



HA-2542/883

Wideband, High Slew Rate,
High Output Current, 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.
- Stable at Gains of 2 or Greater
- Gain Bandwidth 70MHz (Min)
- High Slew Rate 300V/ μ s (Min)
- High Output Current 100mA (Min)
- Power Bandwidth 5.5MHz (Typ)
- Output Voltage Swing ± 10 V (Min)
- Monolithic Bipolar Dielectric Isolation Construction

Applications

- Pulse and Video Amplifiers
- Wideband Amplifiers
- Coaxial Cable Drivers
- Fast Sample and Hold Circuits
- High Frequency Signal Conditioning Circuits

Description

T-79-23

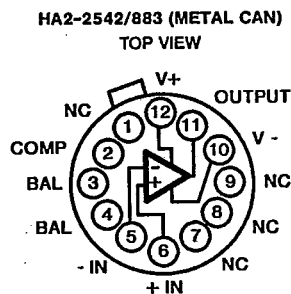
The HA-2542/883 is a wideband, high slew rate, monolithic operational amplifier featuring an outstanding combination of speed, bandwidth, and output drive capability.

Utilizing the advantages of the Harris D.I. technology this amplifier offers 350V/ μ s slew rate, 70MHz gain bandwidth, and ± 100 mA output current. Application of this device is further enhanced through stable operation down to closed loop gains of 2.

For additional flexibility, offset null and frequency compensation controls are included in the HA-2542/883 pinout.

The capabilities of the HA-2542/883 are ideally suited for high speed coaxial cable driver circuits where low gain and high output drive requirements are necessary. With 5.5MHz full power bandwidth, this amplifier is most suitable for high frequency signal conditioning circuits and pulse video amplifiers. Other applications utilizing the HA-2542/883 advantages include wideband amplifiers and fast sample and hold circuits. The HA-2542/883 is specified over the -55°C to $+125^{\circ}\text{C}$ military temperature range and is available in 12 lead (TO-8) package.

Pinout



Case tied to V-

3

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T-79-23

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) 125mA
 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}
 Metal Can Package 47°C/W 29°C/W
 Package Power Dissipation Limit at +75°C For T_J ≤ 175°C
 Metal Can Package 2.1W
 Package Power Dissipation Derating Factor Above +75°C
 Metal Can Package 21.4mW/°C

Recommended Operating Conditions

Operating Temperature Range -55°C to +125°C V_{INCM} ≤ 1/2 (V+ - V-)
 Operating Supply Voltage ±12V to ±15V R_L ≥ 100Ω

TABLE 1. D.C. ELECTRICAL PERFORMANCE CHARACTERISTICS

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		UNITS
					MIN	MAX	
Input Offset Voltage	V _{IO}	V _{CM} = 0V	1	+25°C	-10	10	mV
			2, 3	+125°C, -55°C	-20	20	mV
Input Bias Current	+I _B	V _{CM} = 0V +R _S = 1.1kΩ -R _S = 100Ω	1	+25°C	-35	35	μA
			2, 3	+125°C, -55°C	-50	50	μA
	-I _B	V _{CM} = 0V +R _S = 100Ω -R _S = 1.1kΩ	1	+25°C	-35	35	μA
			2, 3	+125°C, -55°C	-50	50	μA
Input Offset Current	I _{IO}	V _{CM} = 0V +R _S = 1.1kΩ -R _S = 1.1kΩ	1	+25°C	-7	7	μA
			2, 3	+125°C, -55°C	-9	9	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 = 1kΩ	4	+25°C	10	-	kV/V
			5, 6	+125°C, -55°C	5	-	kV/V
	-A _{VOL}	V _{OUT} = 0V and -10V R _L = 1kΩ	4	+25°C	10	-	kV/V
			5, 6	+125°C, -55°C	5	-	kV/V
Common Mode Rejection Ratio	+CMRR	ΔV _{CM} = +10V +V = +5V -V = -25V V _{OUT} = -10V	1	+25°C	70	-	dB
			2, 3	+125°C, -55°C	70	-	dB
	-CMRR	ΔV _{CM} = -10V +V = +25V -V = -5V V _{OUT} = +10V	1	+25°C	70	-	dB
			2, 3	+125°C, -55°C	70	-	dB

CAUTION: This device is sensitive to electrostatic discharge. Proper I.C. handling procedures should be followed.

