HARRIS

HA-2539/883

Very High Slew Rate Wideband Operational Amplifier

January 1989

T-79-07-10

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 ..... 550V/µs (Min) 600V/µs (Typ)
- Open Loop Gain ..... 10K V/V (Min) 15K V/V (Typ)
- Wide Gain Bandwidth ..... 550MHz (Min) 600MHz (Typ)
- Full Power Bandwidth ..... 8.7MHz (Min) 9.5MHz (Typ)
- Low Offset Voltage ..... 10mV (Max)
- Input Voltage Noise @ 1kHz ..... $6nV/\sqrt{Hz}$ (Typ)
- Output Voltage Swing ..... ±10V (Min)

Applications

- Pulse and Video Amplifiers
- Wideband Amplifiers
- High Speed Sample and Hold Circuits
- RF Oscillators

Description

The Harris HA-2539/883 represents the ultimate in high slew rate wideband, monolithic, operational amplifiers. It has been designed and constructed with the Harris high frequency bipolar dielectric isolation process and features dynamic parameters never before available from a truly differential device.

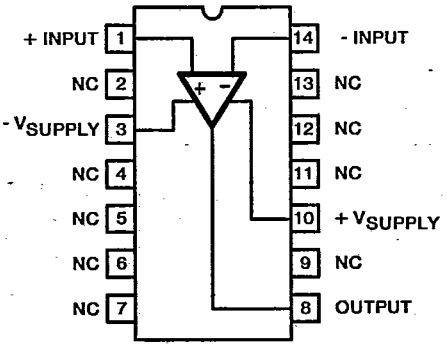
With a 600V/µs slew rate and a 600MHz gain bandwidth product, the HA-2539/883 is ideally suited for use in video and RF amplifier designs, in closed loop gains of 10 or greater. Full ±10V swing coupled with outstanding AC parameters and complemented by high open loop gain makes the device useful in high speed data acquisition systems.

The HA-2539/883 is available in the 14 pin Ceramic DIP and a 20 pin LCC package and is pin-for-pin functional with the Signetics NE5539. The HA-2539/883 operates over the -55°C to +125°C temperature range.

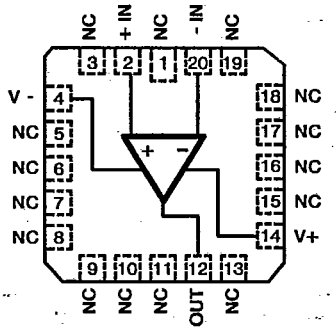
3 OP AMPs & COMPARATORS

Pinouts

HA1-2539/883 (CERAMIC DIP)
TOP VIEW



HA4-2539/883 (CERAMIC LCC)
TOP VIEW



Absolute Maximum Ratings

Voltage Between V+ and V- Terminals 35V
Differential Input Voltage 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

Package Power Dissipation Limit at +75°C For $T_J \leq 175°C$
Ceramic DIP Package 1.03W
Ceramic LCC Package 1.06W
Package Power Dissipation Derating Factor Above +75°C
Ceramic DIP Package ..... 10.2mW/°C
Ceramic LCC Package ..... 10.6mW/°C

Recommended Operating Conditions

Operating Temperature Range ..... -55°C to +125°C
Operating Supply Voltage ..... ±12V to ±15V
$V_{INCM} \leq 1/2 (V+ - V-)$
$R_L \geq 1k\Omega$

