

January 1989

## Video 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.
- Wide Unity Gain Bandwidth ..... 45MHz (Min)
- High Slew Rate ..... 100V/ $\mu$ s (Min)
- Low Supply Current ..... 12mA (Max)
- Differential Gain Error ..... 0.04dB (Max)
- Differential Phase Error ..... 0.11% (Max)
- Gain Tolerance @ 3.58MHz or 4.43MHz ..... 0.15dB (Max)
- Fast Settling Time (10V to 0.1%) ..... 120ns (Typ)

### Applications

- Video Systems
- Video Test Equipment
- Radar Displays
- Imaging Systems
- Pulse Amplifiers
- Signal Conditioning Circuits
- Data Acquisition Systems

### Description

The HA-2544/883 is a fast, unity gain stable, monolithic op amp designed to meet the needs required for accurate reproduction of video or high speed signals. It offers high voltage gain (3.5kV/V min, 6kV/V typ), wide unity gain bandwidth of 45MHz minimum and phase margin of 65 degrees (open loop). Built from high quality Dielectric Isolation, the HA-2544/883 is another addition to the Harris series of high speed, wideband op amps, and offers true video performance combined with the versatility of an op amp.

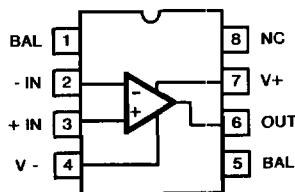
The primary features of the HA-2544/883, include wide bandwidth, 150V/ $\mu$ s (typ) slew rate, < 0.05dB differential gain error, < 0.11 degrees differential phase error and gain tolerance of just 0.15dB at 3.58 MHz and 4.43MHz, therefore proving to be sufficient for video amplification. High performance and low power requirements are met with a supply current of only 10mA typically and 12mA over the full temperature range.

Uses of the HA-2544/883 range from video test equipment guidance systems, radar displays and other precise imaging systems where stringent gain and phase requirements have previously been met with costly hybrids and discrete circuitry. The HA-2544/883 will also be used in non-video systems requiring high speed signal conditioning such as data acquisition systems, medical electronics, specialized instrumentation and communication systems.

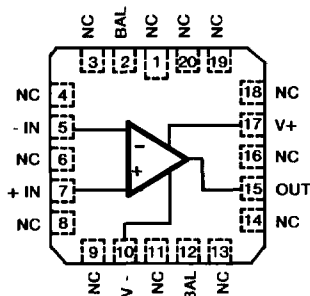
The HA-2544/883 is guaranteed over the military range of -55°C to +125°C and is offered in the 8 pin TO-99 Metal Can and Ceramic Mini-DIP or the 20 pad LCC.

### Pinouts

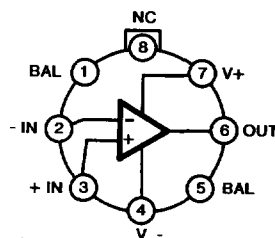
HA1-2544/883 (CERAMIC DIP)  
TOP VIEW



HA4-2544/883 (CERAMIC LCC)  
TOP VIEW



HA2-2544/883 (METAL CAN)  
TOP VIEW



Case tied to V-

### Absolute Maximum Ratings

|                                        |                 |
|----------------------------------------|-----------------|
| Voltage Between V+ and V- Terminals    | 33V             |
| Differential Input Voltage (Note 8)    | 6V              |
| Voltage at Either Input Terminal       | V+ to V-        |
| Peak Output Current (< 10% Duty Cycle) | 40mA            |
| Junction Temperature (T <sub>J</sub> ) | +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                                                  | $\theta_{ja}$ | $\theta_{jc}$ |
|---------------------------------------------------------------------|---------------|---------------|
| Ceramic DIP Package                                                 | 129°C/W       | 47°C/W        |
| Ceramic LCC Package                                                 | 92°C/W        | 32°C/W        |
| Metal Can Package                                                   | 116°C/W       | 35°C/W        |
| Package Power Dissipation Limit at +75°C For T <sub>J</sub> ≤ 175°C |               |               |
| Ceramic DIP Package                                                 | 780mW         |               |
| Ceramic LCC Package                                                 | 1.1W          |               |
| Metal Can Package                                                   | 860mW         |               |
| Package Power Dissipation Derating Factor Above +75°C               |               |               |
| Ceramic DIP Package                                                 | 7.8mW/°C      |               |
| Ceramic LCC Package                                                 | 11mW/°C       |               |
| Metal Can Package                                                   | 8.6mW/°C      |               |

### Recommended Operating Conditions

|                             |                 |                                   |
|-----------------------------|-----------------|-----------------------------------|
| Operating Temperature Range | -55°C to +125°C | V <sub>INcm</sub> ≤ 1/2 (V+ - V-) |
| Operating Supply Voltage    | ±12V to ±15V    | R <sub>L</sub> ≥ 1kΩ              |

TABLE 1. D.C. ELECTRICAL PERFORMANCE CHARACTERISTICS

Device Tested at: Supply Voltage = ±15V, R<sub>SOURCE</sub> = 10Ω, R<sub>LOAD</sub> = 500kΩ, C<sub>LOAD</sub> ≤ 10pF, V<sub>OUT</sub> = 0V, Unless Otherwise Specified.

