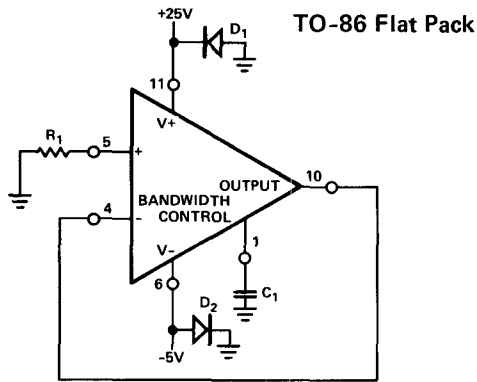


# BURN-IN CIRCUITS

1

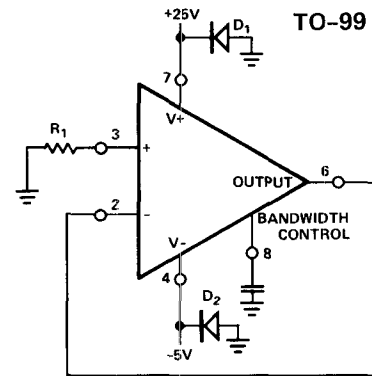
HA-909



NOTES:  
 $T_A = +125^\circ\text{C}$   
 $R_1 = 1 \text{ Megohm}$   
 $C_1 = 0.01 \mu\text{F}, 100\text{V}$

2

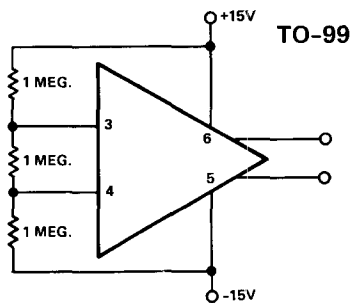
HA-909, HA-2500, HA-2502, HA-2510, HA-2512, HA-2520, HA-2522, HA-2600, HA-2602, HA-2620, HA-2622, HA-2050, HA-2050A, HA-2060, HA-2060A



NOTES:  
 $T_A = +125^\circ\text{C}$   
 $R_1 = 1 \text{ Megohm}$   
 $C_1 = 0.01 \mu\text{F}, 100\text{V}$

3

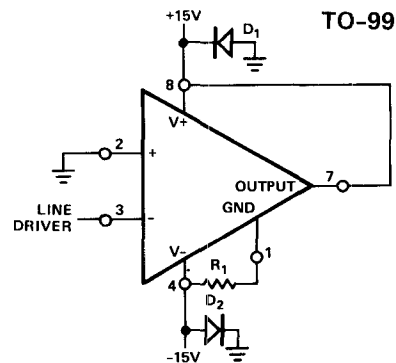
HA-2000



CIRCUIT TYPE:  
 FET Front End  
 DESIGNATION:  
 HA-2000  
 OPERATING LIFE TEST CONDITION:  
 1) TEMPERATURE:  $+125^\circ\text{C}$   
 2) VOLTAGE:  $\pm 15 \text{ Volts}$

4

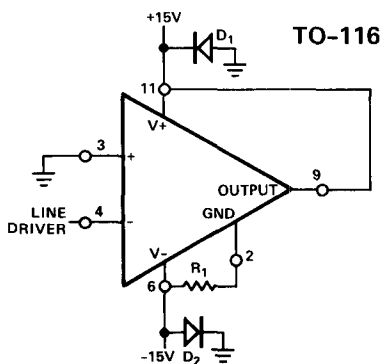
HA-2111



NOTES:  
 $T_A = +125^\circ\text{C}$   
 $R_1 = 300 \Omega$   
 $D_{1,2} = \text{IN4002}$   
 Freq: 50 KHz @ 12V peak to peak

5

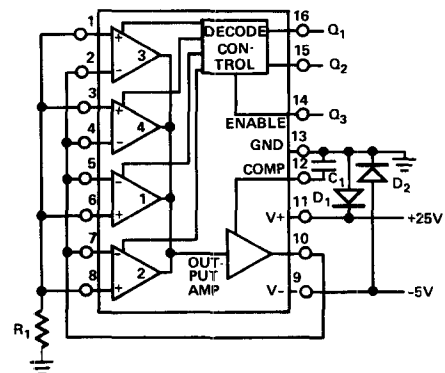
HA-2111



NOTES:  
 $T_A = +125^\circ\text{C}$   
 $R_1 = 300 \Omega$   
 $D_{1,2} = \text{IN4002}$   
 Freq: = 50KHz @ 12V peak to peak