TABLE 1. D.C. ELECTRICAL PERFORMANCE CHARACTERISTICS

Device Tested at: Supply Voltage = ±15V, $R_{SOURCE} = 100\Omega$, $R_{LOAD} = 100k\Omega$, $V_{OUT} = 0V$, 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	-10	10	mV
			2,3	+125°C, -55°C	-15	15	mV
Input Bias Current	$+I_B$	$V_{CM} = 0V$ $+R_S = 1.1k\Omega$ $-R_S = 100\Omega$	1	+25°C	-20	20	µA
			2,3	+125°C, -55°C	-25	25	µA
	$-I_B$	$V_{CM} = 0V$ $+R_S = 100\Omega$ $-R_S = 1.1k\Omega$	1	+25°C	-20	20	µA
			2,3	+125°C, -55°C	-25	25	µA
Input Offset Current	I_{IO}	$V_{CM} = 0V$ $+R_S = 1.1k\Omega$ $-R_S = 1.1k\Omega$	1	+25°C	-6	6	µA
			2,3	+125°C, -55°C	-8	8	µA
Common Mode Range	+CMR	V+ = 5V V- = -25V	1	+25°C	10	-	V
			2,3	+125°C, -55°C	10	-	V
	-CMR	V+ = 25V V- = -5V	1	+25°C	-	-10	V
			2,3	+125°C, -55°C	-	-10	V
Large Signal Voltage Gain	$+A_{VOL}$	$V_{OUT} = 0V$ and $+10V$ $R_L = 1k\Omega$	4	+25°C	10	-	kV/V
			5,6	+125°C, -55°C	5	-	kV/V
	$-A_{VOL}$	$V_{OUT} = 0V$ and $-10V$ $R_L = 1k\Omega$	4	+25°C	10	-	kV/V
			5,6	+125°C, -55°C	5	-	kV/V
Common Mode Rejection Ratio	+CMRR	$\Delta V_{CM} = +10V$ +V = +5V -V = -25V $V_{OUT} = -10V$	1	+25°C	60	-	dB
			2,3	+125°C, -55°C	60	-	dB
	-CMRR	$\Delta V_{CM} = -10V$ +V = +25V -V = -5V $V_{OUT} = +10V$	1	+25°C	60	-	dB
			2,3	+125°C, -55°C	60	-	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} = 100Ω, R_{LOAD} = 100kΩ, V_{OUT} = 0V, Unless Otherwise Specified.

D.C. PARAMETERS	SYMBOL	CONDITIONS	GROUP A SUBGROUP	TEMPERATURE	LIMITS MIN	LIMITS MAX	UNITS
Output Voltage Swing	$+V_{OUT}$	R_L = 1kΩ	1	+25°C	10	-	V
			2,3	+125°C,-55°C	10	-	V
	$-V_{OUT}$	R_L = 1kΩ	1	+25°C	-	-10	V
			2,3	+125°C,-55°C	-	-10	V
Output Current	$+I_{OUT}$	V_{OUT} = -10V	1	+25°C	10	-	mA
	$-I_{OUT}$	V_{OUT} = +10V	1	+25°C	-	-10	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 = +5V, -V = -15V, +V = +15V, -V = -15V	1	+25°C	60	-	dB
			2,3	+125°C,-55°C	60	-	dB
	-PSRR	ΔV_{SUP} = 10V, +V = +15V, -V = -5V, +V = +15V, -V = -15V	1	+25°C	60	-	dB
			2,3	+125°C,-55°C	60	-	dB

TABLE 2. A.C. ELECTRICAL PERFORMANCE CHARACTERISTICS

Table 2 Intentionally Left Blank. See A.C. Specifications on Table 3.

TABLE 3. ELECTRICAL PERFORMANCE CHARACTERISTICS

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

PARAMETERS	SYMBOL	CONDITIONS	NOTES	TEMPERATURE	LIMITS MIN	LIMITS MAX	UNITS
Gain Bandwidth Product	GBWP	V_O = 100mV, f_O = 1MHz	1	+25°C	550	-	MHz
		V_O = 100mV, f_O = 60MHz	1	+25°C	600	-	MHz
Slew Rate	+SR	V_{OUT} = -5V to +5V	1	+25°C	550	-	V/µs
	-SR	V_{OUT} = +5V to -5V	1	+25°C	550	-	V/µs
Full Power Bandwidth	FPBW	V_{PEAK} = 10V	1, 2	+25°C	8.7	-	MHz
Minimum Closed Loop Stable Gain	CLSG	R_L = 1kΩ, $C_L \leq$ 10pF	1	-55°C to +125°C	10	-	V/V
Rise & Fall Time	T_R	V_{OUT} = 0V to +200mV	1, 4	+25°C	-	10	ns
	T_F	V_{OUT} = 0V to -200mV	1, 4	+25°C	-	10	ns
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