| D.C. PARAMETERS             | SYMBOL            | CONDITIONS                                                                  | GROUP A SUBGROUP | TEMPERATURE   | LIMITS |     | UNITS |
|-----------------------------|-------------------|-----------------------------------------------------------------------------|------------------|---------------|--------|-----|-------|
|                             |                   |                                                                             |                  |               | MIN    | MAX |       |
| Input Offset Voltage        | V <sub>IO</sub>   | V <sub>CM</sub> = 0V                                                        | 1                | +25°C         | -15    | 15  | mV    |
|                             |                   |                                                                             | 2, 3             | +125°C, -55°C | -20    | 20  | mV    |
| Input Bias Current          | +I <sub>B</sub>   | V <sub>CM</sub> = 0V<br>+R <sub>S</sub> = 1kΩ<br>-R <sub>S</sub> = 10Ω      | 1                | +25°C         | -15    | 15  | μA    |
|                             |                   |                                                                             | 2, 3             | +125°C, -55°C | -20    | 20  | μA    |
|                             | -I <sub>B</sub>   | V <sub>CM</sub> = 0V<br>+R <sub>S</sub> = 10Ω<br>-R <sub>S</sub> = 1kΩ      | 1                | +25°C         | -15    | 15  | μA    |
|                             |                   |                                                                             | 2, 3             | +125°C, -55°C | -20    | 20  | μA    |
| Input Offset Current        | I <sub>IO</sub>   | V <sub>CM</sub> = 0V<br>+R <sub>S</sub> = 1kΩ<br>-R <sub>S</sub> = 1kΩ      | 1                | +25°C         | -2     | 2   | μA    |
|                             |                   |                                                                             | 2, 3             | +125°C, -55°C | -3     | 3   | μA    |
| Common Mode Range           | +CMR              | V+ = 5V<br>V- = -25V                                                        | 1                | +25°C         | 10     | -   | V     |
|                             |                   |                                                                             | 2, 3             | +125°C, -55°C | 10     | -   | V     |
|                             | -CMR              | V+ = 25V<br>V- = -5V                                                        | 1                | +25°C         | -      | -10 | V     |
|                             |                   |                                                                             | 2, 3             | +125°C, -55°C | -      | -10 | V     |
| Large Signal Voltage Gain   | +A <sub>VOL</sub> | V <sub>OUT</sub> = 0V and +10V<br>R <sub>L</sub> = 1kΩ                      | 4                | +25°C         | 3.5    | -   | kV/V  |
|                             |                   |                                                                             | 5, 6             | +125°C, -55°C | 2.5    | -   | kV/V  |
|                             | -A <sub>VOL</sub> | V <sub>OUT</sub> = 0V and -10V<br>R <sub>L</sub> = 1kΩ                      | 4                | +25°C         | 3.5    | -   | kV/V  |
|                             |                   |                                                                             | 5, 6             | +125°C, -55°C | 2.5    | -   | kV/V  |
| Common Mode Rejection Ratio | +CMRR             | ΔV <sub>CM</sub> = +10V<br>+V = +5V<br>-V = -25V<br>V <sub>OUT</sub> = -10V | 1                | +25°C         | 75     | -   | dB    |
|                             |                   |                                                                             | 2, 3             | +125°C, -55°C | 75     | -   | dB    |
|                             | -CMRR             | ΔV <sub>CM</sub> = -10V<br>+V = +25V<br>-V = -5V<br>V <sub>OUT</sub> = +10V | 1                | +25°C         | 75     | -   | dB    |
|                             |                   |                                                                             | 2, 3             | +125°C, -55°C | 75     | -   | 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 =  $\pm 15\text{V}$ ,  $R_{\text{SOURCE}} = 10\Omega$ ,  $R_{\text{LOAD}} = 500\text{k}\Omega$ ,  $C_{\text{LOAD}} \leq 10\text{pF}$ ,  $V_{\text{OUT}} = 0\text{V}$ ,  
Unless Otherwise Specified.

| D.C. PARAMETERS                   | SYMBOL              | CONDITIONS                                                                           | GROUP A<br>SUBGROUP | TEMPERATURE   | LIMITS             |     | UNITS |
|-----------------------------------|---------------------|--------------------------------------------------------------------------------------|---------------------|---------------|--------------------|-----|-------|
|                                   |                     |                                                                                      |                     |               | MIN                | MAX |       |
| Output Voltage Swing              | +V <sub>OUT</sub>   | R <sub>L</sub> = 1k $\Omega$                                                         | 1                   | +25°C         | 10                 | -   | V     |
|                                   |                     |                                                                                      | 2, 3                | +125°C, -55°C | 10                 | -   | V     |
|                                   | -V <sub>OUT</sub>   | R <sub>L</sub> = 1k $\Omega$                                                         | 1                   | +25°C         | -                  | -10 | V     |
|                                   |                     |                                                                                      | 2, 3                | +125°C, -55°C | -                  | -10 | V     |
| Output Current                    | +I <sub>OUT</sub>   | V <sub>OUT</sub> = -10V                                                              | 1                   | +25°C         | 25                 | -   | mA    |
|                                   | -I <sub>OUT</sub>   | V <sub>OUT</sub> = +10V                                                              | 1                   | +25°C         | -                  | -25 | mA    |
| Quiescent Power<br>Supply Current | +I <sub>CC</sub>    | V <sub>OUT</sub> = 0V<br>I <sub>OUT</sub> = 0mA                                      | 1                   | +25°C         | -                  | 12  | mA    |
|                                   |                     |                                                                                      | 2, 3                | +125°C, -55°C | -                  | 12  | mA    |
|                                   | -I <sub>CC</sub>    | V <sub>OUT</sub> = 0V<br>I <sub>OUT</sub> = 0mA                                      | 1                   | +25°C         | -12                | -   | mA    |
|                                   |                     |                                                                                      | 2, 3                | +125°C, -55°C | -12                | -   | mA    |
| Power Supply<br>Rejection Ratio   | +PSRR               | $\Delta V_{\text{SUP}} = 10\text{V}$<br>+V = +10V, -V = -15V<br>+V = +20V, -V = -15V | 1                   | +25°C         | 70                 | -   | dB    |
|                                   |                     |                                                                                      | 2, 3                | +125°C, -55°C | 70                 | -   | dB    |
|                                   | -PSRR               | $\Delta V_{\text{SUP}} = 10\text{V}$<br>+V = +15V, -V = -10V<br>+V = +15V, -V = -20V | 1                   | +25°C         | 70                 | -   | dB    |
|                                   |                     |                                                                                      | 2, 3                | +125°C, -55°C | 70                 | -   | dB    |
| Offset Voltage<br>Adjustment      | +V <sub>IOAdj</sub> | Note 6                                                                               | 1                   | +25°C         | V <sub>IO</sub> -1 | -   | mV    |
|                                   | -V <sub>IOAdj</sub> | Note 6                                                                               | 1                   | +25°C         | V <sub>IO</sub> +1 | -   | mV    |

TABLE 2. A.C. ELECTRICAL PERFORMANCE CHARACTERISTICS

Device Tested at: Supply Voltage =  $\pm 15\text{V}$ ,  $R_{\text{SOURCE}} = 100\Omega$ ,  $R_{\text{LOAD}} = 1\text{k}\Omega$ ,  $C_{\text{LOAD}} \leq 10\text{pF}$ ,  $V_{\text{OUT}} = 1\text{V/V}$ ,  
Unless Otherwise Specified.

| D.C. PARAMETERS | SYMBOL | CONDITIONS                    | GROUP A<br>SUBGROUP | TEMPERATURE | LIMITS |     | UNITS            |
|-----------------|--------|-------------------------------|---------------------|-------------|--------|-----|------------------|
|                 |        |                               |                     |             | MIN    | MAX |                  |
| Slew Rate       | +SR    | V <sub>OUT</sub> = -3V to +3V | 7                   | +25°C       | 100    | -   | V/ $\mu\text{s}$ |
|                 | -SR    | V <sub>OUT</sub> = +3V to -3V | 7                   | +25°C       | 100    | -   | V/ $\mu\text{s}$ |