6

HA-2400



NOTES:  
 $T_A = +125^\circ\text{C}$   
 $R_1 = 100\text{K}\Omega$   
 $C_1 = 910\text{pF}, 50\text{V}$   
 $D_{1,2} = \text{IN4002}$   
 Freq:  $Q_1 = 100\text{KHz}; Q_2 = 50\text{KHz}; Q_3 = 25\text{KHz}$

DASH 8

# HARRIS OPERATIONAL AMPLIFIERS

## Selection Guide for Military Applications

PARAMETER†	-55°C to +125°C												UNITS	
	HA-909	F.E.T. PREAMP		HA-2050	HA-2050A	HA-2060	HA-2060A	PRAM™	S/H	HA-2500	HA-2502	HA-2510		HA-2512
	HA-2000	HA-2000A												
<b>INPUT CHARACTERISTICS</b>														
Offset Voltage	6	25	12	30	17	30	15	7	6	8	10	11	14	mV
Drift (Typ.)	10	50	20	50	20	50	20	20	5	20	20	20	25	μV/°C
Bias Current	300 (1)	10	10	10	10	10	10	400	400	400	500	400	500	nA
Offset Current	300	5	5	5	5	5	5	100	100	50	100	50	100	nA
Common Mode Range	±12	±10	±10	±10	±10	±10	±10	±10	±10	±10	±10	±10	±10	V
<b>INPUT NOISE (1)</b>														
	5													μVRMS
<b>TRANSFER CHARACTERISTICS</b>														
Large Signal Voltage Gain	25K	.98	.98	5K	5K	60K	60K	25K	25K	15K	10K	7.5K	5K	V/V
Common Mode Rejection Ratio	80	80	80	74	74	74	74	80	80	80	74	80	74	dB
Bandwidth (Typ.) (1)	7	10	10	20(3)	20(3)	24(3)	24(3)	16(3)	2	12	12	12	12	MHz
<b>OUTPUT CHARACTERISTICS</b>														
Output Voltage Swing	±12	±10	±10	±10	±10	±10	±10	±10	±10	±10	±10	±10	±10	V
Output Current (1)	±20	+5(1)	+5(1)	±10(1)	±10(1)	±10(1)	±10(1)	±20(1)	±10	±10	±10	±10	±10	mA
Full Power Bandwidth (Typ.) (1)	25	1,000(3)	1,000(3)	2,000(3)	2,000(3)	600(3)	600(3)	500(3)	70	500	500	1,000	1,000	kHz
<b>TRANSIENT RESPONSE</b>														
Rise Time (1)	75	50(3)	50(3)	50(3)	50(3)	50(3)	50(3)	20(3)	100(3)	50	50	50	50	ns
Overshoot (1)	40	5(3)	5(3)	25(3)	25(3)	25(3)	25(3)	25(3)	20(3)	40	50	40	50	%
Slew Rate (1)	±1.2	100(3)	100(3)	120(3)	120(3)	35(3)	35(3)	50(3)	5(3)	±25	±20	±50	±40	V/μs
Settling Time (Typ.) (1)	(2)	(3) 0.4	(3) 0.4	(3) 0.4	(3) 0.4	(3) 0.8	(3) 0.8	(3) 1.5		0.33	0.33	0.25	0.25	μs
<b>POWER SUPPLY CHARACTERISTICS</b>														
Supply Current (1)	2.5	(1) 1.7	(1) 1.7	(1) 8.0	(1) 8.0	(1) 6.0	(1) 6.0	(1) 6.0	5.0	6.0	6.0	6.0	6.0	mA
Power Supply Rejection Ratio	80	80	80	74	74	74	74	80	80	80	74	80	74	dB
<b>FUNCTIONAL CHARACTERISTICS</b>														
Offset Adjust	Yes*	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	
Compensation Components	0	0	0	0AV>3	0AV>3	0AV>5	0AV>5	0AV>10	0	0	0	0	0	
Output Protection	No	No	No	No	No	Yes	Yes	Yes	Yes	No	No	No	No	

