HARRIS OPERATIONAL AMPLIFIERS

Selection Guide

for Commercial/Industrial Applications

PARAMETER †	0°C to +75°C													UNITS
		F.E.T. PREAMP						PRAM™	S/H					
	HA-911	HA-2005	HA-2005A	HA-2055	HA-2055A	HA-2065	HA-2065A	HA-2405	HA-2425	HA-2505	HA-2515	HA-2525	HA-2535	
INPUT CHARACTERISTICS														
Offset Voltage	7.5	55	12	65	17	65	15	11	8	10	14	14	5	mV
Drift (Typ.)	15	60	40	60	40	60	40	30	5	20	30	20	5	µV/°C
Bias Current	750	1	1	1	1	1	1	500	400	500	500	500	200	nA
Offset Current	450	.5	.5	.5	.5	.5	.5	100	100	100	100	100	20	nA
Common Mode Range	±12	±10	±10	±10	±10	±10	±10	±10	±10	±10	±10	±10	± .5	V
INPUT NOISE (3)	1													µVRMS
TRANSFER CHARACTERISTICS														
Large Signal Voltage Gain	15K	.98	.98	5K	5K	70K	70K	25K	25K	10K	5K	5K	100K	V/V
Common Mode Rejection Ratio	74	70	70	70	70	70	70	74	74	74	74	74	80	dB
Bandwidth (Typ.)	7	10(3)	10(3)	20(3)	20(3)	24(3)	24(3)	18(3)	2(3)	12(3)	12(3)	25	20	MHz
OUTPUT CHARACTERISTICS														
Output Voltage Swing	±11	±10	±10	±10	±10	±10	±10	±10	±10	±10	±10	±10	±10	V
Output Current (1)	±15	± 5	± 5	±10(1)	±10(1)	±10(1)	±10(1)	20(3)	±10	±10	±10	±10	±25	mA
Full Power Bandwidth (Typ.)(1)	35	1,000(3)	1,000(3)	2,000(3)	2,000(3)	600(3)	600(3)	200(3)	70(3)	500	1,000	1,500	5,000	kHz
TRANSIENT RESPONSE														
Rise Time (1)	75	50(3)	50(3)	50(3)	50(3)	50(3)	50(3)	20	100(3)	50	50	50	40	ns
Overshoot (1)	40	5(3)	5(3)	25(3)	25(3)	25(3)	25(3)	25	20(3)	50	50	50	50	%
Slew Rate (1)	± 2.3	100(3)	100(3)	120(3)	120(3)	35(3)	35(3)	15	5(3)	± 20	±40	± 80	±250	V/µs
Settling Time (Typ.) (1)	(2)	0.4(3)	0.4(3)	(3) 0.4	0.4(3)	.8(3)	.8(3)	1.5		0.33	0.25	0.20	.5	µs
POWER SUPPLY CHARACTERISTICS														
Supply Current (1)	2.5	1.7	1.7	8.0	8.0	6.0	6.0	6.0	5.0	6.0	6.0	6.0	6	mA
Power Supply Rejection Ratio	74	70	70	70	70	70	70	74	74	74	74	74	80	dB
FUNCTIONAL CHARACTERISTICS														
Offset Adjust	No	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	
Compensation Components	0	0	0	0 AV>3	0 AV>5	0AV>5	0AV>5	0 AV>10	0	0	0	0AV>3	1	
Output Protection	No	No	No	No	No	Yes	Yes	No	Yes	No	No	No	No	