TABLE 3. ELECTRICAL PERFORMANCE CHARACTERISTICS

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

| PARAMETERS                      | SYMBOL          | CONDITIONS                                                           | NOTES             | TEMPERATURE     | LIMITS |      | UNITS    |
|---------------------------------|-----------------|----------------------------------------------------------------------|-------------------|-----------------|--------|------|----------|
|                                 |                 |                                                                      |                   |                 | MIN    | MAX  |          |
| Differential Gain               | dA <sub>V</sub> | $R_S = 50\Omega$ , $R_L = 1k\Omega$<br>$f_o = 3.58MHz$ and $4.43MHz$ | 1, 5, 7,<br>9, 11 | +25°C           | -      | 0.04 | dB       |
| Differential Phase              | d $\phi$        | $R_S = 50\Omega$ , $R_L = 1k\Omega$<br>$f_o = 3.58MHz$ and $4.43MHz$ | 1, 5,<br>7, 9     | +25°C           | -      | 0.11 | Degrees  |
| Unity Gain Bandwidth            | UGBW            | $V_O = 200mV_{RMS}$ , $f @ -3dB$                                     | 1, 5              | +25°C           | 45     | -    | MHz      |
| Gain Tolerance                  | $\Delta A_V$    | $V_O = 200mV_{RMS}$ , $f_o = 5MHz$                                   | 1, 5, 7           | +25°C           | -0.15  | 0.15 | dB       |
|                                 |                 | $V_O = 200mV_{RMS}$ , $f_o = 10MHz$                                  | 1, 5, 7           | +25°C           | -0.35  | 0.35 | dB       |
| Full Power Bandwidth            | FPBW            | $V_{PEAK} = 1V$                                                      | 1, 2              | +25°C           | 15.9   | -    | MHz      |
|                                 |                 | $V_{PEAK} = 5V$                                                      | 1, 2              | +25°C           | 3.2    | -    | MHz      |
| Minimum Closed Loop Stable Gain | CLSG            | $R_L = 1k\Omega$ , $C_L \leq 1pF$                                    | 1, 5              | -55°C to +125°C | 1      | -    | V/V      |
| Rise & Fall Time                | $T_R$           | $V_{OUT} = 0V$ to +200mV                                             | 1, 4              | +25°C           | -      | 15   | ns       |
|                                 | $T_F$           | $V_{OUT} = 0V$ to -200mV                                             | 1, 4              | +25°C           | -      | 15   | ns       |
| Overshoot                       | +OS             | $V_{OUT} = 0V$ to +200mV                                             | 1                 | +25°C           | -      | 20   | %        |
|                                 | -OS             | $V_{OUT} = 0V$ to -200mV                                             | 1                 | +25°C           | -      | 20   | %        |
| Settling Time                   | $T_S$           | To 0.1% for a 10V Step                                               | 1                 | +25°C           | -      | 150  | ns       |
| Output Resistance               | $R_{OUT}$       | Open Loop                                                            | 1                 | +25°C           | -      | 40   | $\Omega$ |
| Quiescent Power Consumption     | PC              | $V_{OUT} = 0V$ , $I_{OUT} = 0mA$                                     | 1, 3              | -55°C to +125°C | -      | 360  | 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. Quiescent Power Consumption based upon Quiescent Supply Current test maximum. (No load on outputs.)

4. Measured between 10% and 90% points.

5. Sample tested on every lot.

6. Offset adjustment range is  $[V_{IO}(\text{Measured}) \pm 1mV]$  minimum referred to output. This test is for functionality only to assure adjustment through 0V.

7. The video parameter specifications will degrade as the output load resistance decreases.

8. To achieve optimum AC performance, the input stage was designed without protective diode clamps. Exceeding the maximum differential input voltage results in reverse breakdown to the base-emitter junction of the input transistors and probable degradation of the input parameters especially  $V_{OS}$ ,  $I_{OS}$  and Noise.

9. Test signal used is  $200mV_{RMS}$  at each frequency on a 0 and 1 volt offset. For adequate test repeatability, a minimum warm-up of 2 minutes is suggested.

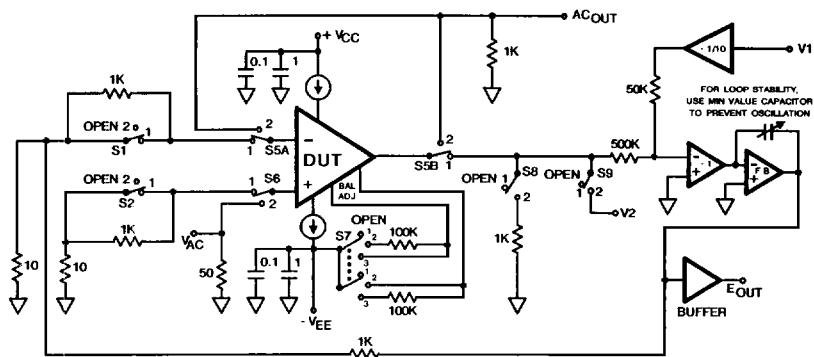
10. C-L Gain and C-L Delay was less than the resolution to the test equipment used which is 0.1dB and 7ns, respectively.

$$11. A_D(\%) = \left[ 10^{\frac{A_D(\text{dB})}{20}} - 1 \right] \times 100$$

TABLE 4. ELECTRICAL TEST REQUIREMENTS

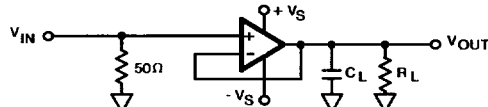
| MIL-STD-883 TEST REQUIREMENTS               | SUBGROUPS (SEE TABLES 1 & 2) |
|---------------------------------------------|------------------------------|
| Interim Electrical Parameters (Pre Burn-in) | 1                            |
| Final Electrical Test Parameters            | 1*, 2, 3, 4, 5, 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 =  $\pm 1\%$  ( $\Omega$ )  
ALL CAPACITORS =  $\pm 10\%$  ( $\mu$ F)

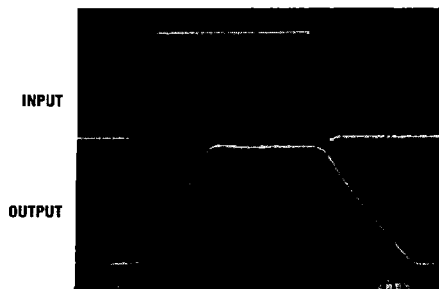
For Detailed Information, Refer to HA-2544/883 Test Tech Brief

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

$V_S = \pm 15V$ ,  $A_V = +1$   
 $R_L = 1k\Omega$ ,  $C_L \leq 10pF$   
 $V_{IN}$  for Large Signal =  $\pm 3V$ ,  
 $V_{IN}$  for Small Signal = 0 to  
 $+200mV$  and 0 to  $-200mV$

**MEASURED LARGE SIGNAL RESPONSE**

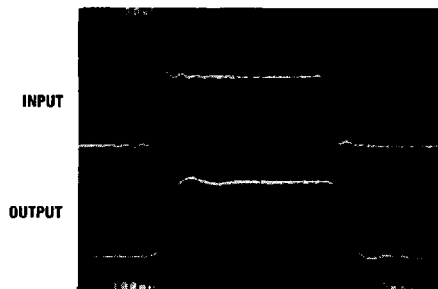
Vertical Scale: (2V/Div.)  
Horizontal Scale: Time: 20ns/Div.



$A_V = +1V/V$ ,  $R_L = 1k\Omega$

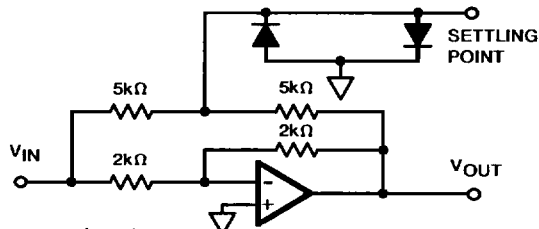
**MEASURED SMALL SIGNAL RESPONSE**

Vertical Scale: (100mV/Div.)  
Horizontal Scale: Time: 20ns/Div.