PARAMETER†	-55°C to +125°C													UNITS	
	HA-2520	HA-2522	HA-2530	HA-2600	HA-2602	HA-2620	HA-2622	HA-2630	HA-2640	HA-2650	HA-2700	HA-2720	HA-2730		HA-2900
<b>INPUT CHARACTERISTICS</b>															
Offset Voltage	11	14	3	6	7	6	7	±300	6	±5	5	(5)	(5)	.06	mV
Drift (Typ.)	20	25	5	5	5	5	5	(2)	15	8	5	8 to 10	8 to 10	.3	μV/°C
Bias Current	400	500	100	30	60	35	60	200	50	200	50	10 to 40	10 to 40	1	nA
Offset Current	50	100	20	30	60	35	60	(2)	35	60	30	7.5 to 20	7.5 to 20	.5	nA
Common Mode Range	±10	±10	±.5	±11	±11	±11	11	±10	±35(4)	±13	±11	±10	±10	±10	V
<b>INPUT NOISE (1)</b>															
												(5)	(5)		μVRMS
<b>TRANSFER CHARACTERISTICS</b>															
Large Signal Voltage Gain	7.5K	5K	100K	70K	60K	70K	60K	.85	75K	20K	100K	25K	25K	10 <sup>6</sup>	V/V
Common Mode Rejection Ratio	80	74	86	80	74	80	74	(2)	80	80	86	80	80	120	dB
Bandwidth (Typ.) (1)	25	25	20	12	12	35	35	8	4	8	1	.01 to 10	.01 to 10	3	MHz
<b>OUTPUT CHARACTERISTICS</b>															
Output Voltage Swing	±10	±10	±10	±10	±10	±10	±10	±10	±35(4)	±13	±11	±13.5(3)	±13.5(3)	±10	V
Output Current (1)	±10	±10	±25	±15	±10	±10	±10	±400	±12	20(3)	±22(3)	±.5 to 5.0(3)	±.5 to 5.0(3)	±10	mA
Full Power Bandwidth (Typ.) (1)	1,500	1,500	5,000	75	75	600	600	8,000	23	30	50	1.5 to 80(3)	1.5 to 80(3)	40	kHz
<b>TRANSIENT RESPONSE</b>															
Rise Time (1)	50	50	40	60	60	45	45	30(3)	60(3)	40(3)	(2)	200 to 2,000(3)	200 to 2,000(3)	200(3)	ns
Overshoot (1)	40	50	45	40	40	(2)	(2)	25(3)	15(3)	15(3)	(2)	5 to 15(3)	5 to 15(3)	20(3)	%
Slew Rate (1)	±100	±80	±280	±4	±4	±25	±20	200	5(3)	±2	±10	.1 to .8(3)	.1 to .8(3)	2.5(3)	V/μs
Settling Time (Typ.) (1)	0.20	0.20	.5	1.5	1.5	0.30	0.30	.5(3)	1.5(3)	1.5(3)	5.0	(2)	(2)	(2)	μs
<b>POWER SUPPLY CHARACTERISTICS</b>															
Supply Current (1)	6.0	6.0	6	3.7	4.0	3.7	4.0	20	3.8	3	0.15	(5)	(5)		mA
Power Supply Rejection Ratio	80	74	86	80	74	80	74	66	80	80	86	.02 to .2	.02 to .2	5	dB
<b>FUNCTIONAL CHARACTERISTICS</b>															
Offset Adjust	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	Dip Pkg. Only	Yes	Yes	Yes	No	
Compensation Components	0AV>3	0AV>3	1	0	0	0AV>5	0AV>5	0	0	0	0	0	0	3	
Output Protection	No	No	No	Yes	Yes	Yes	Yes	External	Yes	Yes	Yes	Yes	Yes	Yes	

- (1) At +25°C                      (3) Typical                      (5) Dependent upon I<sub>set</sub> value  
(2) Not applicable or not specified      (4) V supply = ±40V