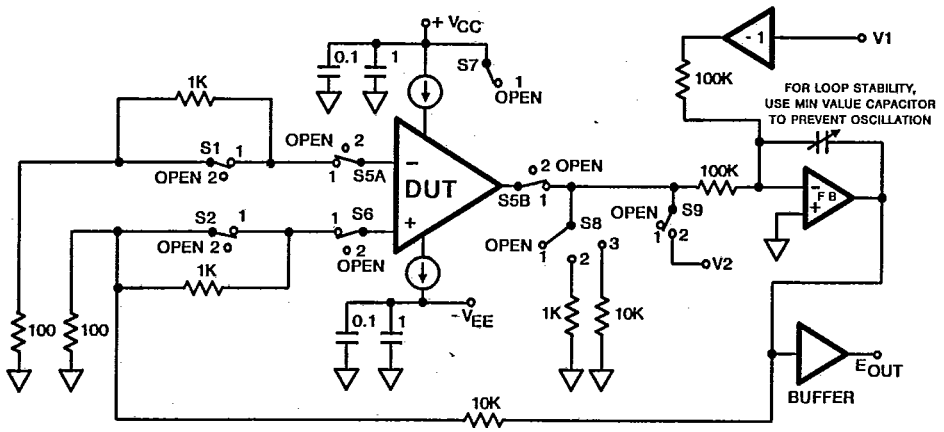
NOTES:
1. Parameters listed in Table 3 are controlled via design or process parameters and are not directly tested at final production. These parameters are lab characterized upon initial design release, or upon design changes. These parameters are guaranteed by characterization based upon data from 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.)
4. Measured between 10% and 90% points.

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
Group A Test Requirements	1, 2, 3, 4, 5, 6
Groups C & D Endpoints	1

* PDA applies to Subgroup 1 only.

Test Circuit (Applies to Table 1)

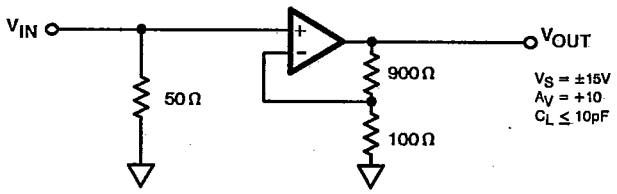


ALL RESISTORS = ± 1% (Ω)
ALL CAPACITORS = ± 10% (μF)

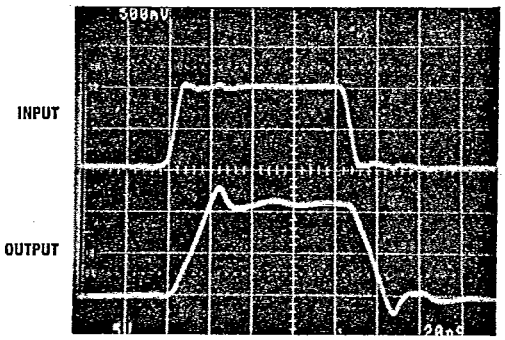
For Detailed Information, Refer to HA-2539/883 Test Tech Brief

Test Waveforms

SIMPLIFIED TEST CIRCUIT FOR LARGE AND SMALL SIGNAL RESPONSE (Applies to Table 3)

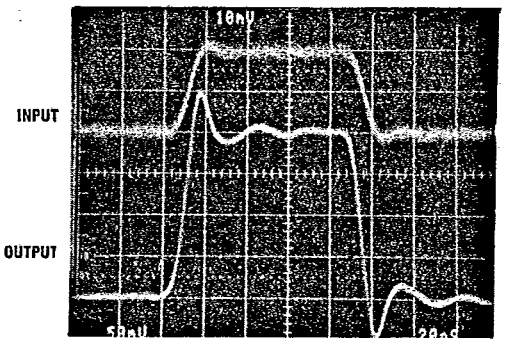


MEASURED LARGE SIGNAL RESPONSE
Vertical Scale: Input = 500mV/Div., Output = 5V/Div.
Horizontal Scale: Time: 20ns/Div.