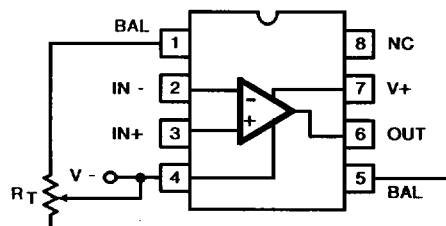


$A_V = +1V/V$ ,  $R_L = 1k\Omega$

Note: Tested on both positive and negative edges.

**SETTLING TIME TEST CIRCUIT FOR TABLE 3**

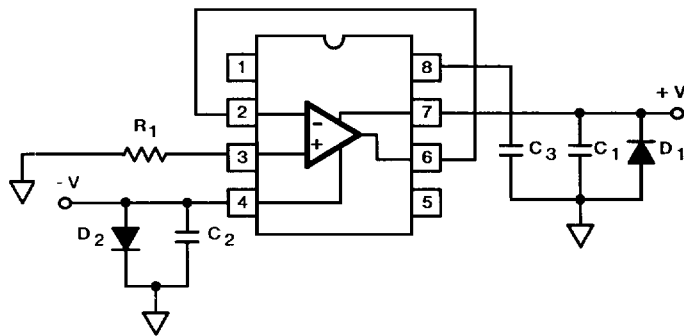
- $A_V = -1$
- Feedback and Summing Resistors Must Be Matched (0.1%).
- HP5082-2810 Clipping Diodes Recommended.
- Tektronix P6201 FET Probe Used At Settling Point.

**OFFSET VOLTAGE ADJUSTMENT CONNECTIONS**

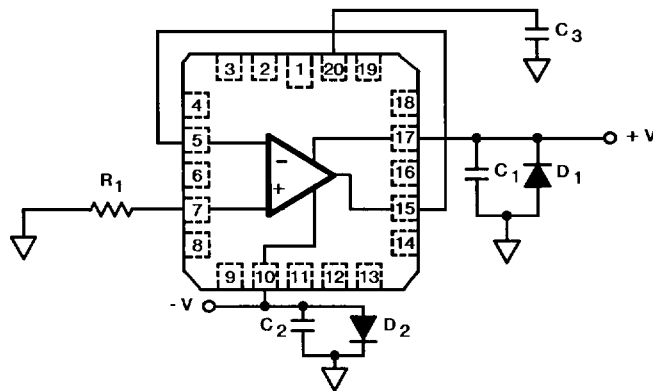
Tested Offset Adjustment Range is  $|V_{OS} + 1mV|$  Minimum Referred To Output. Typical Range For  $R_T = 20k\Omega$  is Approximately  $\pm 30mV$ .

## Burn-In Circuits

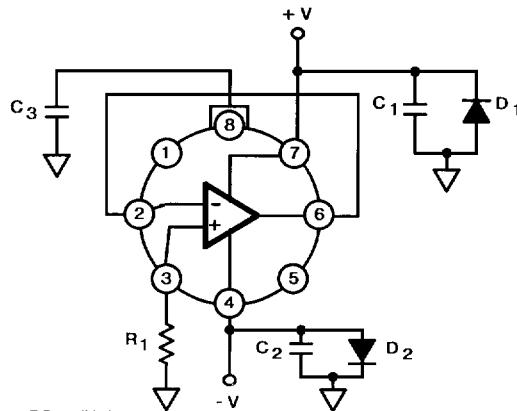
HA7-2544/883 CERAMIC DIP



HA4-2544/883 CERAMIC LCC



HA2-2544/883 TO-99 METAL CAN



## NOTES:

$R_1 = 1\text{M}\Omega, \pm 5\%, 1/4\text{W (Min)}$

$C_1 = C_2 = 0.01\mu\text{F/Socket (Min)}$  or  $0.1\mu\text{F/Row, (Min)}$

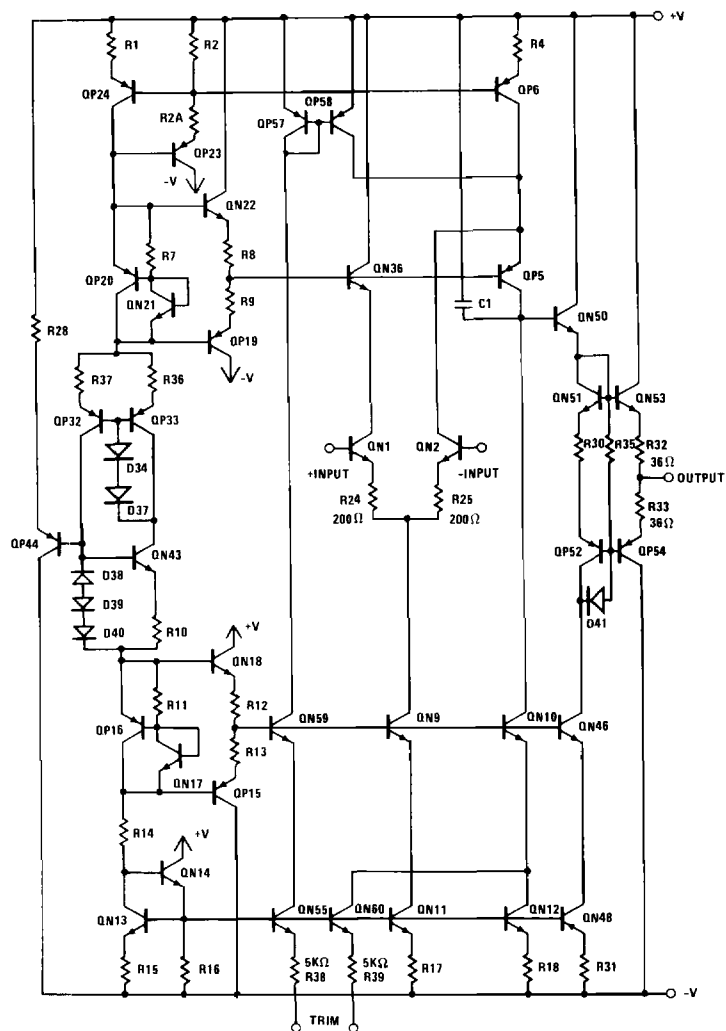
$C_3 = 0.01\mu\text{F/Socket, 10\%}$

$D_1 = D_2 = \text{IN4002 or Equivalent/Board}$

$|V(+)-V(-)| = 30\text{V}$

( $C_3$  is not required for HA-2544/883 compensation. It is shown here as standard pinout fixturing from B.J. boards used.)

