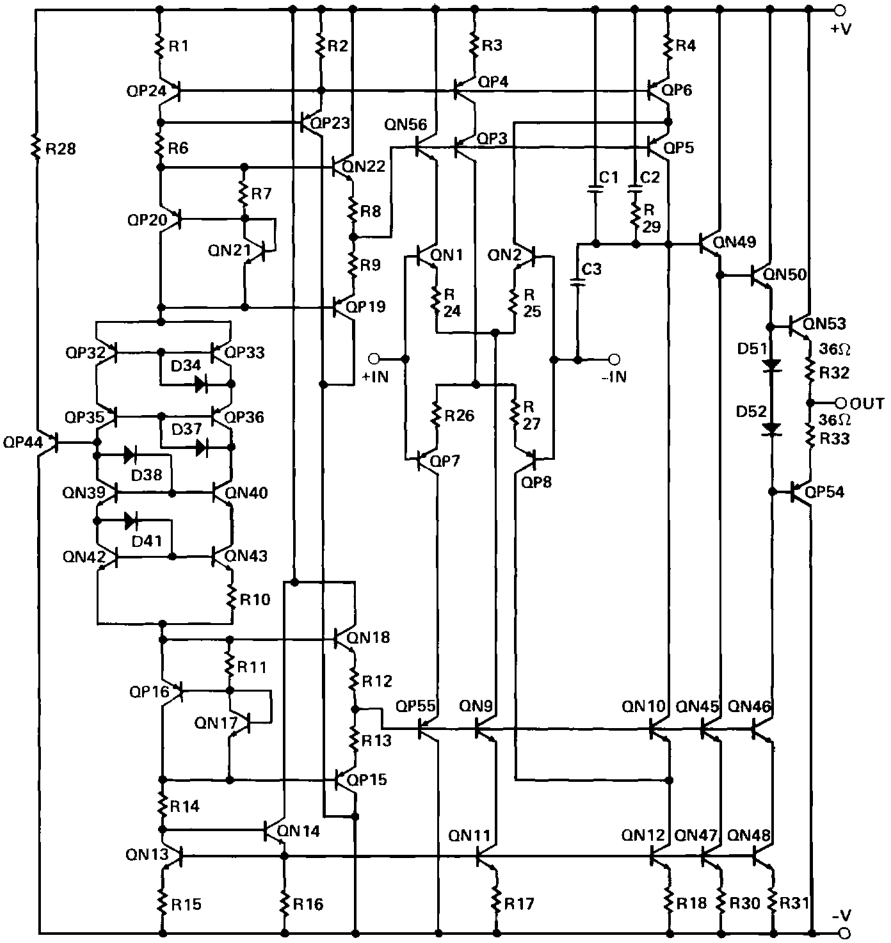
HA2-5190/883 TO-8 METAL CAN



NOTES:

$R_1 = R_2 = 1k\Omega$, ±5%, 1/4W (Min)
$R_3 = 10k\Omega$, ±5%, 1/4W (Min)
$R_4 = R_5 = 100k\Omega$, ±5%, 1/4W (Min)
$R_6 = 1M\Omega$, ±5%, 1/4W (Min)
$C_1 = C2 = 0.01\mu F$/Socket (Min) or $0.1\mu F$/Row, (Min)
$D_1 = D_2$ = IN4002 or Equivalent/Board
$|(V+) - (V-)| \approx 30V$

Schematic Diagram



Die Characteristics

DIE DIMENSIONS:
87 x 52 x 19 mils
(2210 x 1320 x 483 μm)