PARAMETER†	0°C to +75°C									-25°C to +85°C			UNITS
										PRAM™			
	HA-2605	HA-2625	HA-2635	HA-2645	HA-2655	HA-2705	HA-2725	HA-2735	HA-2905	HA-2404	HA-2704	HA-2904	
INPUT CHARACTERISTICS													
Offset Voltage	7	7	300	7	7	7	7	7	.08	7	6	.05	mV
Drift (Typ.)	5	5	(2)	15	8	5	8 to 10	8 to 10	.2	20	5	.2	µV/°C
Bias Current	40	40	200	50	300	70	10 to 40	10 to 40	1	400	50	1	nA
Offset Current	40	40	(2)	50	100	40	7.5 to 20	7.5 to 20	.5	100	30	.5	nA
Common Mode Range	±11	±11	(2)	±35(4)	±13	±11	±10	±10	±10	±10	±11	±10	V
INPUT NOISE (3)													µVRMS
TRANSFER CHARACTERISTICS													
Large Signal Voltage Gain	70K	70K	.85	75K	15K	100K	20K	20K	10^6	25K	100K	10^7	V/V
Common Mode Rejection Ratio	74	74	(2)	74	74	80	74	74	120	80	86	130	dB
Bandwidth (Typ.) (1)	12	35	8	4	8	1	.01 to 10	.01 to 10	3	16(3)	1	3	MHz
OUTPUT CHARACTERISTICS													
Output Voltage Swing	±10	± 10	± 10	±35 (4)	±13	±11	± 13.5(3)	±13.5(3)	±10	±10	±11	± 10	V
Output Current (1)	± 10	± 10	±300	±10	18 (3)	±22 (3)	.5 to 5.0(3)	.5 to 5.0(3)	± 7	20 (1)	±22 (3)	±10	mA
Full Power Bandwidth (typ.)	75	600	8,000	23	30	50	1.5 to 80(3)	1.5 to 80	40	500 (3)	50	40	kHz
TRANSIENT RESPONSE													
Rise Time (1)	60	45	30(3)	60(3)	40(3)	(2)	200 to 2,000 (3)	200 2,000 (3)	200 (3)	20(3)	(2)	200 (3)	ns
Overshoot (1)	40	(2)	25(3)	15(3)	15(3)	(2)	5 to 15 (3)	5 to 15(3)	20 (3)	25(3)	(2)	20(3)	%
Slew Rate (1)	± 4	±20	200	5(3)	2	±10	.1 to .8(3)	.1 to .8	2.5(3)	50	10	2.5 (3)	V/µs
Settling Time (Typ.) (1)	1.5	0.30	.5 (3)	1.5 (3)	1.5 (3)	5.0	(2)	(2)	(2)	1.5 (3)	5.0	(2)	µs
POWER SUPPLY CHARACTERISTICS													
Supply Current (1)	4.0	4.0	23	4.5	4	0.150	.02 to .2	.02 to .2	5	6.0 (1)	0.150	5	mA
Power Supply Rejection Ratio	74	74	66	74	74	80	76	76	120	80	86	130	dB
FUNCTIONAL CHARACTERISTICS													
Offset Adjust	Yes	Yes	No	Yes	Dip Pkg. Only	Yes	Yes	Yes	No	No	Yes	No	
Compensation Components	0	0(AV≥5)	0	0	0	0	0	0	3	0 AV>10	0	3	
Output Protection	Yes	Yes	External	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	

(1) At +25°C
(2) Not applicable or not specified
(3) Typical
(4) V supply = ± 40V
(5) Dependent upon Iset value

* TO-86 only

† Guaranteed for ± 15V supplies and applicable temperature range unless otherwise specified

MANUFACTURER	PART NUMBER	HARRIS EQUIVALENT	NOTES
Solitron	CM4016A	HI-201	C2
	μc4000/4001/4002	HA-2600	C2
	μc4000C/4001C/4002C	HA-2605	C2
	μc4250	HA-2720	A2
	μc4250c	HA-2725	A2
Sprague	μLS/μLN2139	HA-2600/2605	B2
	μLS/μLN2151	HA-2600/2605	B2
	μLS/μLN2156	HA-2600/2605	B2
	μLS/μLN2157	HA-2650/2655	B2
	μLS/μLN2158	HA-2620/2625	B2
	μLS/μLN2171	HA-2600/2605	B2
	μLS/μLN2172	HA-2620/2625	B2
	μLS/μLN2173	HA-2600/2605	B2
	μLS/μLN2174	HA-2620/2625	B2
	μLS/μLN2175	HA-2600/2605	B2
	μLS/μLN2176	HA-2620/2625	B2
	μLS/μLN2177	HA-2060/2065	B2
	μLS/μLN2178	HA-2060/2065	B2
Teledyne Philbrick	1321	HA-2625	A1
	1322	HA-2525	A1
	1323	HA-2705	A1
	1324	HA-2505	B2
	1422	HA-2055/2065	B2
	1427	HA-2065	C2
	1431	HA-2065A	A1
	143101	HA-2060A	A1
Texas Instruments	51/72L022	HA-2730/2735	B2
	52/72088	HA-2904/2905	C2
	52/72310	HA-2500/2505	B2
	52111/72311	HA-2111/2311	A1
	52/72558	HA-2650/2655	A2
	52/72660	HA-2700/2705	B2
	52/72770	HA-2600/2605	B2
	52/72771	HA-2620/2625	B2
	75107A/108A	HD-549	C2
	75109/110	HD-545	C2
	75150	HD-1488	C2
	75152	HD-1489/A	C2
	75154	HD-1489/A	C2
Transitron	TOA7709	HA-2600	B2
	TOA8709	HA-2605	B2
	TOA7809	HA-2060A	B2
	TOA8809	HA-2065A	B2

