

## Wideband, Fast Settling Operational Amplifier

March 1993

### Features

- Very High Slew Rate ..... 400V/ $\mu$ s
- Fast Settling Time ..... 140ns
- Wide Gain Bandwidth ( $A_V \geq 10$ ) ..... 400MHz
- Power Bandwidth ..... 6MHz
- Low Offset Voltage ..... 8mV
- Input Voltage Noise ..... 6nV/ $\sqrt{\text{Hz}}$
- Output Voltage Swing .....  $\pm 10V$
- Monolithic Bipolar Construction

### Applications

- Pulse and Video Amplifiers
- Wideband Amplifiers
- High Speed Sample-Hold Circuits
- Fast, Precise D/A Converters

### Ordering Information

PART NUMBER	TEMPERATURE RANGE	PACKAGE
HA1-2540-2	-55°C to +125°C	14 Lead Ceramic DIP
HA1-2540-5	0°C to +75°C	14 Lead Ceramic DIP
HA1-2540-9	-40°C to +85°C	14 Lead Ceramic DIP
HA1-2540C-5	0°C to +75°C	14 Lead Ceramic DIP
HA1-2540C-9	-40°C to +85°C	14 Lead Ceramic DIP
HA3-2540-5	0°C to +75°C	14 Lead Plastic DIP
HA3-2540-9	-40°C to +85°C	14 Lead Plastic DIP
HA3-2540C-5	0°C to +75°C	14 Lead Plastic DIP
HA4P2540-5	0°C to +75°C	20 Lead PLCC
HA9P2540-5	0°C to +75°C	14 Lead SOIC
HA9P2540-9	-40°C to +85°C	14 Lead SOIC
HA9P2540C-5	0°C to +75°C	14 Lead SOIC
HA9P2540C-9	-40°C to +85°C	14 Lead SOIC

### Description

The Harris HA-2540 is a wideband, very high slew rate, monolithic operational amplifier featuring superior speed and bandwidth characteristics. Bipolar construction coupled with dielectric isolation allows this truly differential device to deliver outstanding performance in circuits where closed loop gain is 10 or greater. Additionally, the HA-2540 has a drive capability of  $\pm 10V$  into a 1k $\Omega$  load. Other desirable characteristics include low input voltage noise, low offset voltage, and fast settling time.

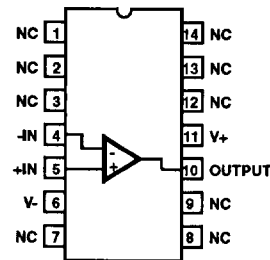
A 400V/ $\mu$ s slew rate ensures high performance in video and pulse amplification circuits, while the 400MHz gain-bandwidth product is ideally suited for wideband signal amplification. A settling time of 140ns also makes the HA-2540 an excellent selection for high speed Data Acquisition Systems.

Refer to Application Note 541 and Application Note 556 for more information on High Speed Op Amp applications. HA-2540/883 MIL-STD-883 data sheet is available on request.

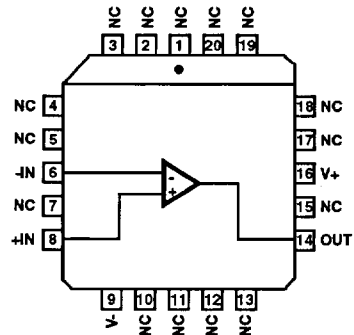
For a lower power version of this product, please see the HA-2840 and HA-2850 datasheets.