METALLIZATION:
Type: Aluminum
Thickness: 20kÅ ± 2kÅ

WORST CASE CURRENT DENSITY:
0.7 x 10^5A/cm^2 @ 3.72mA

SUBSTRATE POTENTIAL (POWERED UP): V-

GLASSIVATION:
Type: Nitride
Thickness: 7kÅ ± 0.7kÅ

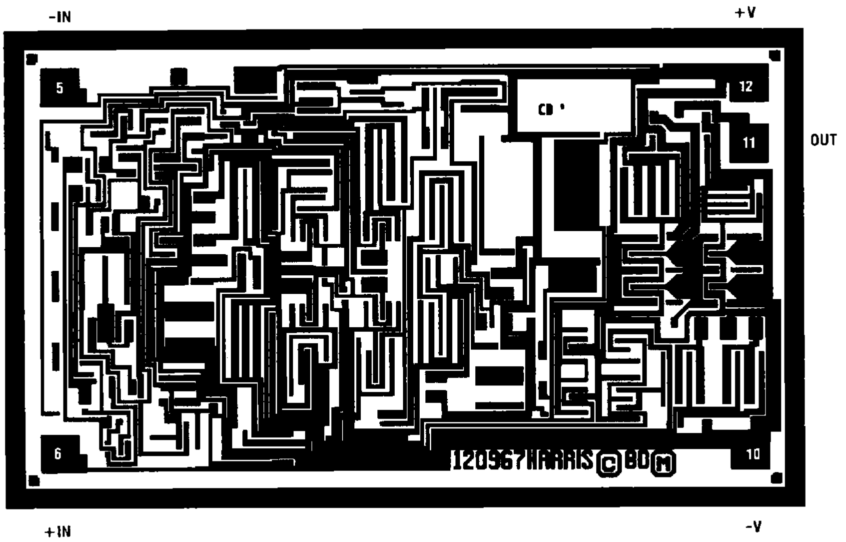
TRANSISTOR COUNT: 49

PROCESS: High Frequency 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

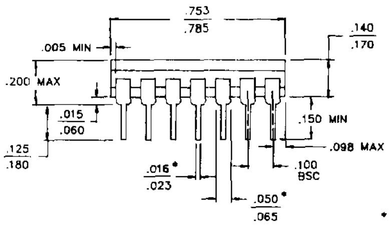
HA-5190/883

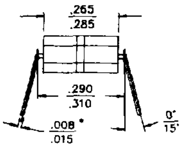


NOTE: Pin Numbers Correspond to 12 Pin (TO-8) Metal Can Package Only.

Packaging †

14 PIN CERAMIC DIP





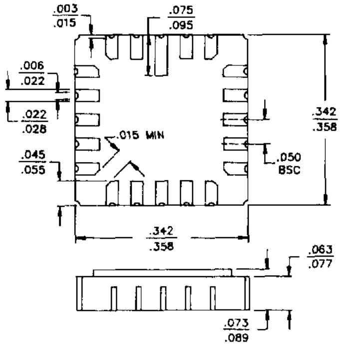
* INCREASE MAX LIMIT BY .003 INCHES MEASURED AT CENTER OF FLAT FOR SOLDER FINISH

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-1

20 PAD CERAMIC LCC

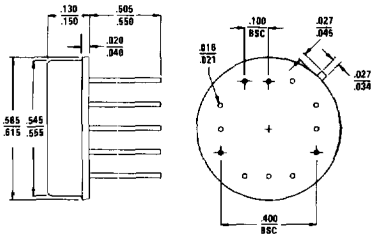


PAD MATERIAL: Type C
PAD FINISH: Type A
FINISH DIMENSION: Type A
PACKAGE MATERIAL: Ceramic, 90% Al_2O_3
PACKAGE SEAL:
- Material: Gold/Tin (80/20)
- Temperature: 320°C ± 10°C
- Method: Furnace Braze

INTERNAL LEAD WIRE:
- Material: Aluminum
- Diameter: 1.25 Mil
- Bonding Method: Ultrasonic

COMPLIANT OUTLINE: 38510 C-2

12 PIN TO-8 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

PACKAGE CASE VOLTAGE POTENTIAL: V-
COMPLIANT PACKAGE: None
PACKAGE USED: JEDEC 'AB'

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

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

HA-5190

DESIGN INFORMATION

Wideband, Fast Settling Operational Amplifier

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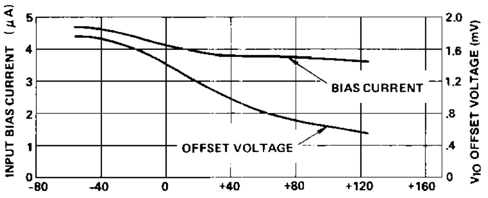
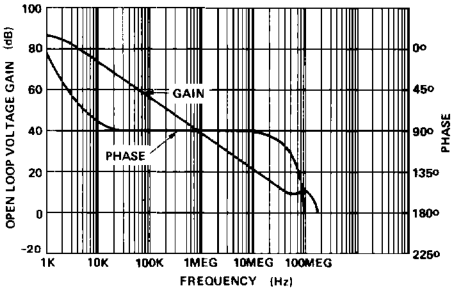
Typical Performance Curves Unless Otherwise Specified: $T_A = +25^oC$, $V_{SUPPLY} = \pm15V$