NOTES:
A. Pin-for-pin replacement
B. Minor pin-out difference (offset adj., compensation, etc.)
C. Not pin compatible — consult data sheets.

1. Identical electrical specifications
2. Harris part superior in most parameters
3. Parameter tradeoffs — consult data sheets

HARRIS SEMICONDUCTOR
A DIVISION OF HARRIS CORPORATION

HA-2060/2065/ 2060A/2065A

Wide Band F.E.T. Input Operational Amplifier

FEATURES

- GAIN BANDWIDTH PRODUCT 100 MHz
- HIGH INPUT IMPEDANCE 10^{12} OHMS
- LOW BIAS CURRENT 1 pA
- HIGH SLEW RATE 35V/μs
- WIDE POWER BANDWIDTH 600 kHz
- TRUE OP AMP - CAN BE OPERATED INVERTING OR NON-INVERTING
- MEETS MIL-STD-883 REQUIREMENTS

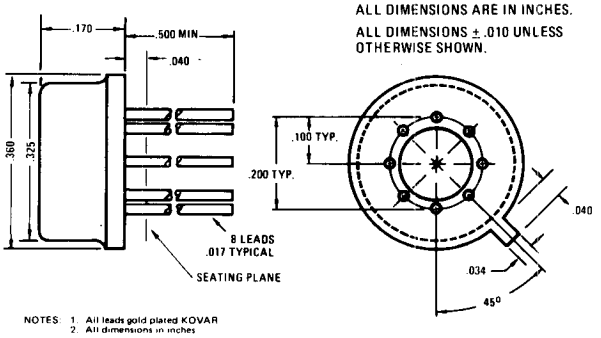
DESCRIPTION

The HA-2060/2065 is an operational amplifier combining the advantages of very wide bandwidth and high slew rate with ultra-low input current and high input resistance. These devices are ideal for use in sample-and-hold circuits, active filters, wide band amplifiers, high gain amplifiers with superior bandwidth, and wherever very low closed loop gain and phase shift errors are required. The device may be operated inverting or non-inverting; and external compensation is required only when operated at closed loop gains less than five. An internal feedback capacitor is provided to cancel phase shift in the feedback loop due to input capacitance.

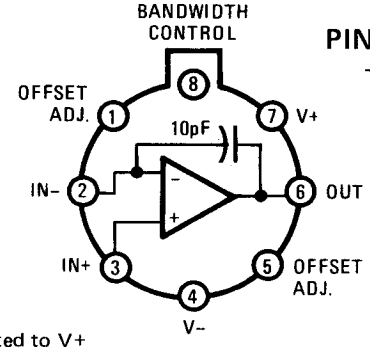
The HA-2060 is guaranteed for operation from -55°C to +125°C and the HA-2065 is guaranteed from 0°C to +75°C.