### Pinouts

HA-2540 (CDIP, PDIP, SOIC)  
TOP VIEW



HA-2540 (PLCC)  
TOP VIEW



CAUTION: These devices are sensitive to electrostatic discharge. Users should follow proper I.C. Handling Procedures.  
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File Number 2897.1

## Specifications HA-2540

### Absolute Maximum Ratings (Note 1)

Voltage Between V+ and V- Terminals	35V
Differential Input Voltage	6V
Output Current	33mA <sub>RMS</sub> (Continuous), 50mA (Peak)
Internal Power Dissipation (Note 2)	
Junction Temperature	+175°C
Junction Temperature (Plastic Packages)	+150°C
Lead Temperature (Soldering 10s)	+300°C

### Operating Conditions

Operating Temperature Range	
HA-2540-2	-55°C ≤ T <sub>A</sub> ≤ +125°C
HA-2540/2540C-5	0°C ≤ T <sub>A</sub> ≤ +75°C
HA-2540/2540C-9	-40°C ≤ T <sub>A</sub> ≤ +85°C
Storage Temperature Range	-65°C ≤ T <sub>A</sub> ≤ +150°C

**CAUTION:** Stresses above those listed in "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress only rating and operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied.

### Electrical Specifications V<sub>SUPPLY</sub> = ±15V, R<sub>L</sub> = 1kΩ, C<sub>L</sub> < 10pF, Unless Otherwise Specified.

PARAMETER	TEMP	HA-2540-2			HA-2540-5, -9			HA-2540C-5, -9			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
<b>INPUT CHARACTERISTICS</b>											
Offset Voltage	+25°C	-	8	10	-	8	15	-	8	15	mV
	Full	-	13	15	-	13	20	-	13	20	mV
Average Offset Voltage Drift	Full	-	20	-	-	20	-	-	20	-	μV/°C
Bias Current	+25°C	-	5	20	-	5	20	-	5	20	μA
	Full	-	-	25	-	-	25	-	-	25	μA
Offset Current	+25°C	-	1	6	-	1	6	-	1	6	μA
	Full	-	-	8	-	-	8	-	-	8	μA
Input Resistance	+25°C	-	10	-	-	10	-	-	10	-	kΩ
Input Capacitance	+25°C	-	1	-	-	1	-	-	1	-	pF
Common Mode Range	Full	±10	-	-	±10	-	-	±10	-	-	V
Input Noise Current (f = 1kHz, R <sub>SOURCE</sub> = 0Ω)	+25°C	-	6	-	-	6	-	-	6	-	pA√Hz
Input Noise Voltage (f = 1kHz, R <sub>SOURCE</sub> = 0Ω)	+25°C	-	6	-	-	6	-	-	6	-	nV√Hz
<b>TRANSFER CHARACTERISTICS</b>											
Large Signal Voltage Gain (Note 3)	+25°C	10	15	-	10	15	-	7	10	-	kV/V
	Full	5	-	-	5	-	-	5	-	-	kV/V
Common-Mode Rejection Ratio (Note 4)	Full	60	72	-	60	72	-	60	72	-	dB
Minimum Stable Gain	+25°C	10	-	-	10	-	-	10	-	-	V/V
Gain Bandwidth Product (Notes 5 & 6)	+25°C	-	400	-	-	400	-	-	400	-	MHz
<b>OUTPUT CHARACTERISTICS</b>											
Output Voltage Swing (Note 3, 10)	Full	±10	-	-	±10	-	-	±10	-	-	V
Output Current (Note 3)	+25°C	±10	±20	-	±10	±20	-	±10	±20	-	mA
Output Resistance	+25°C	-	30	-	-	30	-	-	30	-	Ω
Full Power Bandwidth (Notes 3, 7)	+25°C	5.5	6	-	5.5	6	-	5.5	6	-	MHz