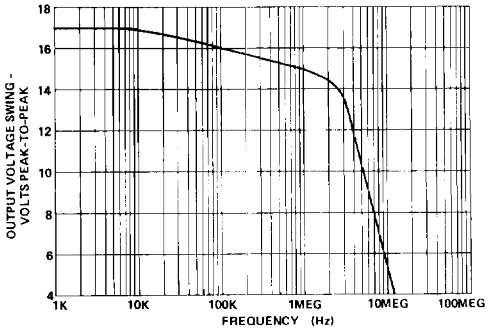
INPUT OFFSET VOLTAGE AND BIAS CURRENT vs. TEMPERATURE



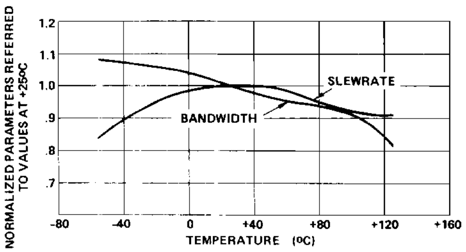
OPEN LOOP FREQUENCY RESPONSE



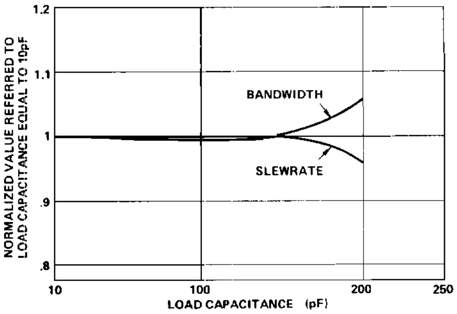
OUTPUT VOLTAGE SWING vs. FREQUENCY



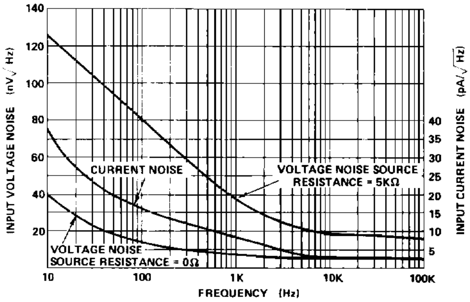
NORMALIZED AC PARAMETERS vs. TEMPERATURE



NORMALIZED AC PARAMETERS vs. LOAD CAPACITANCE



INPUT NOISE VOLTAGE AND NOISE CURRENT vs. FREQUENCY



(Also See Application Notes 525, 526, 556)

DESIGN INFORMATION (Continued)

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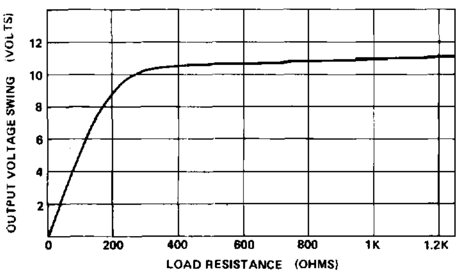
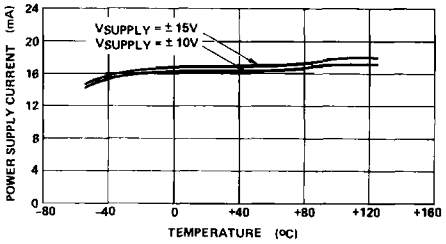
Typical Performance Curves Unless Otherwise Specified: $T_A = +25^oC$, $V_{SUPPLY} = \pm15V$

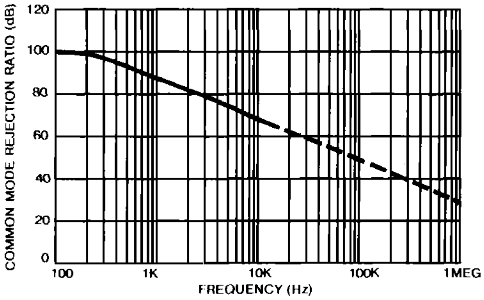
OUTPUT VOLTAGE SWING vs. LOAD RESISTANCE