T-79-23

TABLE 1. D.C. ELECTRICAL PERFORMANCE CHARACTERISTICS (Continued)

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

D.C. PARAMETERS	SYMBOL	CONDITIONS	GROUP A SUBGROUP	TEMPERATURE	LIMITS		UNITS
					MIN	MAX	
Output Voltage Swing	+V _{OUT}	R _L = 1k Ω	1	+25°C	10	-	V
			2,3	+125°C, -55°C	10	-	V
	-V _{OUT}	R _L = 1k Ω	1	+25°C	-	-10	V
			2,3	+125°C, -55°C	-	-10	V
Output Current	+I _{OUT}	V _{OUT} = -5V	1	+25°C	100	-	mA
	-I _{OUT}	V _{OUT} = +5V	1	+25°C	100	-	mA
Quiescent Power Supply Current	+I _{CC}	V _{OUT} = 0V I _{OUT} = 0mA	1	+25°C	-	34.5	mA
			2,3	+125°C, -55°C	-	34.5	mA
	-I _{CC}	V _{OUT} = 0V I _{OUT} = 0mA	1	+25°C	-34.5	-	mA
			2,3	+125°C, -55°C	-34.5	-	mA
Power Supply Rejection Ratio	+PSRR	$\Delta V_{SUP} = 10V$ +V = +5V, -V = -15V +V = +15V, -V = -15V	1	+25°C	70	-	dB
			2,3	+125°C, -55°C	70	-	dB
	-PSRR	$\Delta V_{SUP} = 10V$ +V = +15V, -V = -5V +V = +15V, -V = -15V	1	+25°C	70	-	dB
			2,3	+125°C, -55°C	70	-	dB
Offset Voltage Adjustment	+V _{IOAdj}	Note 5	1	+25°C	V _{IO} -1	-	mV
	-V _{IOAdj}	Note 5	1	+25°C	V _{IO} +1	-	mV

TABLE 2. A.C. ELECTRICAL PERFORMANCE CHARACTERISTICS

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

3

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T-79-23

TABLE 3. ELECTRICAL PERFORMANCE CHARACTERISTICS

Device Characterized at: Supply Voltage = $\pm 15V$, $R_{LOAD} = 1k\Omega$, $C_{LOAD} \leq 10pF$, $A_V = 2V/V$, Unless Otherwise Specified.

PARAMETERS	SYMBOL	CONDITIONS	NOTES	TEMPERATURE	LIMITS		UNITS
					MIN	MAX	
Differential Input Resistance	R_{IN}	$V_{CM} = 0V$	1	+25°C	40	-	k Ω
Gain Bandwidth Product	GBWP	$V_O = 200mV, f_o = 10kHz$	1	+25°C	70	-	MHz
		$V_O = 200mV, f_o = 1MHz$	1	+25°C	70	-	MHz
Slew Rate	+SR	$V_{OUT} = -5V$ to +5V	1	+25°C	300	-	V/ μs
	-SR	$V_{OUT} = +5V$ to -5V	1	+25°C	300	-	V/ μs
Full Power Bandwidth	FPBW	$V_{PEAK} = 10V$	1, 2	+25°C	4.5	-	MHz
Minimum Closed Loop Stable Gain	CLSG	$R_L = 1k\Omega, C_L \leq 10pF$	1	-55°C to +125°C	2	-	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	-	40	%
	-OS	$V_{OUT} = 0V$ to -200mV	1	+25°C	-	40	%
Output Resistance	R_{OUT}	$V_{OUT} = 0V$	1	+25°C	-	25	Ω
Quiescent Power Consumption	PC	$V_{OUT} = 0V, I_{OUT} = 0mA$	1, 3	-55°C to +125°C	-	1.035	W

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.

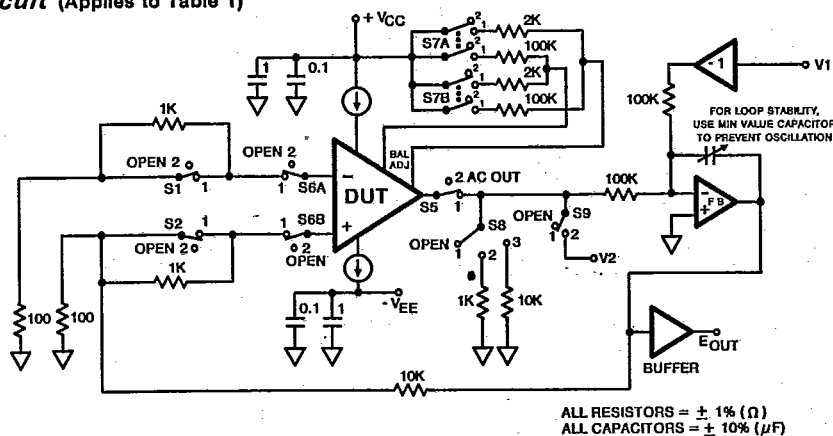
2. Full Power Bandwidth guarantee based on Slew Rate measurement using $FPBW = \text{Slew Rate} / (2\pi V_{PEAK})$.
3. Quiescent Power Consumption based upon Quiescent Supply Current test maximum. (No load on outputs.)
4. Measured between 10% and 90% points.
5. Offset adjustment range is $[V_{IO} (\text{Measured}) \pm 1mV]$ minimum referred to output.
This test is for functionality only to assure adjustment through 0V.