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OPERATIONAL AMPLIFIERS

## Specifications HA-2540

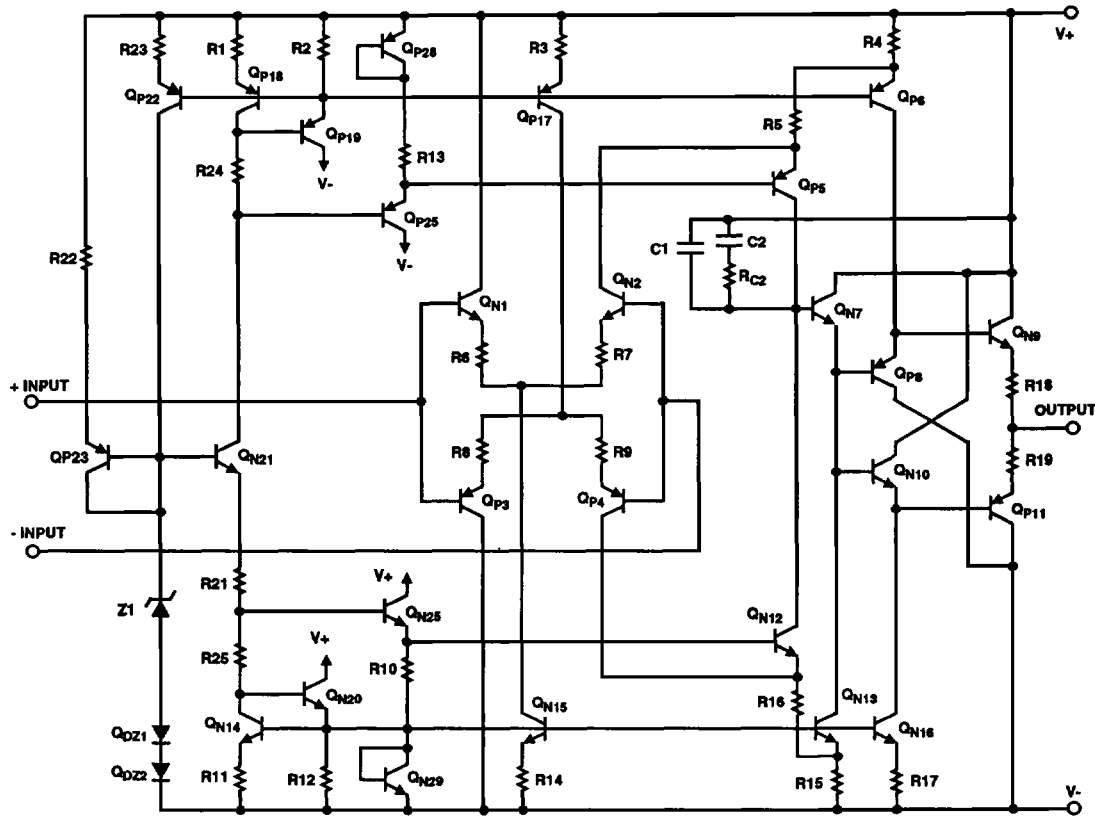
### Electrical Specifications $V_{SUPPLY} = \pm 15V$ , $R_L = 1k\Omega$ , $C_L < 10pF$ , Unless Otherwise Specified. (Continued)

PARAMETER	TEMP	HA-2540-2			HA-2540-5, -9			HA-2540C-5, -9			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
<b>TRANSIENT RESPONSE (Note 8)</b>											
Rise Time	+25°C	-	14	-	-	14	-	-	14	-	ns
Overshoot	+25°C	-	5	-	-	5	-	-	5	-	%
Slew Rate	+25°C	320	400	-	320	400	-	320	400	-	V/ $\mu$ s
Settling Time: 10V Step to 0.1%	+25°C	-	140	-	-	140	-	-	140	-	ns
<b>POWER REQUIREMENTS</b>											
Supply Current	Full	-	20	25	-	20	25	-	20	25	mA
Power Supply Rejection Ratio (Note 9)	Full	60	70	-	60	70	-	60	70	-	dB