AV = +10V/V, RL = 1kΩ

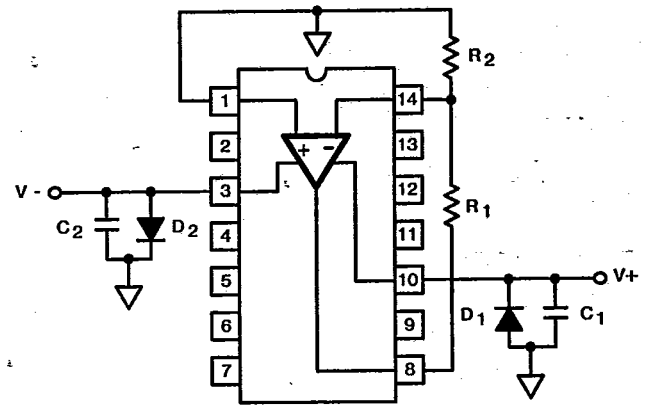
MEASURED SMALL SIGNAL RESPONSE
Vertical Scale: Input = 10mV/Div., Output = 50mV/Div.
Horizontal Scale: 20ns/Div.



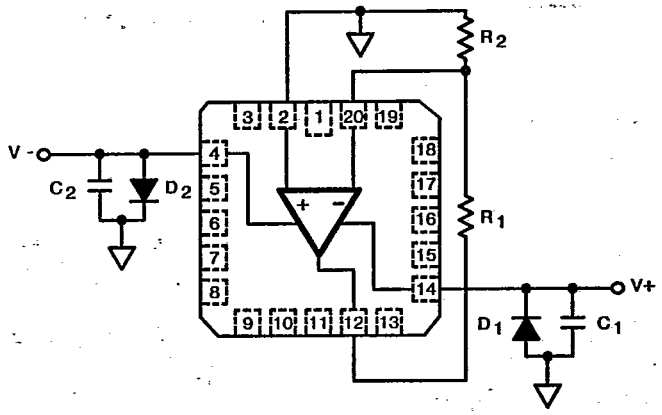
AV = +10V/V, RL = 1kΩ

Burn-In Circuits

HA1-2539/883 CERAMIC DIP

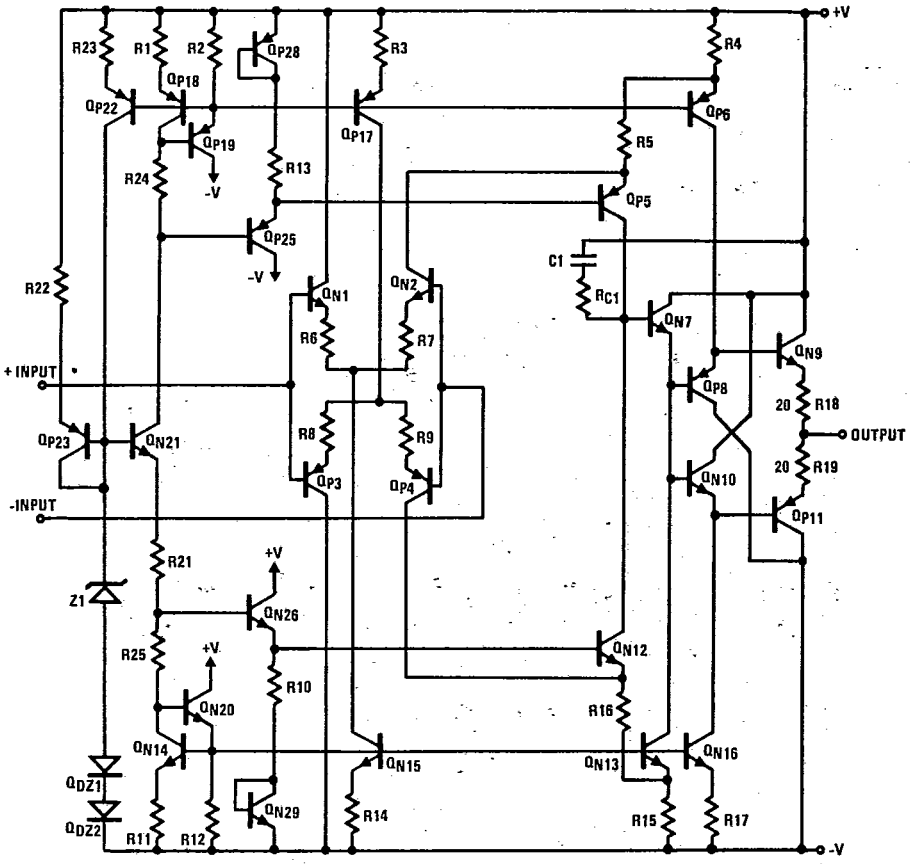


HA4-2539/883 CERAMIC LCC



NOTES:
R_1 = 10kΩ, ±5%, 1/4W (Min)
R_2 = 1kΩ, ±5%, 1/4W (Min)
$C_1 = C_2$ = 0.01µF/Socket (Min) or 0.1µF/Row, (Min)
$D_1 = D_2$ = IN4002 or Equivalent/Board
$|(V+) - (V-)| = 30V$

Schematic Diagram



3 OP AMPs & COMPARATORS

T-79-07-10

Die Characteristics