TABLE 4. ELECTRICAL TEST REQUIREMENTS

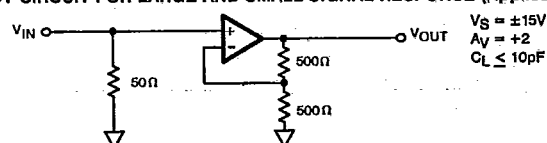
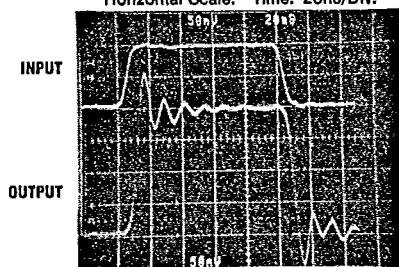
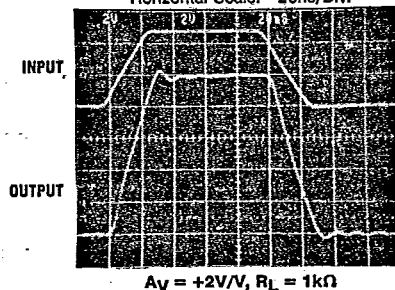
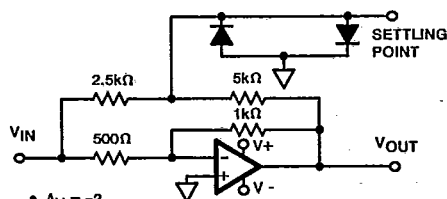
MIL-STD-883 TEST REQUIREMENTS	SUBGROUPS (SEE TABLES 1 & 2)
Interim Electrical Parameters (Pre Burn-In)	1
Final Electrical Test Parameters	1*, 2, 3, 4, 5, 6
Group A Test Requirements	1, 2, 3, 4, 5, 6
Groups C & D Endpoints	1

* PDA applies to Subgroup 1 only.

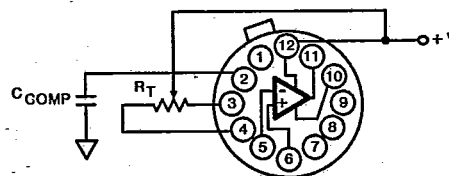
T-79-23

Test Circuit (Applies to Table 1)

For Detailed Information, Refer to HA-2542/883 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 = 2V/Div., Output = 2V/Div.
Horizontal Scale: Time: 20ns/Div.**MEASURED SMALL SIGNAL RESPONSE**
Vertical Scale: Input = 50mV/Div., Output = 50mV/Div.
Horizontal Scale: 20ns/Div.**SETTLING TIME TEST CIRCUIT FOR TABLE 3**

- $A_V = -2$
- Feedback and Summing Resistors Must Be Matched (0.1%).
- HP5082-2810 Clipping Diodes Recommended.
- Tektronix P6201 FET Probe Used At Settling Point.
- For 0.01% settling time, heat sinking is suggested to reduce thermal effects and an analog ground plane with supply decoupling is suggested to minimize ground loop errors.

SUGGESTED OFFSET VOLTAGE ADJUSTMENT AND COMPENSATION CONNECTIONS

- Suggested compensation scheme 5-20pF
- Tested Offset Adjustment Range is $|V_{OS} + 1mV|$ Minimum Referred To Output. Typical Range For $R_T = 20k\Omega$ Is Approximately $\pm 30mV$.