**NOTES:**

1. 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.
2. Maximum power dissipation with load conditions must be designed to maintain the maximum junction temperature below +175°C for the ceramic package, and below +150°C for the plastic package. By using Application Note 556 on Safe Operating Area Equations, along with the packaging thermal resistances listed in the Die Characteristics section, proper load conditions can be determined. Heat sinking is recommended above +75°C with suggested models:  
Thermalloy #6007 ( $\theta_{SA} \approx 40^\circ\text{C/W}$ ) or AAVID #5602B ( $\theta_{SA} \approx 16^\circ\text{C/W}$ ).
3.  $R_L = 1k\Omega$ ,  $V_O = \pm 10V$ .
4.  $V_{CM} = \pm 10V$ .
5.  $V_O = 90mV$ .
6.  $A_V = 10$ .
7. Full power bandwidth guaranteed based on slew rate measurement using: 
$$FPBW = \frac{\text{Slew Rate}}{2\pi V_{PEAK}}$$
8. Refer to Test Circuits section of the data sheet.
9.  $V_{SUPPLY} = +5V, -15V$  and  $+15V, -5V$ .
10. Guaranteed range for output voltage is  $\pm 10V$ . Functional operation outside of this range is not guaranteed.

Schematic Diagram



Die Characteristics

Transistor Count .....	30
Die Dimensions .....	75 x 61 x 19 mils (1910 $\mu$ m x 1550 $\mu$ m x 483 $\mu$ m)
Substrate Potential (Power Up)* .....	V-
Process .....	High Frequency Bipolar-DI
Passivation .....	Nitride

Thermal Constants ( $^{\circ}$ C/W)	$\theta_{JA}$	$\theta_{JC}$
Ceramic DIP .....	71	14
Plastic DIP .....	107	38
SOIC .....	119	36
PLCC .....	74	33

\*The substrate may be left floating (Insulating Die Mount) or it may be mounted on a conductor at V- potential.

Test Circuits

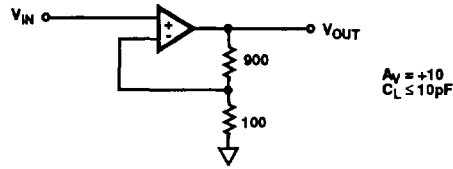
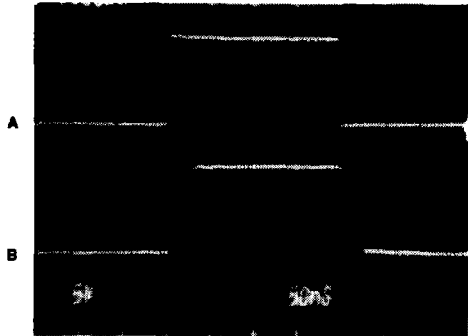


FIGURE 1. LARGE AND SMALL SIGNAL RESPONSE TEST CIRCUIT

LARGE SIGNAL RESPONSE

Vertical Scale: (Volts: A = 0.5V/Div., B = 5.0V/Div.)  
Horizontal Scale: (Time: 50ns/Div.)



SMALL SIGNAL RESPONSE

Vertical Scale: Input = 10mV/Div.; Output = 50mV/Div.  
Horizontal Scale: 20ns/Div.

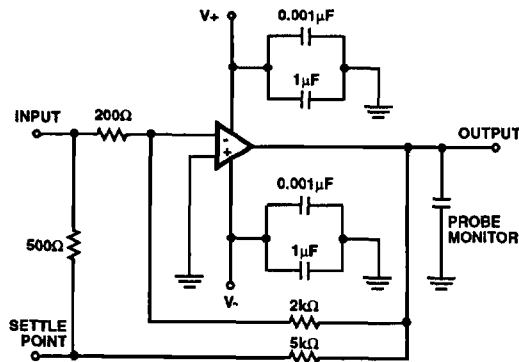
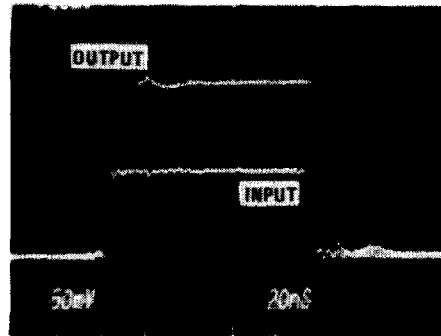


FIGURE 2. SETTLING TIME TEST CIRCUIT

- $A_V = -10$ .
- Load Capacitance should be less than 10pF. Turn on time delay typically 4ns.
- It is recommended that resistors be carbon composition and the 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.