DIE DIMENSIONS:
75.2 x 61 x 19 mils
(1910 x 1550 x 483 µm)

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

WORST CASE CURRENT DENSITY:
$2 \times 10^5 A/cm^2$ @ 11mA

SUBSTRATE POTENTIAL (POWERED UP): V-

GLASSIVATION:
Type: Nitride over Silox
Silox Thickness: 12kÅ ± 2kÅ
Nitride Thickness: 3.5kÅ ± 1kÅ

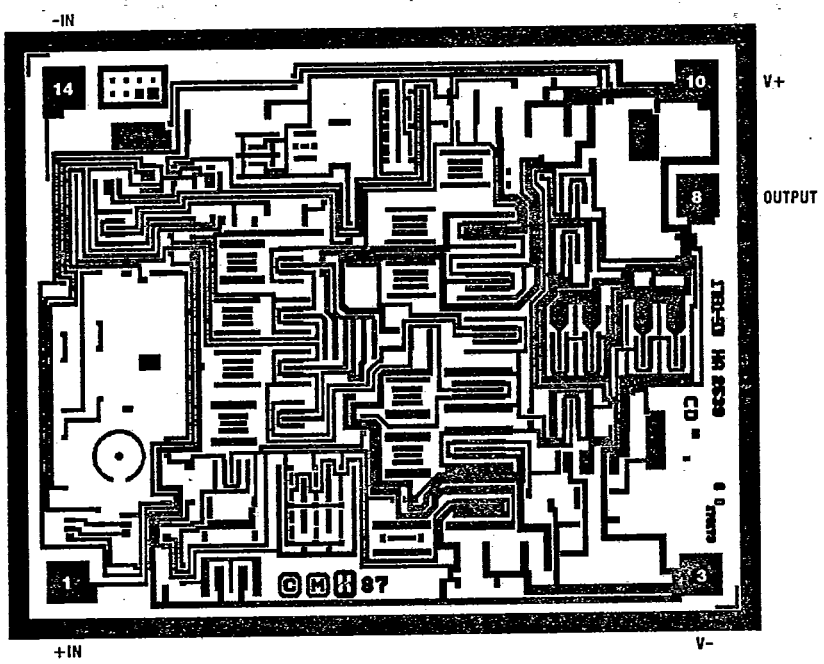
TRANSISTOR COUNT: 30

PROCESS: High Frequency Bipolar Dielectric Isolation

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

Metallization Mask Layout

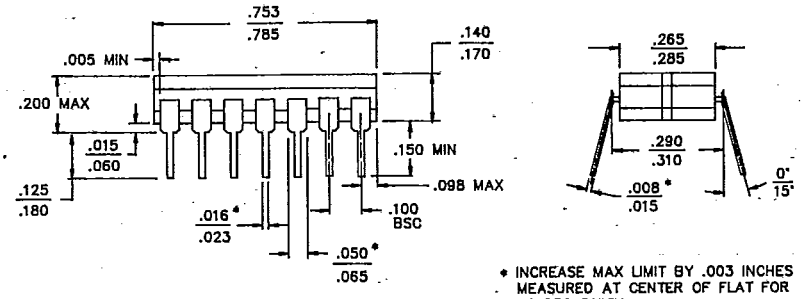
HA-2539/883



NOTE: Pin Numbers Correspond to 14 Pin DIP Package Only.