## Schematic Diagram



**Die Characteristics****DIE DIMENSIONS:**

79.9 x 64.2 x 19 mils  
(2030 x 1630 x 483  $\mu$ m)

**METALLIZATION:**

Type: Aluminum  
Thickness:  $16\text{k}\text{\AA} \pm 2\text{k}\text{\AA}$

**WORST CASE CURRENT DENSITY:**

$0.3 \times 10^5 \text{A/cm}^2$

**SUBSTRATE POTENTIAL (POWERED UP):** V-

**GLASSIVATION:**

Type: Nitride  
Thickness:  $7\text{k}\text{\AA} \pm 0.7\text{k}\text{\AA}$

**TRANSISTOR COUNT: 44**

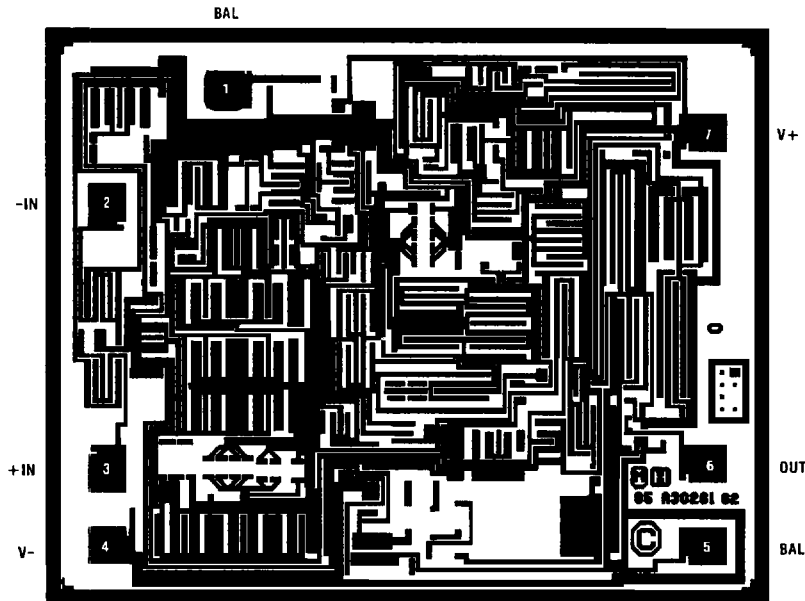
**PROCESS:** High Frequency Bipolar Dielectric Isolation

**DIE ATTACH:**

Material: Gold/Silicon Eutectic Alloy  
Temperature: Ceramic DIP —  $460^\circ\text{C}$  (Max)  
Ceramic LCC —  $420^\circ\text{C}$  (Max)  
Metal Can —  $420^\circ\text{C}$  (Max)

**Metallization Mask Layout**

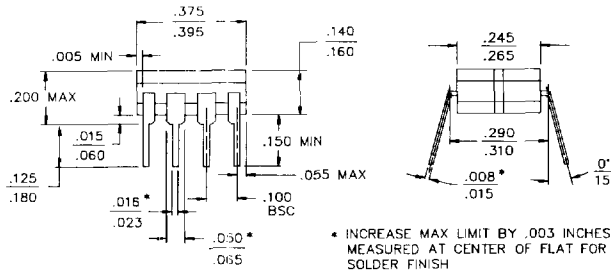
HA-2544/883



NOTE: Pin Numbers Correspond to Ceramic Mini-DIP and 8 Pin (TO-99) Metal Can Packages Only.

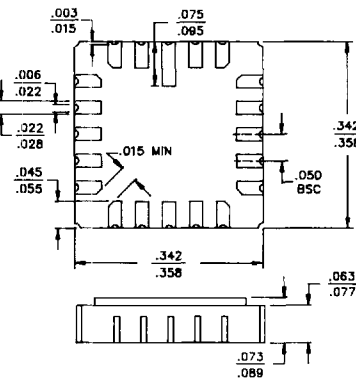
# Packaging †

## 8 PIN CERAMIC DIP



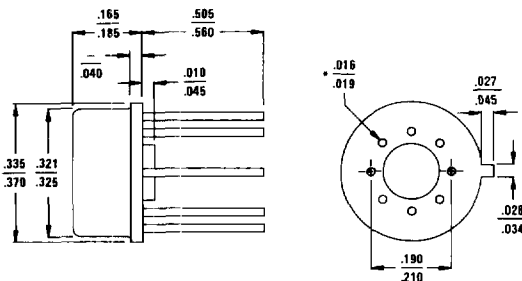
**LEAD MATERIAL:** Type B  
**LEAD FINISH:** Type A  
**PACKAGE MATERIAL:** Ceramic, 90% Alumina  
**PACKAGE SEAL:**  
 Material: Glass Frit  
 Temperature: 450°C ± 10°C  
 Method: Furnace Seal  
**INTERNAL LEAD WIRE:**  
 Material: Aluminum  
 Diameter: 1.25 Mil  
 Bonding Method: Ultrasonic  
**COMPLIANT OUTLINE:** 38510 D-4

## 20 PAD CERAMIC LCC



**PAD MATERIAL:** Type C  
**PAD FINISH:** Type A  
**FINISH DIMENSION:** Type A  
**PACKAGE MATERIAL:** Ceramic, 90% Al<sub>2</sub>O<sub>3</sub>  
**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

## 8 PIN TO-99 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  
**COMPLIANT OUTLINE:** 38510 A-1

\*Dimension Maximum Limits Are Increased by 0.003 inches for Solder Dip Finish

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

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

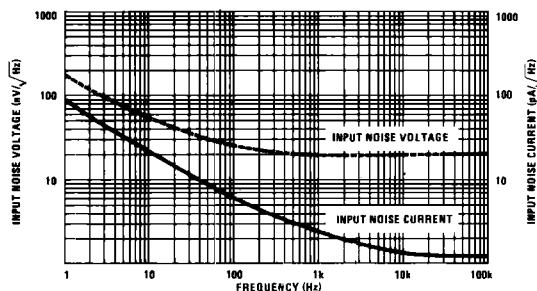
## DESIGN INFORMATION

## Video Operational Amplifier

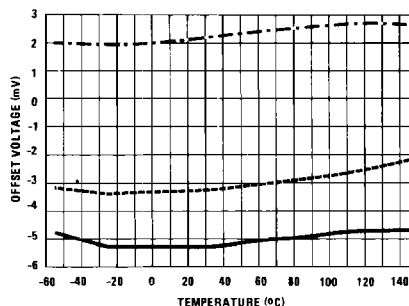
The information contained in this section has been developed through characterization by Harris Semiconductor and is for use as application and design aid only. These characteristics are not 100% tested and no product guarantee is implied.