Performance Curves

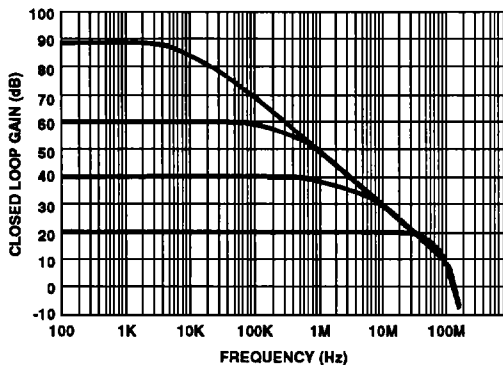


FIGURE 3. CLOSED LOOP FREQUENCY RESPONSE

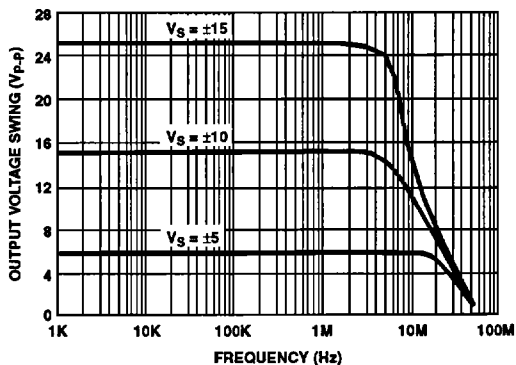


FIGURE 4. OUTPUT VOLTAGE SWING vs FREQUENCY

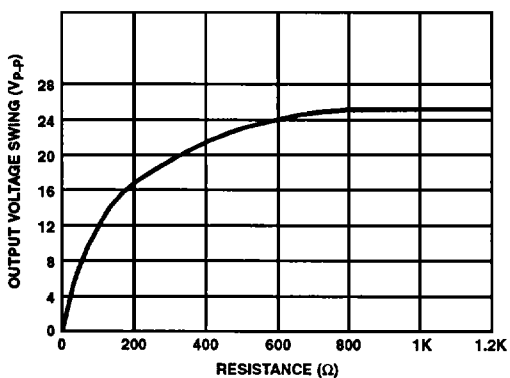


FIGURE 5. OUTPUT VOLTAGE SWING vs LOAD RESISTANCE

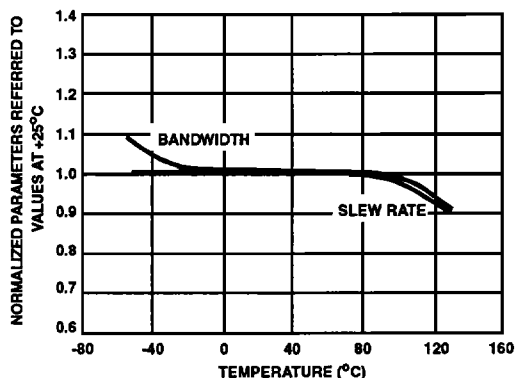


FIGURE 6. NORMALIZED AC PARAMETERS vs TEMPERATURE

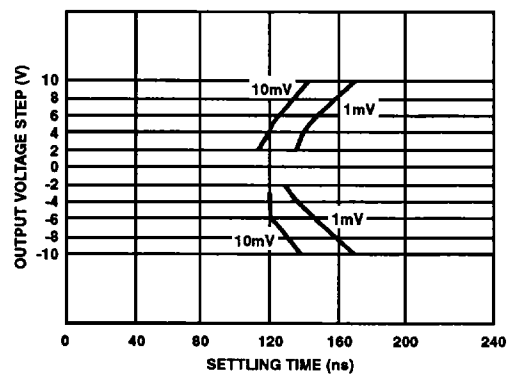


FIGURE 7. SETTLING TIME FOR VARIOUS OUTPUT STEP VOLTAGES

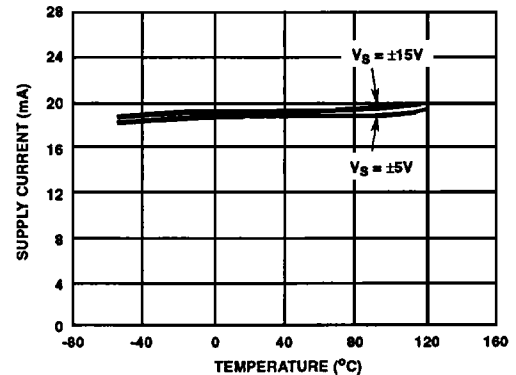