Packaging†

14 PIN CERAMIC DIP

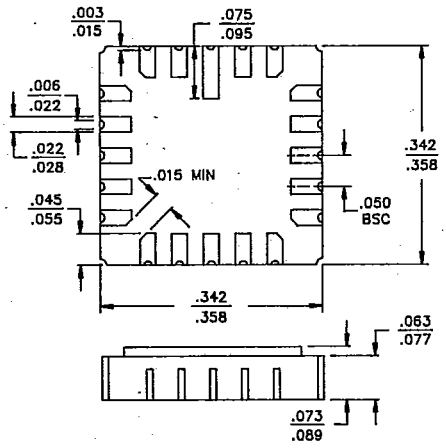


* INCREASE MAX LIMIT BY .003 INCHES MEASURED AT CENTER OF FLAT FOR SOLDER FINISH

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: Multilayer Ceramic, 90% Alumina
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

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

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

HA-2539

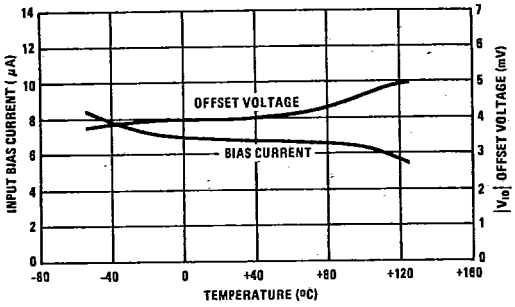
DESIGN INFORMATION

Very High Slew Rate Wideband Operational Amplifier

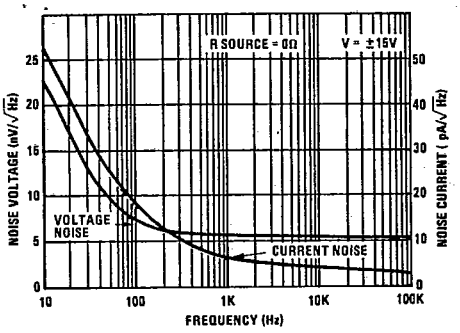
The information contained in this section has been developed through characterization by Harris Semiconductor and is for use as application and design aid only. These characteristics are not 100% tested and no product guarantee is implied.

Typical Performance Curves Unless Otherwise Specified: T_A = +25°C, V_{SUPPLY} = ±15V

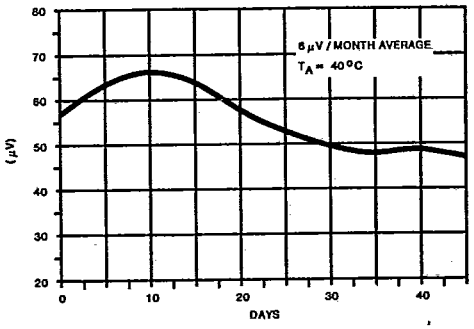
INPUT OFFSET VOLTAGE AND BIAS CURRENT vs. TEMPERATURE



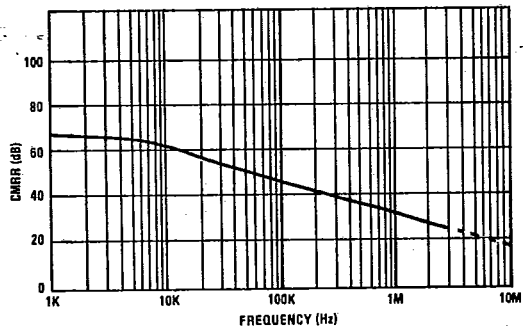
INPUT NOISE VOLTAGE AND NOISE CURRENT vs. FREQUENCY