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

**INPUT NOISE VOLTAGE AND NOISE CURRENT vs. FREQUENCY**

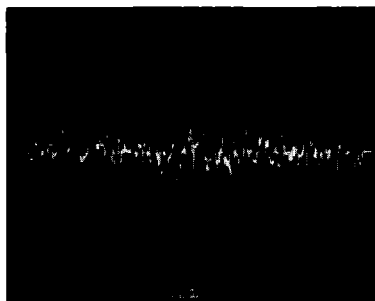


**INPUT OFFSET VOLTAGE vs. TEMPERATURE**  
3 Typical Units

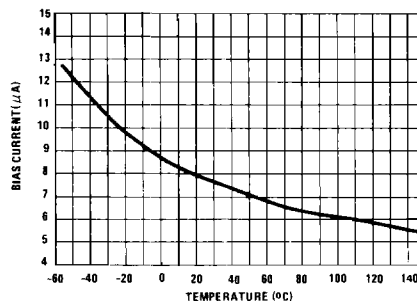


**BROADBAND NOISE**

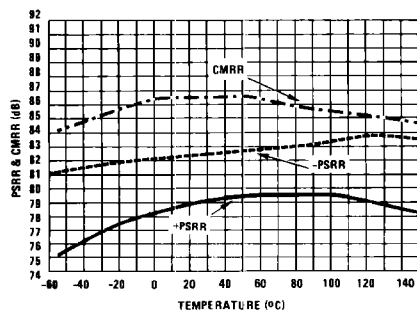
$A_V = 1000$ , 0.1Hz to 10Hz, Noise Voltage =  $0.97\mu\text{V}_{\text{p-p}}$



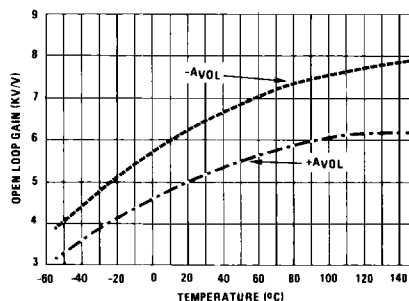
**INPUT BIAS CURRENT vs. TEMPERATURE**  
 $V_S = \pm 15\text{V}$ ,  $R_L = 1\text{k}\Omega$



**PSRR AND CMRR vs. TEMPERATURE**  
 $V_S = \pm 15\text{V}$ ,  $R_L = 1\text{k}\Omega$

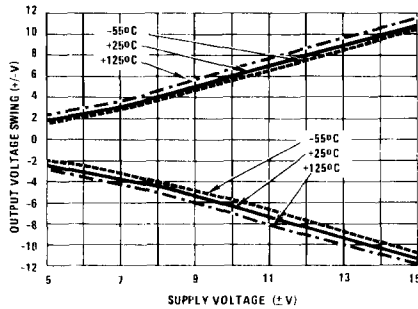
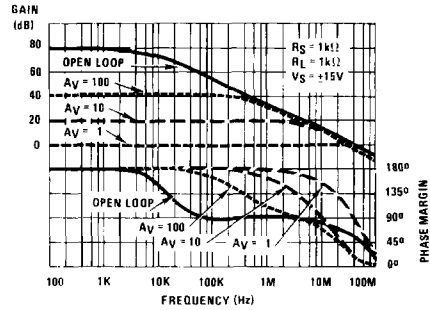
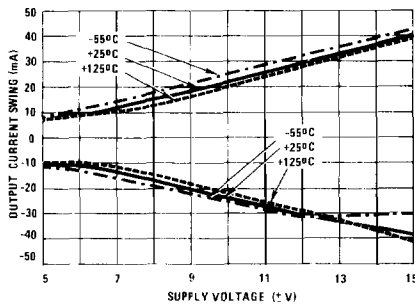
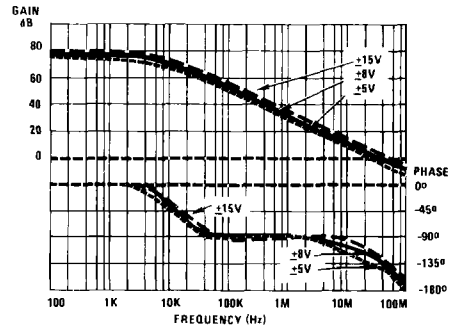
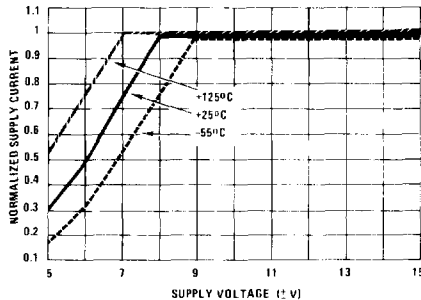
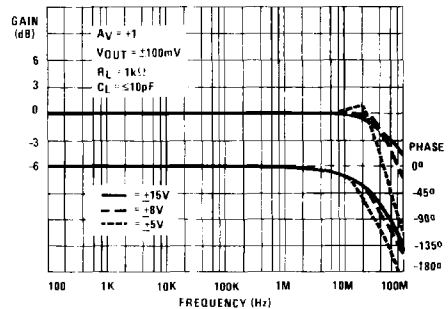


**OPEN LOOP GAIN vs. TEMPERATURE**  
 $V_S = \pm 15\text{V}$ ,  $R_L = 1\text{k}\Omega$



**DESIGN INFORMATION** (Continued)

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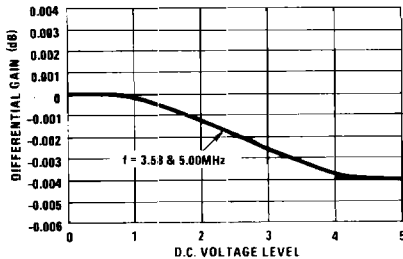
**Typical Performance Curves** Unless Otherwise Specified:  $T_A = +25^\circ\text{C}$ ,  $V_{S\text{SUPPLY}} = \pm 15\text{V}$ **OUTPUT VOLTAGE SWING vs. SUPPLY VOLTAGE**  
(Over Full Temperature)**FREQUENCY RESPONSE AT VARIOUS GAINS**  
 $R_S = 1\text{k}\Omega$ ,  $R_L = 1\text{k}\Omega$ ,  $V_S = \pm 15\text{V}$ **OUTPUT CURRENT vs. SUPPLY VOLTAGE**  
(Over Full Temperature)**OPEN LOOP RESPONSE vs. SUPPLY VOLTAGE**  
 $V_{OUT} = \pm 100\text{mV}$ **SUPPLY CURRENT vs. SUPPLY VOLTAGE**  
Normalized at  $V_S = \pm 15\text{V}$  at  $+25^\circ\text{C}$ **VOLTAGE FOLLOWER RESPONSE vs. SUPPLY VOLTAGE**  
 $A_V = +1$ ,  $R_L = 1\text{k}\Omega$ ,  $C_L \leq 10\text{pF}$ 

**DESIGN INFORMATION** (Continued)

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

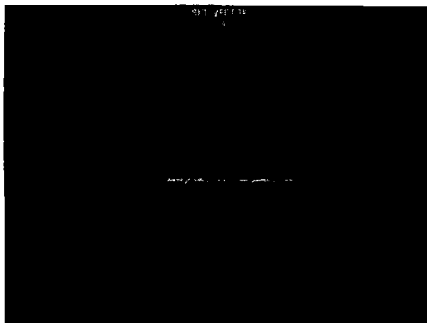
**A.C. GAIN VARIATION vs. D.C. OFFSET LEVELS**  
(Differential Gain)