FIGURE 8. POWER SUPPLY CURRENT vs TEMPERATURE AND SUPPLY VOLTAGE

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OPERATIONAL  
AMPLIFIERS

Performance Curves (Continued)

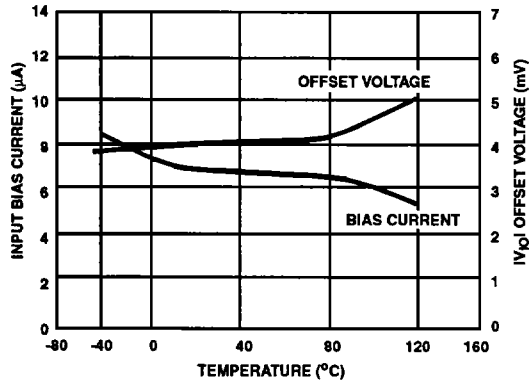


FIGURE 9. INPUT OFFSET VOLTAGE AND BIAS CURRENT vs TEMPERATURE

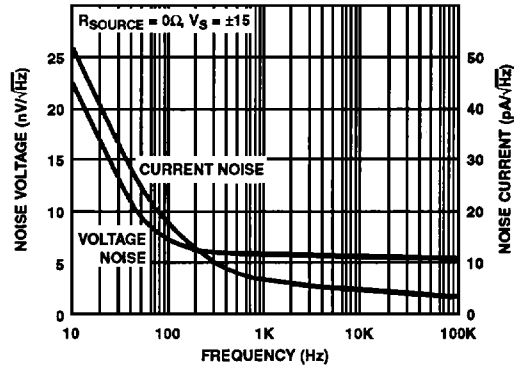


FIGURE 10. INPUT NOISE VOLTAGE AND NOISE CURRENT vs FREQUENCY

Vertical Scale: 10mV/Div.  
Horizontal Scale: 50ms/Div.

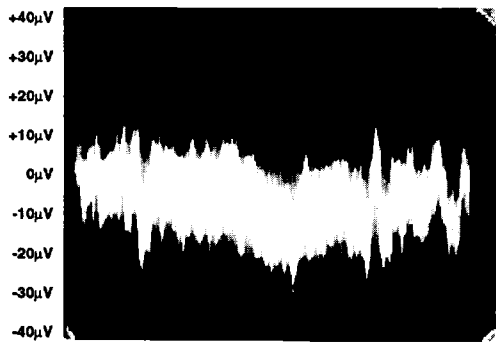


FIGURE 11. BROADBAND NOISE (0.1Hz TO 1MHz)