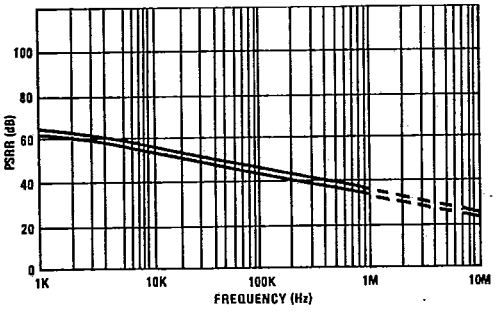
HA-2539 OFFSET VOLTAGE DRIFT vs. TIME



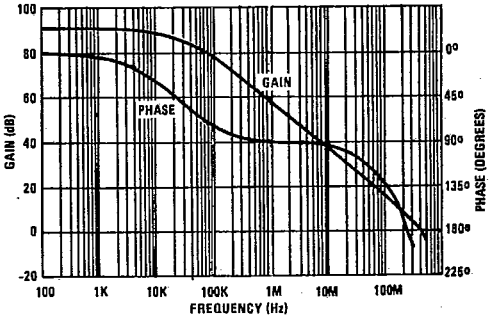
COMMON MODE REJECTION RATIO vs. FREQUENCY



POWER SUPPLY REJECTION RATIO vs. FREQUENCY



OPEN LOOP GAIN/PHASE vs. FREQUENCY HA-2539

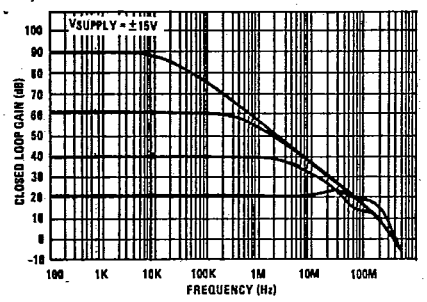


DESIGN INFORMATION (Continued)

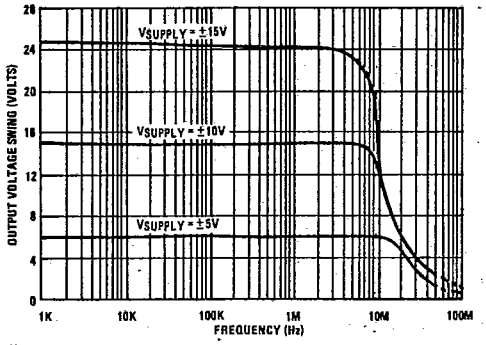
The information contained in this section has been developed through characterization by Harris Semiconductor and is for use as application and design aid only. These characteristics are not 100% tested and no product guarantee is implied.

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

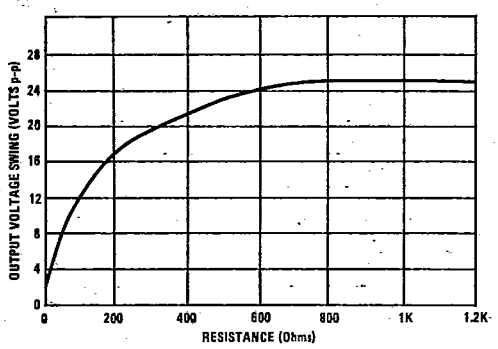
CLOSED LOOP FREQUENCY RESPONSE FOR VARIOUS CLOSED LOOP GAINS



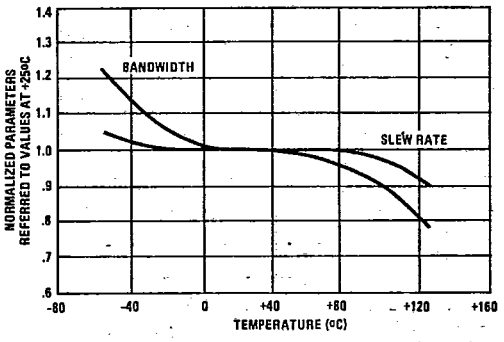
OUTPUT VOLTAGE SWING vs. FREQUENCY



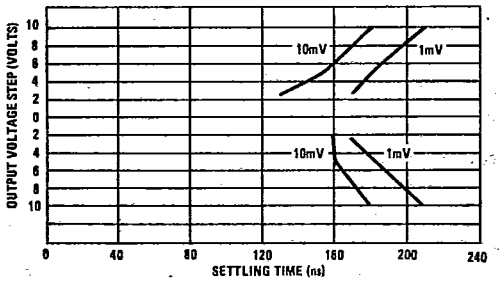
OUTPUT VOLTAGE SWING vs. LOAD RESISTANCE