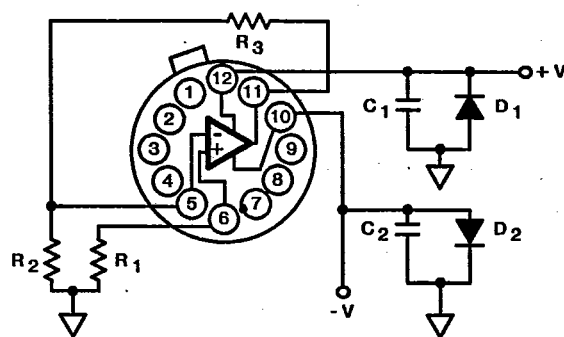
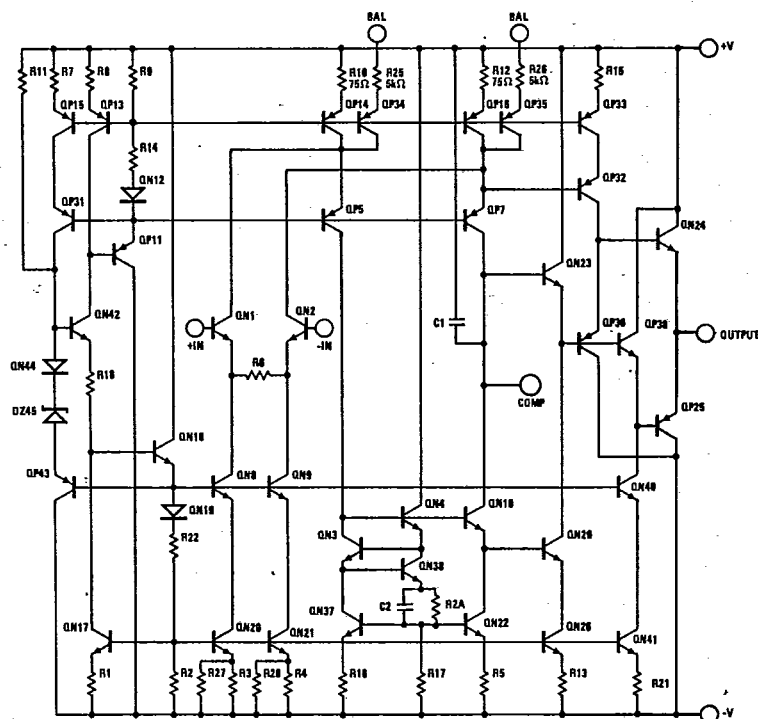
3

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T-79-23

Burn-In Circuits

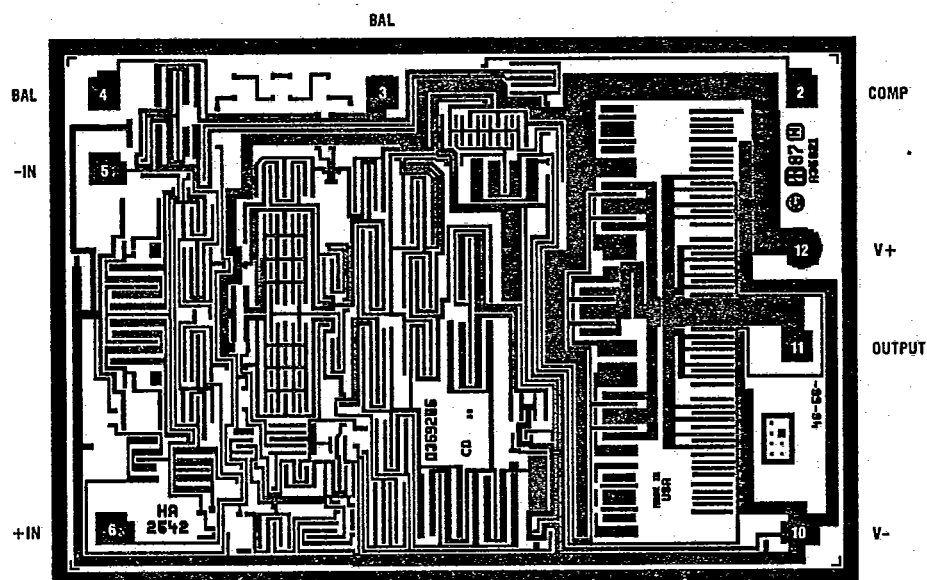
HA2-2542/883 TO-8 METAL CAN

**NOTES:** $R_1 = R_2 = 100k\Omega, \pm 5\%, 1/4W$ (Min) $R_3 = 1M\Omega, \pm 5\%, 1/4W$ (Min) $C_1 = C_2 = 0.01\mu F/\text{Socket}$ (Min) or $0.1\mu F/\text{Row}$, (Min) $D_1 = D_2 = \text{IN4002 or Equivalent/Board}$ $|V_+ - V_-| = 30V$ **Schematic Diagram**

T-79-23

Die Characteristics**DIE DIMENSIONS:**106.3 x 72.8 x 19 mils
(2700 x 1850 x 483 μ m)**METALLIZATION:**Type: Aluminum
Thickness: $16\text{k}\text{\AA} \pm 2\text{k}\text{\AA}$ **WORST CASE CURRENT DENSITY:** $0.4 \times 10^5 \text{A/cm}^2$ @ 1.87mA**SUBSTRATE POTENTIAL (POWERED UP): V-****GLASSIVATION:**Type: Nitride
Thickness: $7\text{k}\text{\AA} \pm 0.7\text{k}\text{\AA}$ **TRANSISTOR COUNT: 43****PROCESS: High Frequency Bipolar Dielectric Isolation****DIE ATTACH:**Material: Gold/Silicon Eutectic Alloy
Temperature: Metal Can — 420°C (Max)**Metallization Mask Layout**