**DIFFERENTIAL GAIN**

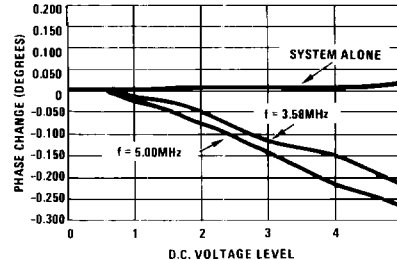
NTSC Method,  $R_L = 1\text{k}\Omega$

Differential Gain  $< 0.05\%$  at  $T_A = +75^\circ\text{C}$

No Visual Difference at  $T_A = -55^\circ\text{C}$  or  $+125^\circ\text{C}$



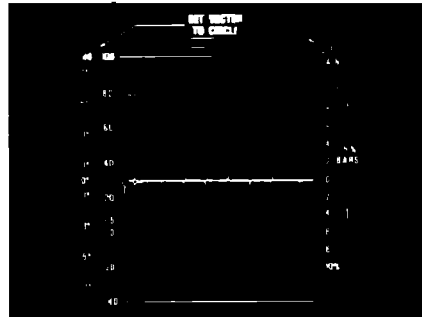
**A.C. PHASE VARIATION vs. D.C. OFFSET LEVELS**  
(Differential Phase)

**DIFFERENTIAL PHASE**

NTSC Method,  $R_L = 1\text{k}\Omega$

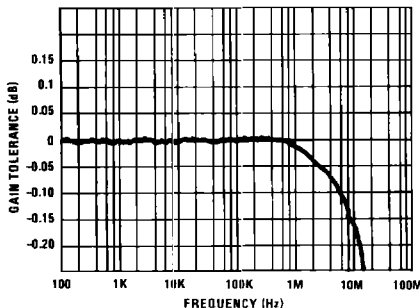
Differential Phase  $< 0.05$  Degree at  $T_A = +75^\circ\text{C}$

No Visual Difference at  $T_A = -55^\circ\text{C}$  or  $+125^\circ\text{C}$

**GAIN TOLERANCE**

$A_V = +1$ ,  $V_{IN} = \pm 100\text{mV}$

$R_L = 1\text{K}$ ,  $C_L \leq 10\text{pF}$

**CHROMINANCE TO LUMINANCE DELAY**

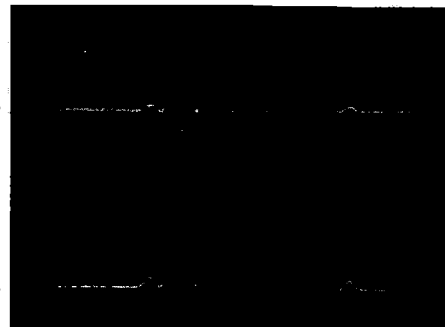
NTSC Method,  $R_L = 1\text{k}\Omega$

C-L Delay  $< 7\text{ns}$  at  $T_A = +75^\circ\text{C}$

No Visual Difference at  $T_A = -55^\circ\text{C}$  or  $+125^\circ\text{C}$

INPUT

OUTPUT



Vertical Scale: Input = 100mV/Div.

Output = 50mV/Div.

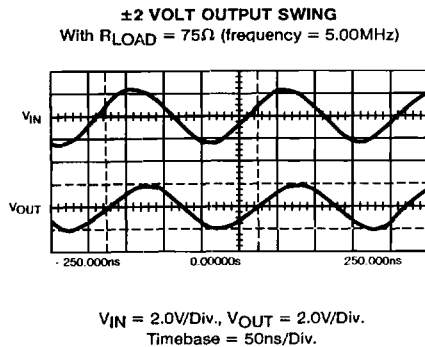
Horizontal Scale: 500ns/Div.

## DESIGN INFORMATION (Continued)

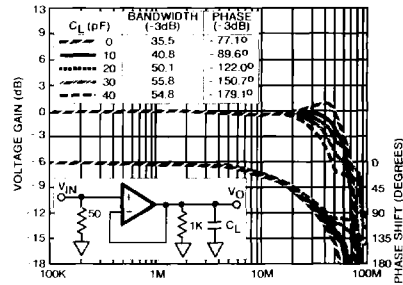
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### Typical Video Performance Curves (Continued)

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



**BANDWIDTH vs. LOAD CAPACITANCE**  
 $A_V = +1$ ,  $V_S = \pm 15\text{V}$ ,  $R_L = 1\text{k}\Omega$



### Applications And Product Guidelines

The HA-2544 is a true differential op amp that is as versatile as any op amp but offers the advantages of high unity gain bandwidth, high speed and low supply current. More important than its' general purpose applications is that the HA-2544 was especially designed to meet the requirements found in a video amplifier system. These requirements include fine picture resolution and accurate color rendition, and must meet broadcast quality standards.

In a video signal, the video information is carried in the amplitude and phase as well as in the D.C. level. The amplifier must pass the 30Hz line rate luminance level and the 3.58MHz (NTSC) or 4.43MHz (PAL) color band without altering phase or gain. The HA-2544's key specifications aimed at meeting this include high bandwidth (50MHz), very low gain tolerance ( $< \pm 0.15\text{dB}$  at 5MHz), near unmeasurable differential gain and differential phase ( $< 0.04\text{dB}$  and  $0.11$  degrees), and low noise ( $20\text{nV}/\sqrt{\text{Hz}}$ ). The HA-2544 meets these guidelines and are sample tested for standard grade product (/883, -2, -7, -5) at 5 and/or 10MHz. If a customer wishes to 100% test these specifications, arrangement can be made.

The HA-2544 also offers the advantage of a full output voltage swing of  $\pm 10\text{V}$  into a  $1\text{k}\Omega$  load. This equates to a full power bandwidth of 2.4MHz for this  $\pm 10\text{V}$  signal. If video signal levels of  $\pm 2\text{V}$  maximum is used (with  $R_L = 1\text{k}\Omega$ ), the full power bandwidth would be 11.9MHz without clipping distortion. Another usage might be required for a direct  $50\Omega$  or  $75\Omega$  load where the HA-2544 will still swing this  $\pm 2\text{V}$  signal as shown in the above display. One important note that must be realized is that as load resistance decreases the video parameters are also degraded. For optimal video performance a  $1\text{k}\Omega$  load is recommended.

If lower supply voltage are required, such as  $\pm 5\text{V}$ , many of the characterization curves indicate where the parameters vary. As shown the bandwidth, slew rate and supply current are still very well maintained.

### Prototyping and PC Board Layout

When designing with the HA-2544 video op amp as with any high performance device, care should be taken to use high frequency layout techniques to avoid unwanted parasitic effects. Short lead lengths, low source impedance and lower value feedback resistors help reduce unwanted poles or zeros. This layout would also include ground plane construction and power supply decoupling as close to the supply pins with suggested parallel capacitors of  $0.1\mu\text{F}$  and  $0.001\mu\text{F}$  ceramic to ground.

In the noninverting configuration, the amplifier is sensitive to stray capacitance ( $< 40\text{pF}$ ) to ground at the inverting input. Therefore, the inverting node connections should be kept to a minimum. Phase shift will also be introduced as load parasitic capacitance is increased. A small series resistor ( $20\Omega$  to  $100\Omega$ ) before the capacitance effectively decouples this effect.