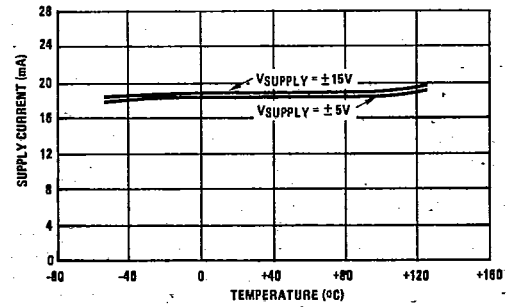
NORMALIZED AC PARAMETERS vs. TEMPERATURE



SETTLING TIME FOR VARIOUS OUTPUT STEP VOLTAGES



POWER SUPPLY CURRENT vs. TEMPERATURE AND SUPPLY VOLTAGE



3 OP AMPs & COMPARATORS

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: Supply Voltage = ±15V, R_L = 1kΩ, $C_L \leq$ 10pF, A_V = 10V/V, Unless Otherwise Specified.

PARAMETERS	CONDITIONS	TEMP	TYPICAL	DESIGN LIMIT	UNITS
Offset Voltage	V_{CM} = 0V	+25°C	8	Table 1	mV
Average Offset Voltage Drift	Versus Temperature	-55°C to +125°C	20	30	µV/°C
	Versus Time	+40°C	6	12	µV/Month
Bias Current	V_{CM} = 0V	+25°C	6	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	22	40	$nV/\sqrt{Hz}$
	f_O = 100Hz	+25°C	8	20	$nV/\sqrt{Hz}$
	f_O = 1kHz	+25°C	6	15	$nV/\sqrt{Hz}$
Input Noise Current Density	f_O = 10Hz	+25°C	50	80	$pA/\sqrt{Hz}$
	f_O = 100Hz	+25°C	20	30	$pA/\sqrt{Hz}$
	f_O = 1kHz	+25°C	6	10	$pA/\sqrt{Hz}$
Broadband Noise	0.1Hz to 1MHz	+25°C	50	75	μV_{p-p}
Slew Rate	V_{OUT} = ±5V	+25°C	600	Table 3	V/µs
		-55°C to +125°C	450	425	V/µs
Full Power Bandwidth	V_{PEAK} = 10V	+25°C	9.5	Table 3	MHz
		-55°C to +125°C	7.2	6.7	MHz
Settling Time	A_V = -10V/V, 10V to 0.1%	+25°C	180	250	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

Application Information

When using the HA-2539 for high frequency performance, care must be given in the system's design to optimize this component's use. High frequency layout techniques, ground planning, supply decoupling, and short lead lengths will help eliminate unwanted parasitic effects. A suggested component's choice for the feedback and input resistor is to keep their valve as small as possible, preferably less than 1kΩ. Capacitive loading, which cause a loss of phase margin can be increased by adding series resistance in the output path. Closed loop gain of less than 10 should not be designed due also to a loss of phase margin. If circuits must be designed in lower gains, inverting methods are recommended. Output saturation to the -V rail which may cause regeneration or oscillation during saturation, should also be avoided.

For other application suggestions, please refer to Application Note 541 which includes methods for DC error reductions, frequency compensation, higher output current and voltage circuits and other high frequency circuits.

Heat Sinking

Although not required for compliancy of /883, heat sinking is suggested in high ambient conditions (> 75°C). Suggested models include thermalloy model 6007 or AAVID model 5602B. Junction temperature should be maintained below +175°C. Further information is provided in Application Note 556, and proper thermal resistance values are provided in the thermal information section.