



HA-2400, HA-2404 HA-2405

PRAM Four Channel Programmable Amplifiers

March 1993

Features

- Programmability
- High Rate Slew..... 30V/ μ s
- Wide Gain Bandwidth..... 40MHz
- High Gain..... 150kV/V
- Low Offset Current..... 5nA
- High Input Impedance..... 30M Ω
- Single Capacitor Compensation
- DTL/TTL Compatible Inputs

Applications

- Thousands of Applications; Program
 - Signal Selection/Multiplexing
 - Operational Amplifier Gain
 - Oscillator Frequency
 - Filter Characteristics
 - Add-Subtract Functions
 - Integrator Characteristics
 - Comparator Levels
- For Further Design Ideas, See App. Note 514.

Description

HA-2400/04/05 comprise a series of four-channel programmable amplifiers providing a level of versatility unsurpassed by any other monolithic operational amplifier. Versatility is achieved by employing four input amplifier channels, any one (or none) of which may be electronically selected and connected to a single output stage through DTL/TTL compatible address inputs. The device formed by the output and the selected pair of inputs is an op amp which delivers excellent slew rate, gain bandwidth and power bandwidth performance. Other advantageous features for these dielectrically isolated amplifiers include high voltage gain and input impedance coupled with low input offset voltage and offset current. External compensation is not required on this device at closed loop gains greater than 10.

Each channel of the HA-2400/04/05 can be controlled and operated with suitable feedback networks in any of the standard op amp configurations. This specialization makes these amplifiers excellent components for multiplexing signal selection and mathematical function designs. With 30V/ μ s slew rate, 40MHz gain bandwidth and 30M Ω input impedance these devices are ideal building blocks for signal generators, active filters and data acquisition designs. Programmability, coupled with 4mV typical offset voltage and 5nA offset current, makes these amplifiers outstanding components for signal conditioning circuits.

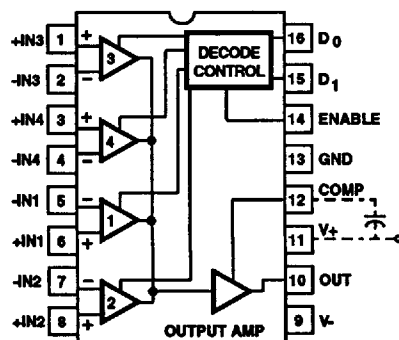
2
OPERATIONAL
AMPLIFIERS

Ordering Information

PART NUMBER	TEMP. RANGE	PACKAGE
HA1-2400-2	-55°C to +125°C	16 Lead Ceramic DIP
HA1-2404-4	-25°C to +85°C	16 Lead Ceramic DIP
HA1-2405-5	0°C to +75°C	16 Lead Ceramic DIP
HA3-2405-5	0°C to +75°C	16 Lead Plastic DIP
HA4P2405-5	0°C to +75°C	20 Lead PLCC

Pinouts

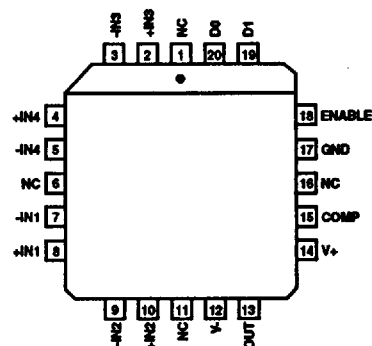
HA-2400/04 (CDIP)
HA-2405 (CDIP, PDIP)
TOP VIEW



TRUTH TABLE

D ₁	D ₀	EN	SELECTED CHANNEL
L	L	H	1
L	H	H	2
H	L	H	3
H	H	H	4
X	X	L	None

HA-2405 (PLCC)
TOP VIEW



Specifications HA-2400, HA-2404, HA-2405

Absolute Maximum Ratings

Voltage Between V+ and V- Terminals	45.0V
Differential Input Voltage	V_{SUPPLY}
Digital Input Voltage	-0.76V to +10.0V
Output Current	Short Circuit Protected, $I_{SC} < 33mA$
Internal Power Dissipation (Note 13)	
Junction Temperature	+175°C
Junction Temperature (Plastic Package)	+150°C
Lead Temperature (Soldering 10 Sec.)	+300°C

Operating Conditions

Operating Temperature Range	
HA-2400-2	$-55^{\circ}C \leq T_A \leq +125^{\circ}C$
HA-2404-4	$-25^{\circ}C \leq T_A \leq +85^{\circ}C$
HA-2405-5	$0^{\circ}C \leq T_A \leq +75^{\circ}C$
Storage Temperature Range	$-65^{\circ}C \leq T_A \leq +150^{\circ}C$

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

Test Conditions: $V_{SUPPLY} = \pm 15V$, Unless Otherwise Specified. Digital Inputs: $V_{IL} = +0.5V$, $V_{IH} = +2.4$. Limits apply to each of the four channels, when addressed.