PACKAGE

CODE 2A Bottom View TO-99



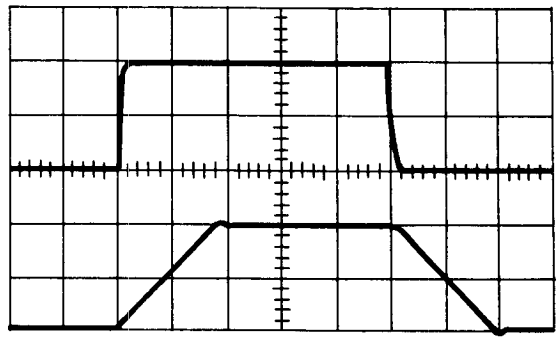
NOTES: 1. All leads gold plated KOVAR
2. All dimensions in inches



PIN-OUT
Top View

Case Connected to V+

SLEWING WAVEFORM



Horizontal Scale: 200ns/Div.
Upper Trace: Input; 1.0V/Div.
Lower Trace: Output; 5.0V/Div.
Gain = +5, R_L = 2K Ohms, C_L = 50pF

SPECIFICATIONS

ABSOLUTE MAXIMUM RATINGS

Voltage Between V+ and V- Terminals	35.0V	Internal Power Dissipation (Note 10)	300mW
Differential Input Voltage	±12V	Operating Temp. Range	$-55^{o}C \leq T_A \leq +125^{o}C$ (HA-2060)
Output Current / Full Short Circuit Protection			$0^{o}C \leq T_A \leq +75^{o}C$ (HA-2065)
		Storage Temp. Range	$-65^{o}C \leq T_A \leq +150^{o}C$

ELECTRICAL CHARACTERISTICS

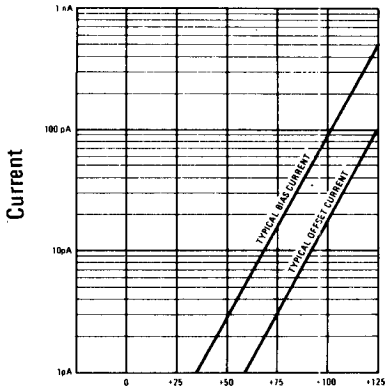
Test Conditions: V_{Supply} = ±15.0V unless otherwise specified.

		HA-2060/HA-2060A -55°C to +125°C			HA-2065/HA-2065A 0°C to +75°C			
		LIMITS			LIMITS			
PARAMETER	TEMP.	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	UNITS
INPUT CHARACTERISTICS								
Offset Voltage (Note 1)								
HA-2060 / HA-2065	+25°C		15	25		15	60	mV
	Full			30			65	mV
HA-2060A / HA-2065A	+25°C		7	12		7	12	mV
	Full			15			15	mV
Bias Current	+25°C		1	20		1	20	ρA
	Full		0.5	10		0.02	1	nA
Offset Current	+25°C		0.5	20		0.5	20	ρA
	Full		0.1	5		.005	.5	nA
Input Resistance	+25°C		10^{12}			10^{12}		Ω
Input Capacitance	+25°C		5			5		ρF
Common Mode Range	Full	±10.0			±10.0			V
TRANSFER CHARACTERISTICS								
Large Signal Voltage Gain (Note 2, 5)	+25°C	80K	150K		80K	150K		V/V
	Full	60K			70K			V/V
Common Mode Rejection Ratio (Note 3)	Full	74	90		70	90		dB
Gain Bandwidth Product (Note 4)	+25°C		100			100		MHz
OUTPUT CHARACTERISTICS								
Output Voltage Swing (Note 2)	Full	±10	±12		±10	±12		V
Output Current	+25°C	±10	±18		±10	±18		mA
Full Power Bandwidth (Note 5)	+25°C		600			600		kHz
TRANSIENT RESPONSE (NOTES 2, 8, 9)								
Rise Time (Note 6)	+25°C		50			50		ns
Overshoot (Note 6)	+25°C		25			25		%
Slew Rate (Note 5)	+25°C		35			35		V/μs
POWER SUPPLY CHARACTERISTICS								
Supply Current	+25°C		4.0	6.0		4.0	6.0	mA
Power Supply Rejection Ratio (Note 7)	Full	74	90		70	90		dB

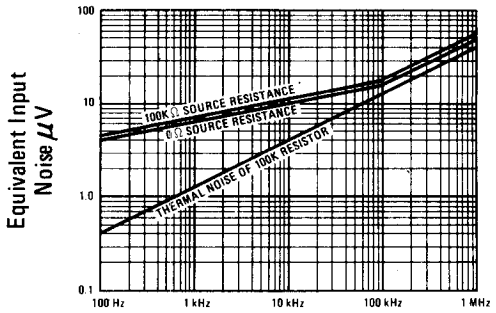
NOTES:
1. Adjustable to zero with 100KΩ pot between pins 1 and 5; wiper to V+.
2. R_L = 2K
3. V_{CM} = ±5.0V
4. $A_V > 10$
5. V_O = ±10V
6. V_O = ±200mV
7. ΔV = ±5.0V
8. C_L = 50 ρF
9. A_V = +5, See transient response test circuits and waveforms, page 4.
10. Derate by 6.6mW/°C above 105°C