\* TO-86 only                      † Guaranteed for ±15V supplies and applicable temperature range unless otherwise specified



**HARRIS**  
SEMICONDUCTOR  
A DIVISION OF HARRIS CORPORATION

# HA-2000/2005/2000A/2005A

## F.E.T. Input Preamplifier

LINEAR

### FEATURES

- CONVERTS ANY OP AMP OR COMPARATOR TO F.E.T. INPUT
- INPUT BIAS CURRENT: 1pA
- INPUT RESISTANCE:  $10^{12}$  OHMS
- SLEW RATE: 100 V/ $\mu$ S
- BANDWIDTH: 10 MHz
- MEETS MIL-STD-883 REQUIREMENTS

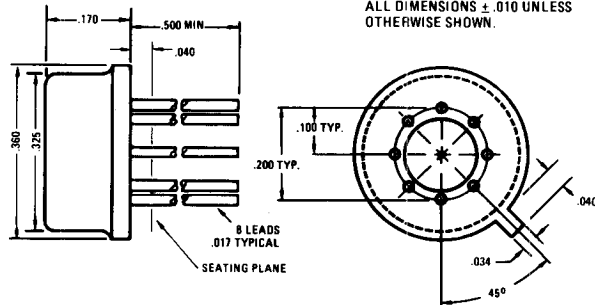
### DESCRIPTION

The HA-2000/2005 is a monolithic unity gain differential amplifier stage with J.F.E.T. inputs and bipolar transistor outputs. It is intended for use as a preamplifier for operational amplifiers and comparators to produce high input resistance and low bias currents without sacrificing high speed performance. The circuit has a much wider common mode range than simple F.E.T. pairs, allowing op amps to be connected as voltage followers with full output swing. The circuit can also be used as a high impedance unity gain buffer for differential or two single-ended signals for frequencies from D.C. to R.F.

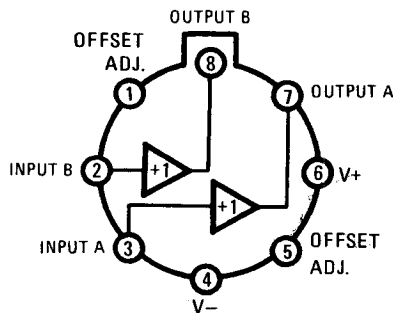
The HA-2000 is guaranteed for operation from  $-55^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$  while the HA-2005 is guaranteed from  $0^{\circ}\text{C}$  to  $+75^{\circ}\text{C}$ .

### PACKAGES

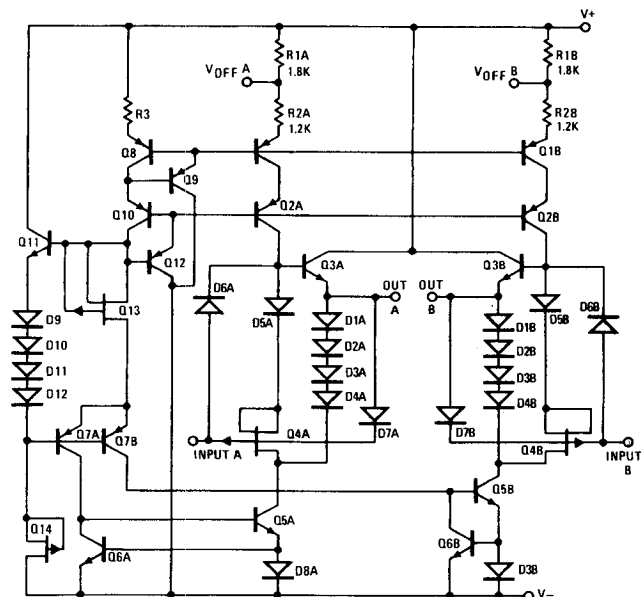
#### CODE 2A



#### PIN-OUT



### SCHEMATIC



# SPECIFICATIONS

## ABSOLUTE MAXIMUM RATINGS

Voltage Between V+ and V- Terminals	35V	Internal Power Dissipation (Note 8)	300mW
Differential Input Voltage	$\pm V_{Supply}$	Operating Temp. Range	$-55^{\circ}\text{C} \leq T_A \leq +125^{\circ}\text{C}$ (HA-2000)
Output Current	30mA		$0^{\circ}\text{C} \leq T_A \leq +75^{\circ}\text{C}$ (HA-2005)
		Storage Temp. Range	$-65^{\circ}\text{C} \leq T_A \leq +150^{\circ}\text{C}$