HA-2542/883

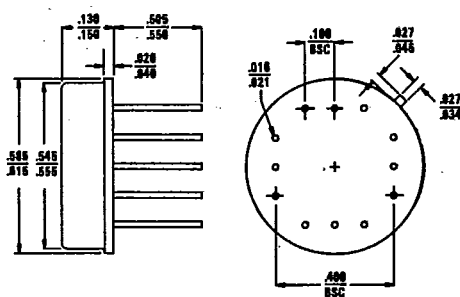


NOTE: Pin Numbers Correspond to 12 Pin (TO-8) Metal Can Package Only.

3

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T-79-23

Packaging†**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

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.



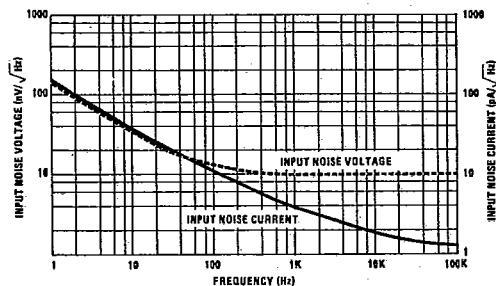
DESIGN INFORMATION

Wideband, High Slew Rate,
High Output Current, Operational Amplifier

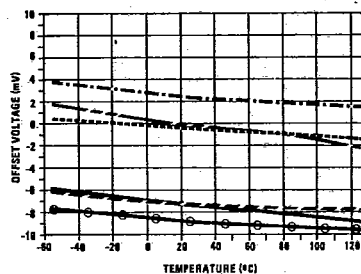
The information contained in this section has been developed through characterization by Harris Semiconductor and is for use as application and design aid only. These characteristics are not 100% tested and no product guarantee is implied.

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

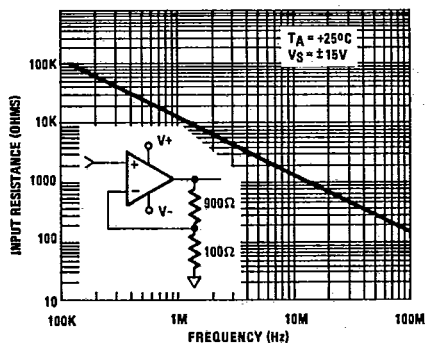
INPUT NOISE VOLTAGE AND INPUT NOISE CURRENT vs. FREQUENCY



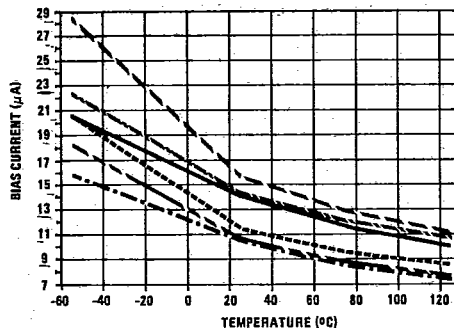
OFFSET VOLTAGE DRIFT WITH TEMPERATURE
Of Six Representative Units, $V_S = \pm 12\text{V}$



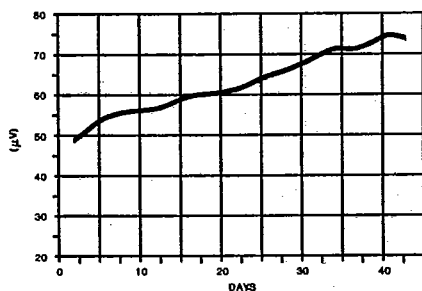
INPUT RESISTANCE vs. FREQUENCY



BIAS CURRENT DRIFT WITH TEMPERATURE
Of Six Representative Units, $V_S = \pm 12\text{V}$

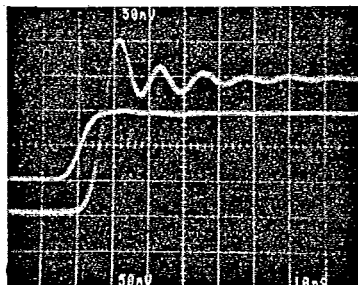


AVERAGE OFFSET VOLTAGE DRIFT vs. TIME
16.2 μV /Month Average



TIME DELAY

Vertical Scale: Volts: 100mV/Div.
Horizontal Scale: Time: 10ns/Div.



$V_S = \pm 15\text{V}$, $R_L = 1\text{k}\Omega$, $T = +25^\circ\text{C}$

Propagation delay variance is negligible over full temperature range.