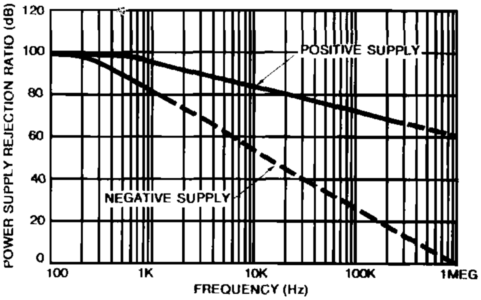
POWER SUPPLY CURRENT vs. TEMPERATURE



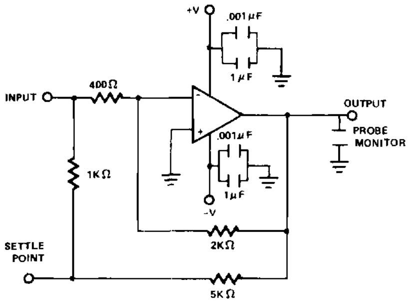
COMMON MODE REJECTION RATIO vs. FREQUENCY



POWER SUPPLY REJECTION RATIO vs. FREQUENCY

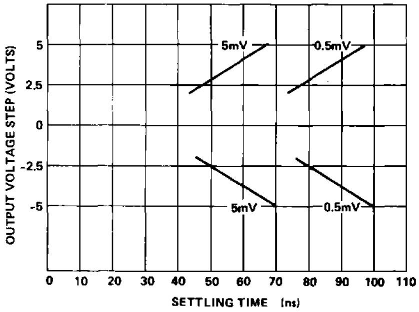


SETTLING TIME TEST CIRCUIT



- $A_V = -5$
- Load Capacitance should be less than 10pF.
- It is recommended that resistors be carbon composition and that feedback and summing network ratios be matched to 0.1%.
- Settle Point (Summing Node) capacitance should be less than 10pF. For optimum settling time results, it is recommended that the test circuit be constructed directly onto the device pins. A Tektronix 568 Sampling Oscilloscope with S-3A sampling heads is recommended as a settle point monitor.

SETTLING TIME FOR VARIOUS OUTPUT STEP VOLTAGES



DESIGN INFORMATION (Continued)

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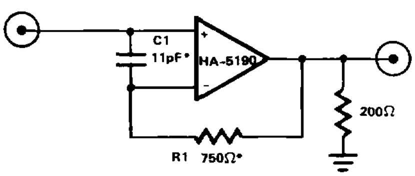
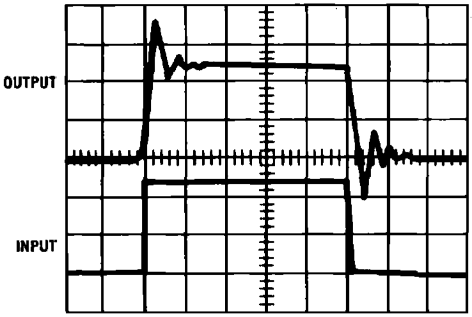
Typical Applications (Also see Application Notes 525 and 526)

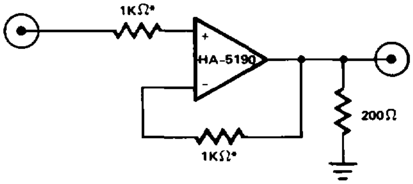
SUGGESTED COMPENSATION FOR UNITY GAIN STABILITY:

NONINVERTING

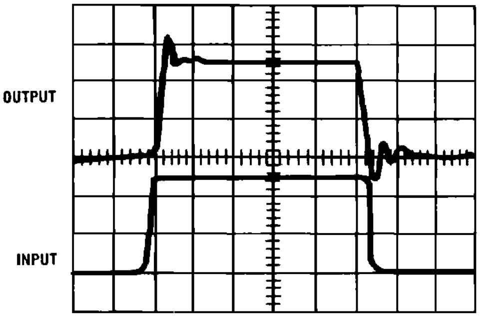


Vertical Scale: (Volts: 2V/Div.)
Horizontal Scale: (Time: 100ns/Div.)



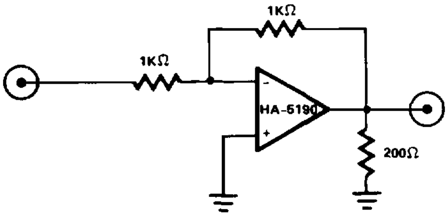


Vertical Scale: (Volts: 2V/Div.)
Horizontal Scale: (Time: 100ns/Div.)