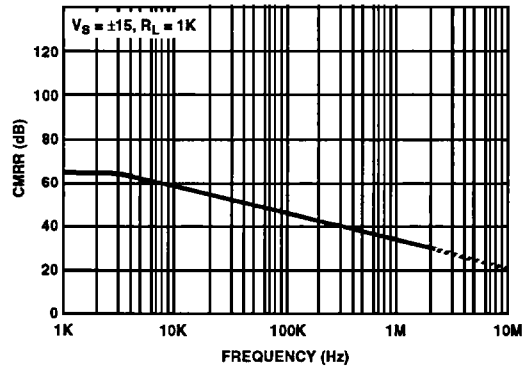


FIGURE 12. COMMON MODE REJECTION RATIO vs FREQUENCY

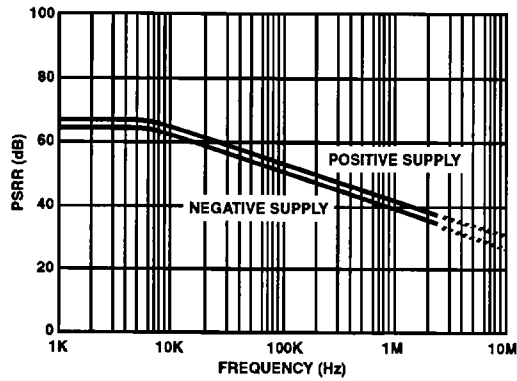


FIGURE 13. POWER SUPPLY REJECTION RATIO vs FREQUENCY

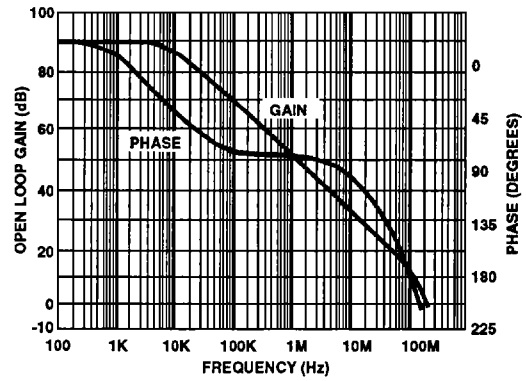


FIGURE 14. OPEN LOOP GAIN/PHASE vs FREQUENCY

Applications

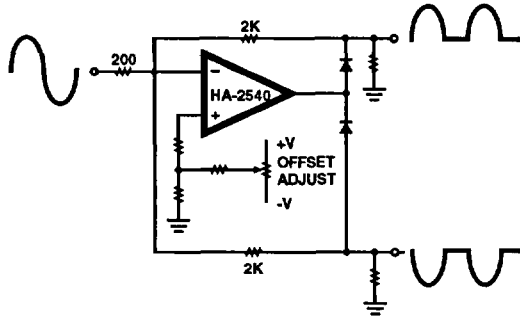


FIGURE 15. WIDEBAND SIGNAL SPLITTER

NOTE: With one HA-2540 and two low capacitance switching diodes, signals exceeding 10MHz can be separated. This circuit is most useful for full wave rectification, AM detectors or sync generation.

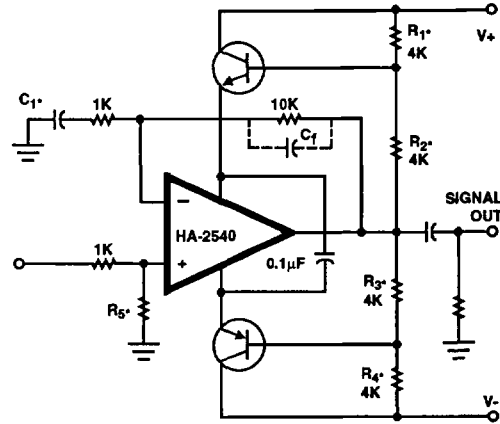


FIGURE 16. BOOTSTRAPPING FOR MORE OUTPUT CURRENT AND VOLTAGE SWING

NOTES:

1. Used for experimental purposes.  $C_1 \approx 3\text{pF}$ .
2.  $C_1$  is optional ( $0.001\mu\text{F} \rightarrow 0.01\mu\text{F}$  ceramic).
3.  $R_5$  is optional and can be utilized to reduce input signal amplitude and/or balance input conditions.  $R_5 = 500\Omega$  to  $1\text{k}\Omega$ .

Refer to Application Note 541 For Further Applications Information