V+ = 15VDC, V- = 15VDC, T_A = 25°C UNLESS OTHERWISE STATED

INPUT BIAS AND OFFSET CURRENT
VS. TEMPERATURE

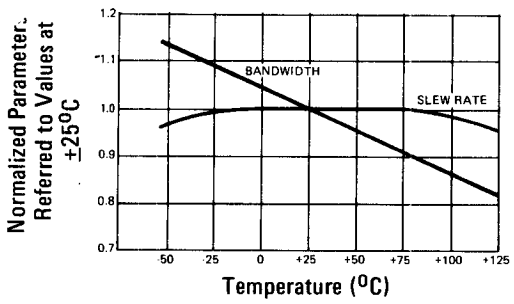


EQUIVALENT INPUT NOISE
VS. BANDWIDTH

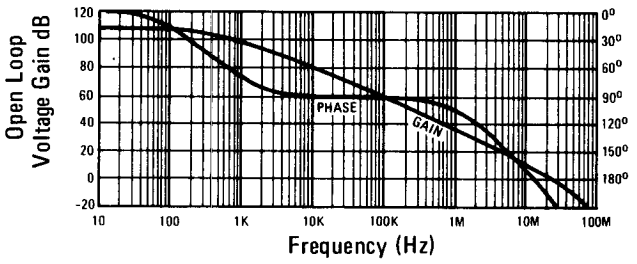


Upper 3dB Frequency
Lower 3dB Frequency - 10 Hz

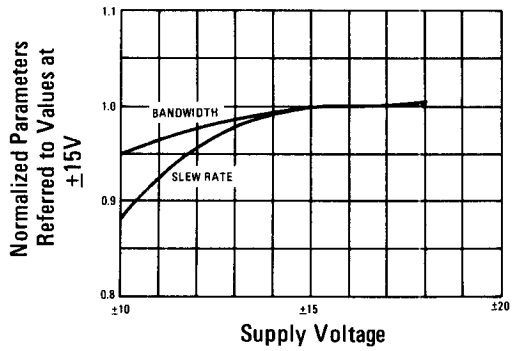
NORMALIZED AC PARAMETERS
VS. TEMPERATURE



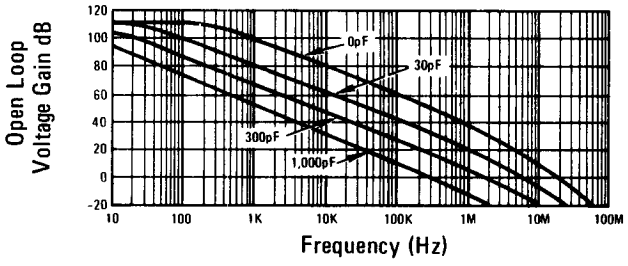
OPEN-LOOP FREQUENCY AND PHASE RESPONSE



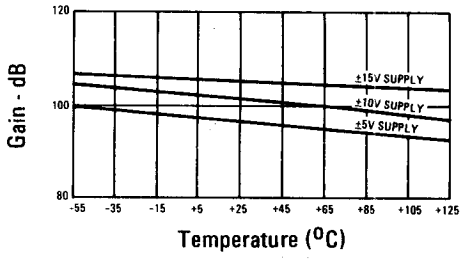
NORMALIZED AC PARAMETERS
VS. SUPPLY VOLTAGE AT +25°C



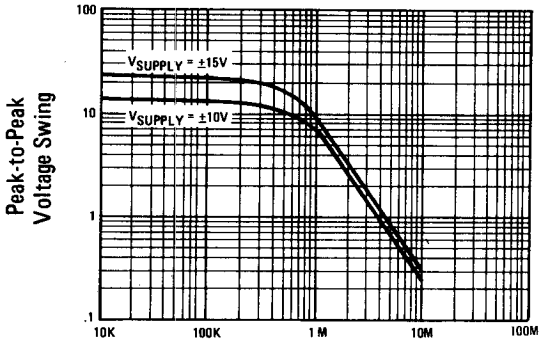
OPEN LOOP FREQUENCY RESPONSE FOR VARIOUS
VALUES OF CAPACITORS FROM BANDWIDTH CONTROL
PIN TO GROUND