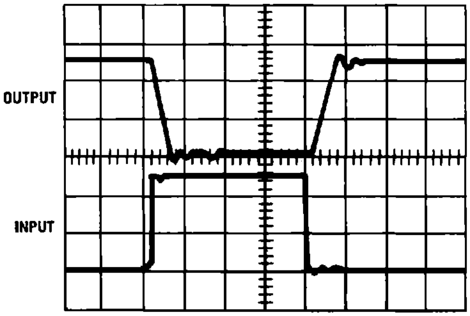


* Values were determined experimentally for optimum speed and settling time. R1 and C1 should be optimized for each particular application to ensure best overall frequency response.

INVERTING



Vertical Scale: (Volts: 2V/Div.)
Horizontal Scale: (Time: 50ns/Div.)



DESIGN INFORMATION (Continued)

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TYPICAL PERFORMANCE CHARACTERISTICS

Device Characterized at: Supply Voltage = ±15V, R_L = 200Ω, $C_L \leq$ 100pF, A_V = 5V/V, Unless Otherwise Specified.

PARAMETERS	CONDITIONS	TEMP	TYPICAL	DESIGN LIMIT	UNITS
Offset Voltage	V_{CM} = 0V	+25°C	3	Table 1	mV
Average Offset Voltage Drift	Versus Temperature	-55°C to +125°C	20	30	μV/°C
	Versus Time	+40°C	8	15	μV/Month
Bias Current		+25°C	5	Table 1	μA
Differential Input Resistance		+25°C	10	5	kΩ
Input Capacitance		+25°C	1	3	pF
Input Noise Voltage Density	f_O = 10Hz	+25°C	14	30	$nV/\sqrt{Hz}$
	f_O = 100Hz	+25°C	10	20	$nV/\sqrt{Hz}$
	f_O = 1kHz	+25°C	6	10	$nV/\sqrt{Hz}$
Input Noise Current Density	f_O = 10Hz	+25°C	35	60	$pA/\sqrt{Hz}$
	f_O = 100Hz	+25°C	10	30	$pA/\sqrt{Hz}$
	f_O = 1kHz	+25°C	5	15	$pA/\sqrt{Hz}$
Slew Rate	V_{OUT} = ±5V	+25°C	200	Table 2	V/μs
		-55°C to +125°C	125	110	V/μs
Full Power Bandwidth	V_{PEAK} = 10V	-55°C to +125°C	4	3.5	MHz
Settling Time	A_V = -5V/V, 5V Step to 0.1%	+25°C	70	130	ns
	A_V = -5V/V, 5V Step to 0.01%	+25°C	100	200	ns
	A_V = -5V/V, 2.5V Step to 0.1%	+25°C	50	110	ns
	A_V = -5V/V, 2.5V Step to 0.01%	+25°C	80	185	ns
Differential Gain Error	$f_O \leq$ 5MHz	+25°C	3	5	%
Differential Phase Error	$f_O \leq$ 5MHz	+25°C	1	2	Degree
Output Resistance	Open Loop	+25°C	30	Table 3	Ω
Supply Current	I_{OUT} = 0mA	-55°C to +125°C	19	Table 1	mA
Minimum Supply Voltage	Functional Operation Only. Other Parameters Will Vary.	+25°C	±5	±7	V

Applying the HA-5190

1. POWER SUPPLY DECOUPLING: Although not absolutely necessary, it is recommended that all power supply lines be decoupled with 0.01μF ceramic capacitors to ground. Decoupling capacitors should be located as near to the amplifier terminals as possible.
2. STABILITY CONSIDERATIONS: HA-5190 is stable at gains > 5. Gains ≤ 5 are covered elsewhere in this data sheet. Feedback resistors should be of carbon composition located as near to the input terminals as possible.
3. WIRING CONSIDERATIONS: Video pulse circuits should be built on a ground plane. Minimum point to point connections directly to the amplifier terminals should be used. When ground planes cannot be used, good single point grounding techniques should be applied.
4. OUTPUT SHORT CIRCUIT: HA-5190 does not have output short circuit protection. Short circuits to ground can be tolerated for approximately 10 seconds. Short circuits to either supply will result in immediate destruction of the device.
5. HEAVY CAPACITIVE LOADS: When driving heavy capacitive loads (≥ 100pF) a small resistor (≈ 100Ω) should be connected in series with the output and inside the feedback loop.
6. HEAT SINKING: Although not required for /883 qualification, heat sinking is suggested in high ambient conditions. Recommended heat sinks include thermalloy #2240A or #2268B for TO-8 Metal Can; AAVID #5602B for 14 pin Ceramic DIP. Heat sinking power density may be necessary depending on package used to maintain $T_J \leq$ +175°C.