## ELECTRICAL CHARACTERISTICS

PARAMETER	TEMP.	HA-2000/HA-2000A			HA-2005/HA-2005A			UNITS
		$-55^{\circ}\text{C}$ to $+125^{\circ}\text{C}$			$0^{\circ}\text{C}$ to $+75^{\circ}\text{C}$			
		MIN.	LIMITS TYP.	MAX.	MIN.	LIMITS TYP.	MAX.	
<b>INPUT CHARACTERISTICS</b>								
Offset Voltage (Note 1)	$+25^{\circ}\text{C}$		12	20		25	50	mV
HA-2000 / HA-2005		Full		25		55		mV
	$+25^{\circ}\text{C}$		5	10		5	10	mV
HA-2000A / HA-2005A		Full		12		12		mV
Bias Current	$+25^{\circ}\text{C}$		1	20		1	20	$\rho\text{A}$
		Full		0.5	10		0.02	1
Offset Current	$+25^{\circ}\text{C}$		0.5	20		0.5	20	$\rho\text{A}$
		Full		0.1	5		.005	.5
Input Resistance	$+25^{\circ}\text{C}$		$10^{12}$			$10^{12}$		$\Omega$
Input Capacitance	$+25^{\circ}\text{C}$		5			5		$\rho\text{F}$
Common Mode Range	Full	$\pm 10.0$			$\pm 10.0$			V
<b>TRANSFER CHARACTERISTICS</b>								
Large Signal Voltage Gain (Note 2)	$+25^{\circ}\text{C}$	.98	.999		.98	.999		V/V
		Full	.98			.98		
Common Mode Rejection Ratio (Note 3)	Full	80	90		70	90		dB
-3dB Bandwidth	$+25^{\circ}\text{C}$		10			10		MHz
<b>OUTPUT CHARACTERISTICS</b>								
Output Voltage Swing (Note 2)	Full	$\pm 10$			$\pm 10$			V
Output Current Source	$+25^{\circ}\text{C}$	+5			+5			mA
Sink	$+25^{\circ}\text{C}$	-65			-65			$\mu\text{A}$
Output Common Mode Offset Voltage	Full			0.5			0.5	V
Full Power Bandwidth (Notes 4,5)	$+25^{\circ}\text{C}$		1,000			1,000		kHz
<b>TRANSIENT RESPONSE</b>								
Rise Time (Notes 4,6)	$+25^{\circ}\text{C}$		50			50		ns
Overshoot (Notes 4,6)	$+25^{\circ}\text{C}$		5			5		%
Slew Rate (Notes 4,5)	$+25^{\circ}\text{C}$		100			100		V/ $\mu\text{s}$
<b>POWER SUPPLY CHARACTERISTICS</b>								
Supply Current	$+25^{\circ}\text{C}$		0.7	1.7		0.7	1.7	mA
Power supply Rejection Ratio (Note 7)	Full	80	90		70	90		dB

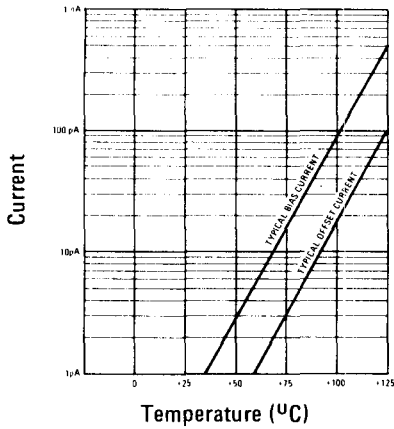
- NOTES: 1. Adjustable to 0 with  $100\text{K}\Omega$  pot between pins 1 and 5 wiper to V+
2.  $R_L = 1\text{M}$
3.  $V_{CM} = \pm 5.0\text{V}$