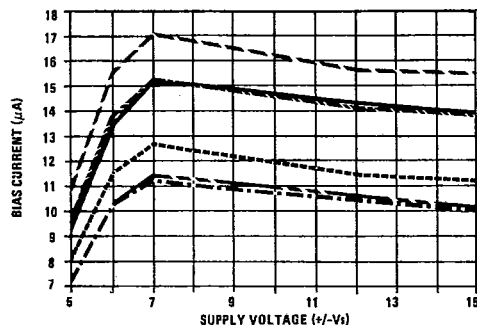
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DESIGN INFORMATION (Continued)

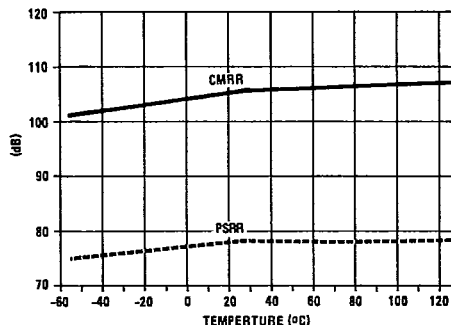
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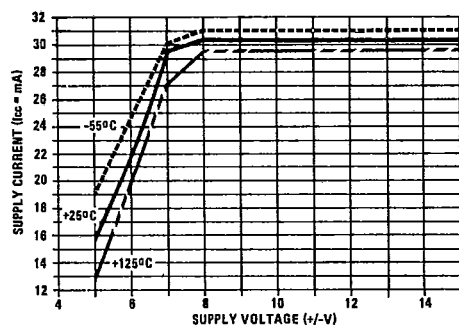
BIAS CURRENT vs. POWER SUPPLY
Six Units At Various Supplies At $+25^\circ\text{C}$



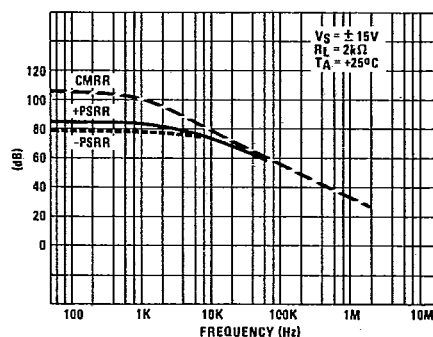
PSRR AND CMRR vs. TEMPERATURE
 $V_s = \pm 15\text{V}$



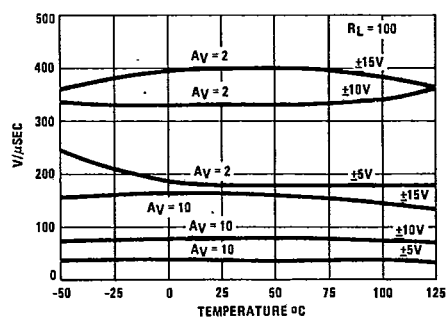
SUPPLY CURRENT vs. SUPPLY VOLTAGE
At Various Temperatures



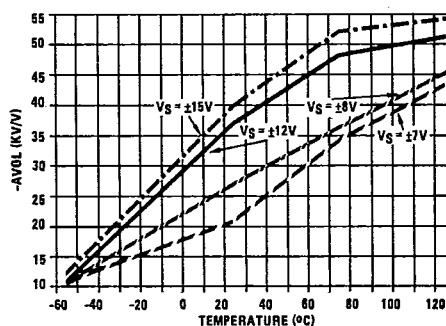
PSRR AND CMRR vs. FREQUENCY



SLEW RATE vs. TEMPERATURE
At Various Supply Voltages With $R_{\text{Load}} = 100\Omega$



OPEN LOOP GAIN vs. TEMPERATURE
At Various Supply Voltages



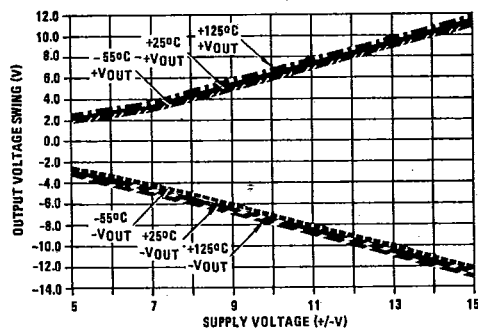
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DESIGN INFORMATION (Continued)