OPEN LOOP VOLTAGE GAIN
VS. TEMPERATURE



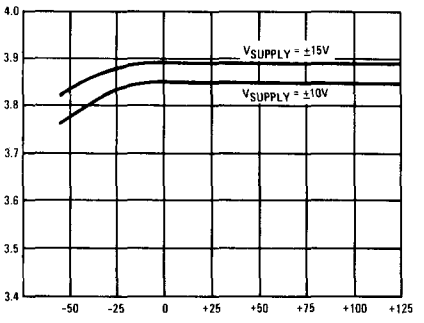
OUTPUT VOLTAGE SWING
VS. FREQUENCY AT +25°C



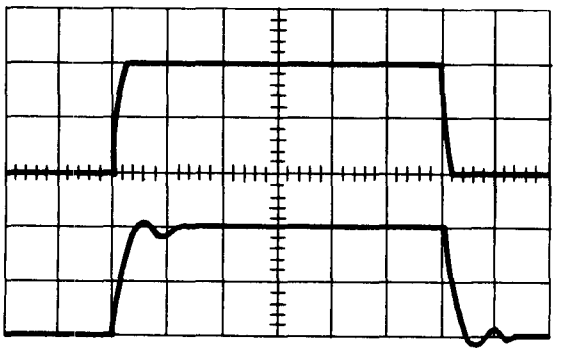
LINEAR

PERFORMANCE CURVES (continued)

POWER SUPPLY CURRENT VS. TEMPERATURE

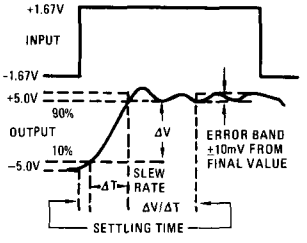


TRANSIENT RESPONSE; A_V = +5

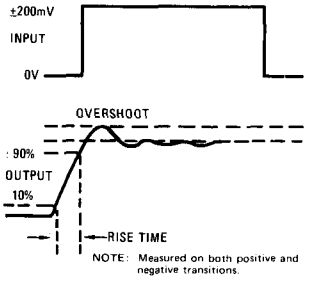


R_L = 2K Ohms, C_L = 50pF
Upper Trace: Input; 20mV/Div.
Lower Trace: Output; 100mV/Div.
Horizontal = 100ns/Div.
T_A = +25°C, V_S = ±15V

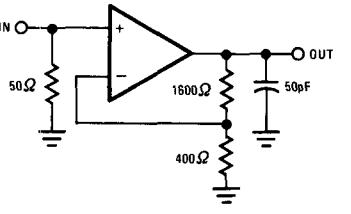
SLEW RATE AND SETTLING TIME



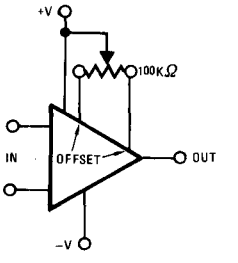
TRANSIENT RESPONSE



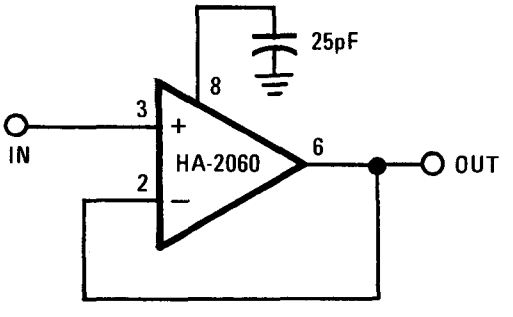
SLEW RATE AND TRANSIENT RESPONSE



SUGGESTED OFFSET ZERO ADJUST HOOK-UP



TYPICAL APPLICATIONS



COMPENSATION CIRCUIT FOR UNITY GAIN

SLEW RATE ≈ 5 V/μs

BANDWIDTH ≈ 10 MHz

LINEAR