4.  $R_L = 10\text{K}$  to V-
5.  $V_O = \pm 10\text{V}$
6.  $V_O = \pm 200\text{mV}$
7.  $V_S = \pm 9\text{V}$  to  $\pm 15\text{V}$
8. Derate by  $6.6\text{mW}/^{\circ}\text{C}$  above  $105^{\circ}\text{C}$

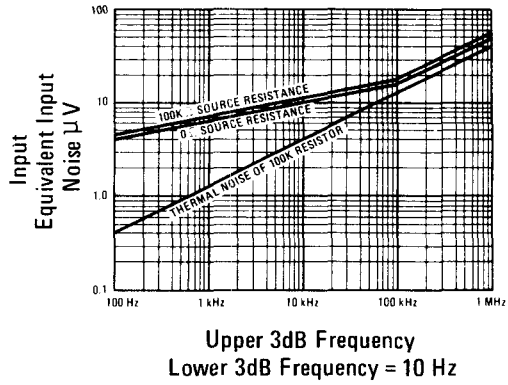
# PERFORMANCE CURVES

$V+ = 15\text{ VDC}$ ,  $V- = 15\text{ VDC}$ ,  $T_A = 25^\circ\text{C}$  UNLESS OTHERWISE STATED.

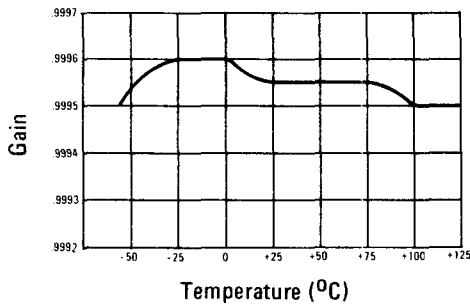
INPUT BIAS AND OFFSET CURRENT VS. TEMPERATURE



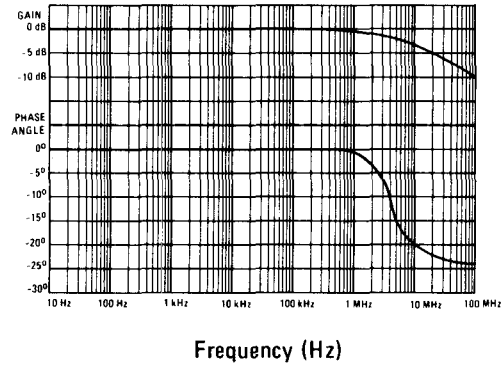
EQUIVALENT INPUT NOISE VS. BANDWIDTH



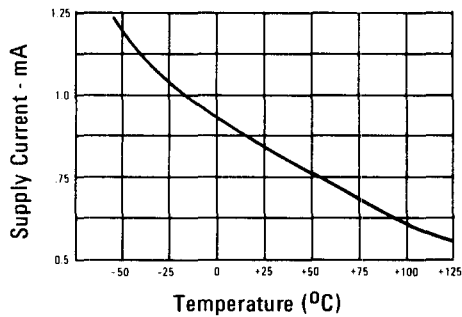
D.C. GAIN VS. TEMPERATURE



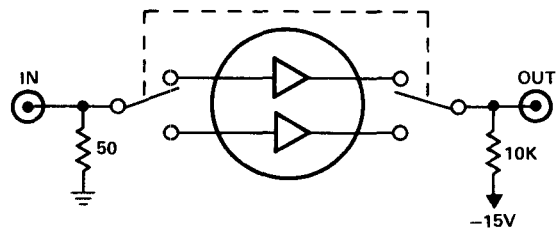
GAIN, PHASE ANGLE VS. FREQUENCY



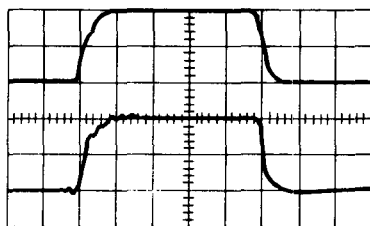
POWER SUPPLY CURRENT VS. TEMPERATURE



TRANSIENT RESPONSE, SLEW RATE TEST HOOK-UP



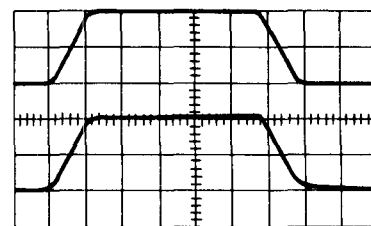
TYP. TRANSIENT RESPONSE WAVEFORM



Typical Transient Response Waveforms

Upper Trace: Input      Vertical Scale: 100mV/Div.  
Lower Trace: Output      Horizontal Scale: 100ns/Div.