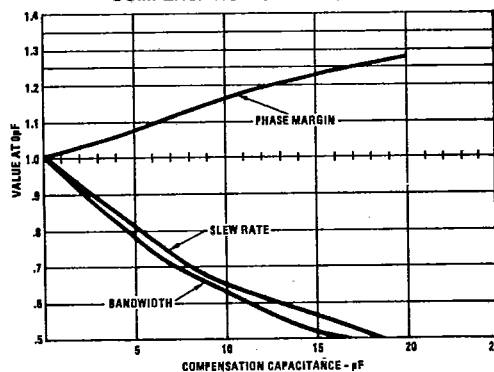
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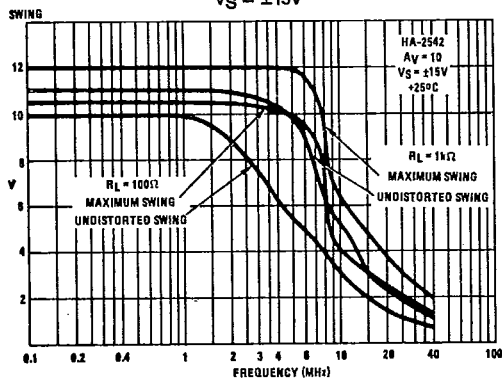
OUTPUT VOLTAGE SWING vs. SUPPLY VOLTAGE
At Various Temperatures



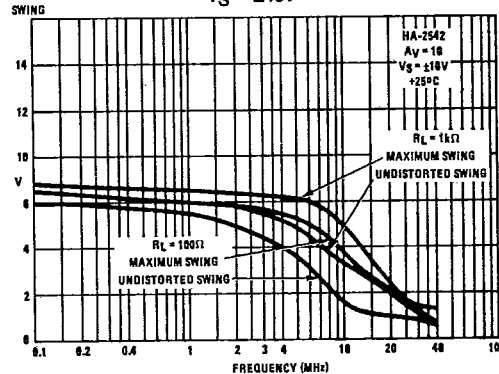
NORMALIZED AC PARAMETERS vs.
COMPENSATION CAPACITANCE



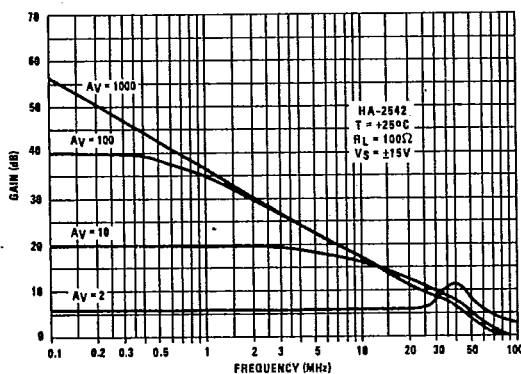
OUTPUT VOLTAGE SWING vs. FREQUENCY
 $V_S = \pm 15\text{V}$



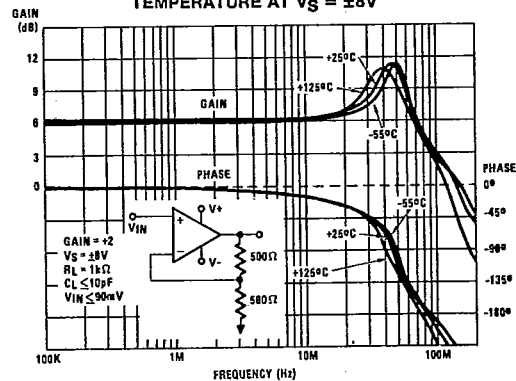
OUTPUT VOLTAGE SWING vs. FREQUENCY
 $V_S = \pm 10\text{V}$



FREQUENCY RESPONSE CURVES



HA-2542 CLOSED LOOP GAIN vs. FREQUENCY AND
TEMPERATURE AT $V_S = \pm 8\text{V}$



3

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T-79-23

DESIGN INFORMATION (Continued)

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TYPICAL PERFORMANCE CHARACTERISTICS

Device Characterized at: Supply Voltage = $\pm 15V$, $R_L = 1k\Omega$, $C_L \leq 100pF$, $A_V = 2V/V$, Unless Otherwise Specified.