### Stability/Phase Margin/Compensation

The HA-2544 has not sacrificed unity gain stability in achieving its superb AC performance. For this device, the phase margin exceeds 60 degrees at the unity crossing point of the open loop frequency response. Large phase margin is critical in order to reduce the differential phase and differential gain errors caused by most other op amps. Because this part is unity gain stable, no compensation pin is brought out. If compensation is desired to reduce the noise bandwidth, most standard methods may be used. One method suggested for an inverting scheme would be a series R-C from the inverting node to ground which will reduce bandwidth, but not effect slew rate. If the user wishes to achieve even higher bandwidth ( $> 50\text{MHz}$ ), and can tolerate some slight gain peaking and lower phase margin, experimenting with various load capacitance can be done.

**DESIGN INFORMATION (Continued)**

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**TYPICAL PERFORMANCE CHARACTERISTICS**

Device Characterized at: Supply Voltage =  $\pm 15\text{V}$ ,  $R_L = 1\text{k}\Omega$ ,  $C_L \leq 10\text{pF}$ ,  $A_V = 1\text{V/V}$ , Unless Otherwise Specified.

| PARAMETERS                     | CONDITIONS                                                | TEMP                | TYPICAL    | DESIGN LIMIT | UNITS                        |
|--------------------------------|-----------------------------------------------------------|---------------------|------------|--------------|------------------------------|
| Offset Voltage                 | $V_{CM} = 0\text{V}$                                      | $+25^\circ\text{C}$ | 6          | Table 1      | mV                           |
| Average Offset Voltage Drift   | Versus Temperature                                        | Full                | 10         | 15           | $\mu\text{V}/^\circ\text{C}$ |
| Bias Current                   | $V_{CM} = 0\text{V}$                                      | $+25^\circ\text{C}$ | 7          | Table 1      | $\mu\text{A}$                |
| Average Bias Current Drift     | Versus Temperature                                        | Full                | 0.04       | 0.1          | $\mu\text{A}/^\circ\text{C}$ |
| Offset Current                 | $V_{CM} = 0\text{V}$                                      | $+25^\circ\text{C}$ | 0.2        | Table 1      | $\mu\text{A}$                |
|                                |                                                           | Full                | 0.8        | Table 1      | $\mu\text{A}$                |
| Common Mode Range              |                                                           | Full                | $\pm 11.5$ | Table 1      | V                            |
| Differential Input Resistance  |                                                           | $+25^\circ\text{C}$ | 90         | 50           | $\text{k}\Omega$             |
| Differential Input Capacitance |                                                           | $+25^\circ\text{C}$ | 3          | 4            | pF                           |
| Input Noise Voltage Density    | $f_o \geq 1\text{kHz}$                                    | $+25^\circ\text{C}$ | 20         | 24           | $\text{nV}/\sqrt{\text{Hz}}$ |
| Input Noise Current Density    | $f_o \geq 1\text{kHz}$                                    | $+25^\circ\text{C}$ | 2.4        | 4            | $\text{pA}/\sqrt{\text{Hz}}$ |
| Large Signal Voltage Gain      | $V_{OUT} = \pm 5\text{V}$                                 | $+25^\circ\text{C}$ | 6          | Table 1      | $\text{kV/V}$                |
|                                |                                                           | Full                | 3.5        | Table 1      | $\text{kV/V}$                |
| CMRR                           | $\Delta V_{CM} = \pm 10\text{V}$                          | Full                | 89         | Table 1      | dB                           |
| Gain Bandwidth Product         |                                                           | $+25^\circ\text{C}$ | 50         | 45           | MHz                          |
| Phase Margin                   | 0dB GBWP Crossing                                         | $+25^\circ\text{C}$ | 65         | 55           | Degrees                      |
| Output Voltage Swing           |                                                           | Full                | $\pm 11$   | Table 1      | V                            |
| Full Power Bandwidth           | $V_{PEAK} = 5\text{V}$                                    | $+25^\circ\text{C}$ | 4.2        | 3.5          | MHz                          |
| Peak Output Current            | Note A                                                    | $+25^\circ\text{C}$ | $\pm 35$   | Table 1      | mA                           |
| Output Resistance              | Open Loop                                                 | $+25^\circ\text{C}$ | 20         | 40           | $\Omega$                     |
| Rise/Fall Time                 | $V_{OUT} = +200\text{mV}, -200\text{mV}$                  | $+25^\circ\text{C}$ | 7          | Table 3      | ns                           |
| $\pm$ Overshoot                | $V_{OUT} = +200\text{mV}, -200\text{mV}$                  | $+25^\circ\text{C}$ | 10         | Table 3      | %                            |
| + Slew Rate                    | $V_{OUT} = -5\text{V to } +5\text{V}$                     | $+25^\circ\text{C}$ | +165       | Table 2      | $\text{V}/\mu\text{s}$       |
| - Slew Rate                    | $V_{OUT} = +5\text{V to } -5\text{V}$                     | $+25^\circ\text{C}$ | -125       | Table 2      | $\text{V}/\mu\text{s}$       |
| Settling Time                  | $A_V = -1\text{V/V}, 10\text{V to } 0.1\%$                | $+25^\circ\text{C}$ | 110        | 140          | ns                           |
|                                | $A_V = -1\text{V/V}, 10\text{V to } 0.01\%$               | $+25^\circ\text{C}$ | 120        | 150          | ns                           |
| Differential Phase             | $R_S = 50\Omega \text{ to } 75\Omega$ , Notes 7 and 9     | $+25^\circ\text{C}$ | 0.05       | Table 3      | Degrees                      |
|                                | $R_S = 1\text{k}\Omega$ , Notes 7 and 9                   | $+25^\circ\text{C}$ | 0.4        | 0.6          | Degrees                      |
| Differential Gain              | $R_S = 50\Omega \text{ to } 75\Omega$ , Notes 7, 9, 11    | $+25^\circ\text{C}$ | 0.02       | Table 3      | dB                           |
|                                | $R_S = 1\text{k}\Omega$ , Notes 7, 9, 11                  | $+25^\circ\text{C}$ | 0.15       | 0.3          | dB                           |
| Chrominance to Luminance Gain  | Note 10                                                   | $+25^\circ\text{C}$ | 0.1        | N/A          | dB                           |
| Chrominance to Luminance Delay | Note 10                                                   | $+25^\circ\text{C}$ | 7          | N/A          | ns                           |
| Gain Tolerance                 | 5MHz                                                      | $+25^\circ\text{C}$ | -0.10      | Table 3      | dB                           |
|                                | 10MHz                                                     | $+25^\circ\text{C}$ | -0.12      | Table 3      | dB                           |
| Supply Current                 | $I_{OUT} = 0\text{mA}$                                    | Full                | 10         | Table 1      | mA                           |
| PSRR                           | $\Delta V_S = \pm 10\text{V to } \pm 20\text{V}$          | Full                | 80         | Table 1      | dB                           |
| Minimum Supply Voltage         | Functional Operation Only.<br>Other Parameters Will Vary. | $+25^\circ\text{C}$ | $\pm 5$    | $\pm 6$      | V                            |
| Saturation Recovery Time       | Full Saturation                                           | $+25^\circ\text{C}$ | 0.6        | 1.1          | $\mu\text{s}$                |