TYP. SLEWING RESPONSE WAVEFORM

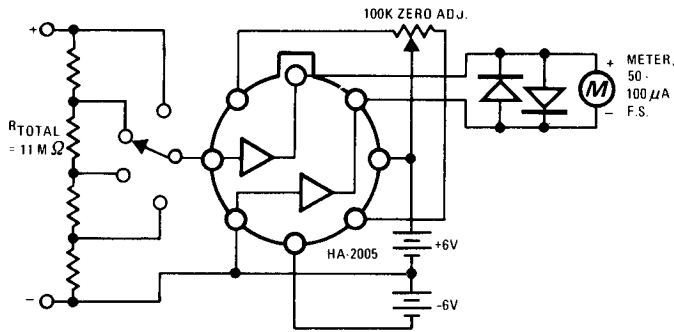


Typical Slewing Response Waveforms

Upper Trace: Input      Vertical Scale: 5V/Div.  
Lower Trace: Output      Horizontal Scale: 100ns/Div.

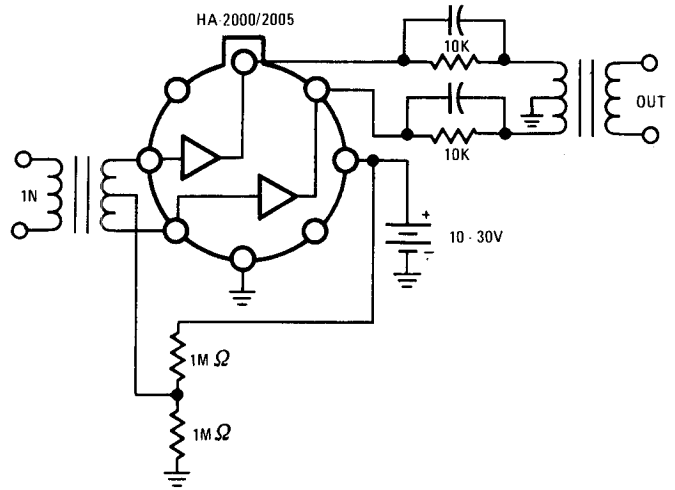
LINEAR

# TYPICAL APPLICATIONS

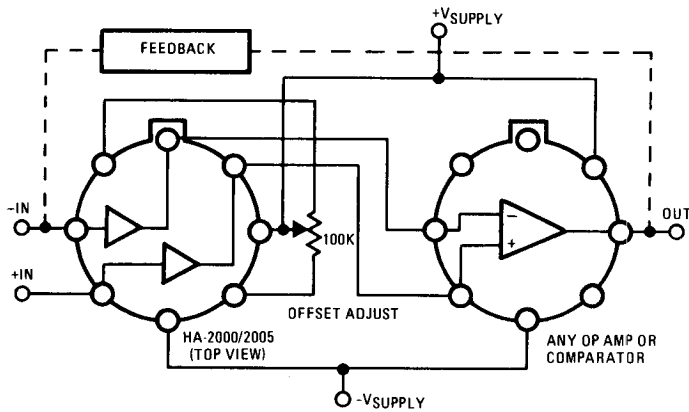


F.E.T. VOLTMETER

BALANCED LINE AMPLIFIER FOR AUDIO TO 100MHz SIGNALS



LINEAR



HOOKUP TO CREATE F.E.T. INPUT OP AMP OR COMPARATOR

ALTERNATE HOOKUP TO ADJUST FOR MINIMUM OFFSET VOLTAGE TEMPERATURE COEFFICIENT

Adjust  $R_1$  to point of minimum offset voltage change over temperature range. Adjust  $R_2$  to zero offset voltage. Drifts of less than  $10 \mu V / \text{oC}$  can typically be achieved.