PARAMETERS	CONDITIONS	TEMP	TYPICAL	DESIGN LIMIT	UNITS
Offset Voltage	$V_{CM} = 0V$	+25°C	5	Table 1	mV
Average Offset Voltage Drift	Versus Temperature	-55°C to +125°C	8	15	$\mu V/^\circ C$
	Versus Time	+40°C	16	20	$\mu V/\text{Month}$
Bias Current	$V_{CM} = 0V$	+25°C	13	Table 1	μA
Differential Input Resistance		+25°C	100	Table 3	k Ω
Input Capacitance		+25°C	1	3	pF
Input Noise Voltage Density	$f_o = 10\text{Hz}$	+25°C	40	60	$nV/\sqrt{Hz}$
	$f_o = 100\text{Hz}$	+25°C	15	30	$nV/\sqrt{Hz}$
	$f_o = 1\text{kHz}$	+25°C	10	20	$nV/\sqrt{Hz}$
Input Noise Current Density	$f_o = 10\text{Hz}$	+25°C	40	80	$pA/\sqrt{Hz}$
	$f_o = 100\text{Hz}$	+25°C	10	30	$pA/\sqrt{Hz}$
	$f_o = 1\text{kHz}$	+25°C	4	10	$pA/\sqrt{Hz}$
Slew Rate	$V_{OUT} = \pm 5V$	-55°C to +125°C	400	250	V/ μs
Full Power Bandwidth	$V_{PEAK} = 10V$	-55°C to +125°C	6.4	3.2	MHz
Settling Time	$A_V = -2V/V$, 10V Step to 0.1%	+25°C	100	150	ns
Differential Gain Error	$f_o \leq 5\text{MHz}$	+25°C	0.1	0.5	%
Differential Phase Error	$f_o \leq 5\text{MHz}$	+25°C	0.2	1	Degree
Output Resistance	$V_{OUT} = 0V$	+25°C	12	Table 3	Ω
	$I_{OUT} > 25\text{mA}$	+25°C	3	10	Ω
Propagation Delay	$V_{OUT} = \pm 200\text{mV}$	+25°C	12	20	ns
Minimum Supply Voltage	Functional Operation Only. Other Parameters Will Vary.	+25°C	± 5	± 7	V

Applying the HA-2542

- POWER SUPPLY DECOUPLING:** Although not absolutely necessary, it is recommended that all power supply lines be decoupled with 0.01 μF ceramic capacitors to ground. Decoupling capacitors should be located as near to the amplifier terminals as possible.
- STABILITY CONSIDERATIONS:** HA-2542 is stable at gains ≥ 2 . Gains < 2 are covered elsewhere in this data sheet. Feedback resistors should be of carbon composition located as near to the input terminals as possible.
- 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.
- OUTPUT SHORT CIRCUIT:** HA-2542 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.
- HEAVY CAPACITIVE LOADS:** When driving heavy capacitive loads ($\geq 100pF$) a small resistor ($\approx 100\Omega$) should be connected in series with the output and inside the feedback loop.
- 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. Also review Application Note 556 for safe operating area information. Maximum power dissipation with load conditions must be designed to maintain the maximum junction temperature below +175°C.

T-79-23

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 Applications

(Refer to Application Note 552 for further information)

The Harris HA-2542 is a state of the art monolithic device which also approaches the "ALL-IN-ONE" amplifier concept. This device features an outstanding set of AC parameters augmented by excellent output drive capability providing for suitable application in both high speed and high output drive circuits.

Primarily intended to be used in balanced 50Ω and 75Ω coaxial cable systems as a driver, the HA-2542 could also be used as a power booster in audio systems as well as a power amp in power supply circuits. This device would also be suitable as a small DC motor driver.

Prototyping Guidelines

For best overall performance in any application, it is recommended that high frequency layout techniques be used. This should include: 1) mounting the device through a ground plane; 2) connecting unused pins (N.C.) to the ground plane; 3) mounting feedback components on Teflon standoffs and/or locating these components as close to the device as possible; 4) placing power supply decoupling capacitors from device supply pins to ground.

As a result of speed and bandwidth optimization, the HA-2542 can's case potential, when powered-up, is equal to the V- potential. Therefore, contact with other circuitry or ground should be avoided.

Frequency Compensation

The HA-2542 may be externally compensated with a single capacitor to ground. This provides the user the additional flexibility in tailoring the frequency response of the amplifier. A guideline to the response is demonstrated on the typical performance curve showing the normalized A.C. parameters versus compensation capacitance. It is suggested that the user check and tailor the accurate compensation value for each application. As shown additional phase margin is achieved at the loss of slew rate and bandwidth.

For example, for a voltage gain of +2 (or -1) and a load of 500pF/2kΩ, 20pF is needed for compensation to give a small signal bandwidth of 30MHz with 40° of phase margin. If a full power output voltage of ±10V is needed, this same configuration will provide a bandwidth of 5MHz and a slew rate of 200V/μs.

If maximum bandwidth is desired and no compensation is needed, care must be given to minimize parasitic capacitance at the compensation pin. In some cases where minimum gain applications are desired, bending up or totally removing this pin may be the solution. In this case, care must also be given to minimize load capacitance.

For wideband positive unity gain applications, the HA-2542 can also be over-compensated with capacitance greater than 30pF to achieve bandwidths of around 25MHz. This over-compensation will also improve capacitive load handling or lower the noise bandwidth. This versatility along with the ±100mA output current makes the HA-2542 an excellent high speed driver for many power applications.

3

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