PARAMETER	TEMP	HA-2400/04 LIMITS			HA-2405 LIMITS			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
INPUT CHARACTERISTICS								
Offset Voltage	+25°C	-	4	9	-	4	9	mV
	Full	-	-	11	-	-	11	mV
Bias Current (Note 12)	+25°C	-	50	200	-	50	250	nA
	Full	-	-	400	-	-	500	nA
Offset Current (Note12)	+25°C	-	5	50	-	5	50	nA
	Full	-	-	100	-	-	100	nA
Input Resistance (Note 12)	+25°C	-	30	-	-	30	-	MΩ
Common Mode Range	Full	±9.0	-	-	±9.0	-	-	V
TRANSFER CHARACTERISTICS								
Large Signal Voltage Gain (Notes 1, 5)	+25°C	50	150	-	50	150	-	kV/V
	Full	25	-	-	25	-	-	kV/V
Common Mode Rejection Ratio (Note 2)	Full	80	100	-	74	100	-	dB
Gain Bandwidth (Notes 3, 14)	+25°C	20	40	-	20	40	-	MHz
Gain Bandwidth (Notes 4, 14)	+25°C	4	8	-	4	8	-	MHz
OUTPUT CHARACTERISTICS								
Output Voltage Swing (Note 1)	Full	±10.0	±12.0	-	±10.0	±12.0	-	V
Output Current	+25°C	10	20	-	10	20	-	mA
Full Power Bandwidth (Notes 3, 5, 15)	+25°C	640	950	-	640	950	-	kHz
Full Power Bandwidth (Notes 4, 5, 15)	+25°C	200	250	-	200	250	-	kHz
TRANSIENT RESPONSE (Note 16)								
Rise Time (Notes 4, 6)	+25°C	-	20	45	-	20	50	ns
Overshoot (Notes 4, 6)	+25°C	-	25	40	-	25	40	%
Slew Rate (Notes 3, 7)	+25°C	20	30	-	20	30	-	V/μs
Slew Rate (Notes 4, 7, 14)	+25°C	6	8	-	6	8	-	V/μs
Settling Time (Notes 4, 7, 8, 14)	+25°C	-	1.5	2.5	-	1.5	2.5	μs
CHANNEL SELECT CHARACTERISTICS								
Digital Input Current (V _{IN} = 0V)	Full	-	1	1.5	-	1	1.5	mA
Digital Input Current (V _{IN} = +5.0V)	Full	-	5	-	-	5	-	nA
Output Delay (Notes 9, 14)	+25°C	-	100	250	-	100	250	ns
Crosstalk (Note 10)	+25°C	-80	-110	-	-74	-110	-	dB

Specifications HA-2400, HA-2404, HA-2405

Electrical Specifications

Test Conditions: $V_{\text{SUPPLY}} = \pm 15\text{V}$, Unless Otherwise Specified. Digital Inputs: $V_{\text{IL}} = +0.5\text{V}$, $V_{\text{IH}} = +2.4$. Limits apply to each of the four channels, when addressed. (Continued)

PARAMETER	TEMP	HA-2400/04 LIMITS			HA-2405 LIMITS			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
POWER SUPPLY CHARACTERISTICS								
Supply Current	+25°C	-	4.8	6.0	-	4.8	6.0	mA
Power Supply Rejection Ratio (Note 11)	Full	74	90	-	74	90	-	dB

NOTES:

1. $R_L = 2\text{k}\Omega$
2. $V_{\text{CM}} = \pm 5\text{VDC}$
3. $A_V = +10$, $C_{\text{COMP}} = 0$, $R_L = 2\text{k}\Omega$, $C_L = 50\text{pF}$.
4. $A_V = +1$, $C_{\text{COMP}} = 15\text{pF}$, $R_L = 2\text{k}\Omega$, $C_L = 50\text{pF}$.
5. $V_{\text{OUT}} = 20\text{V}$ peak to peak.
6. $V_{\text{OUT}} = 200\text{mV}$ peak.
7. $V_{\text{OUT}} = 10.0\text{V}$ peak to peak.
8. To 0.1% of final value.
9. To 10% of final value; output then slews at normal rate to final value
10. Unselected input to output; $V_{\text{IN}} = \pm 10\text{VDC}$
11. $V_{\text{SUPPLY}} = \pm 10\text{VDC}$ to $\pm 20\text{VDC}$
12. Unselected channels have approximately the same input parameters.
13. Maximum power dissipation including output load, must be designed to maintain the junction temperature below +175°C for the ceramic package, and below +150°C for the plastic packages.
14. Guaranteed by design.
15. Full Power Bandwidth based on slew rate measurement using: $\text{FPBW} = \frac{\text{SR}}{2\pi V_{\text{PEAK}}}$; $V_{\text{PEAK}} = 5\text{V}$
16. See Figure 11 for test circuit.

Schematic Diagram

HA-2400

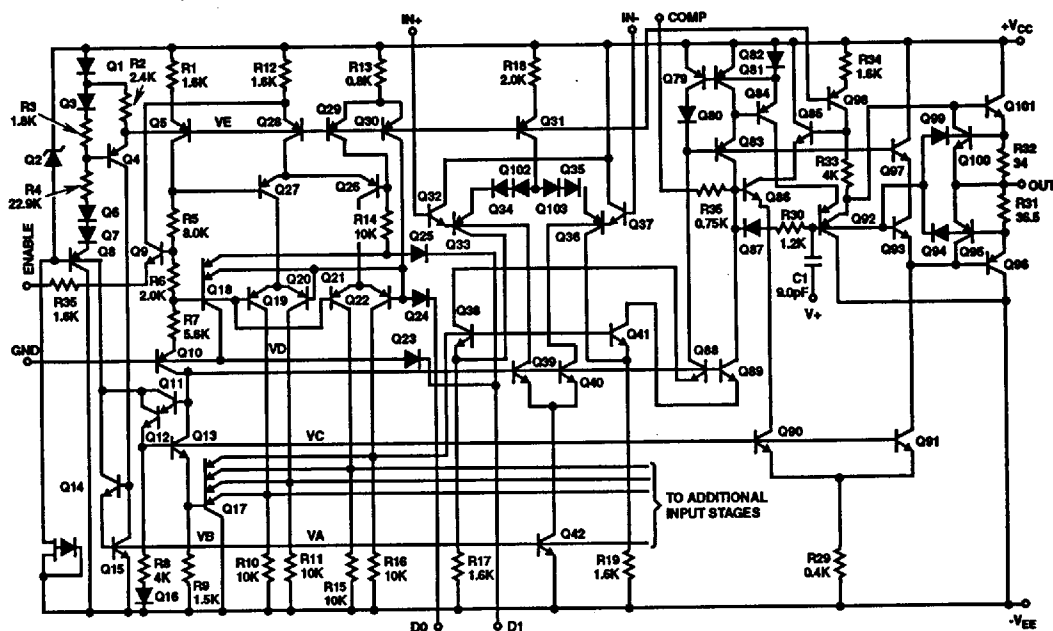


Diagram Includes: One Input Stage, Decode Control, Bias Network, and Output Stage

Typical Performance Curves

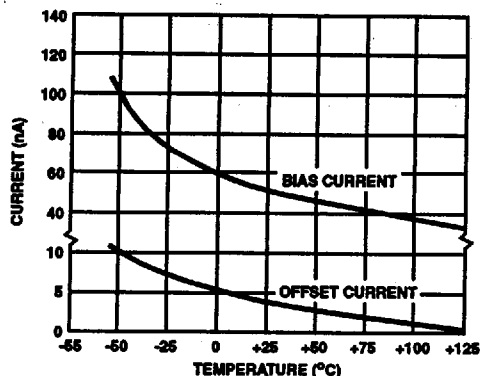


FIGURE 1. INPUT BIAS CURRENT AND OFFSET CURRENT vs TEMPERATURE

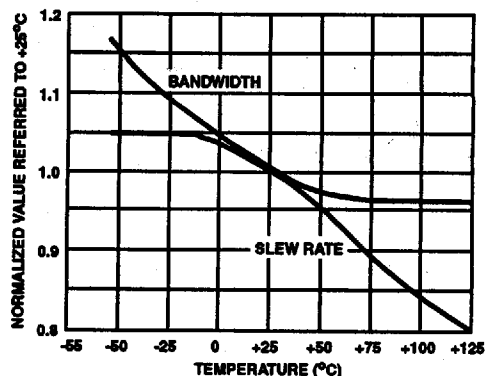


FIGURE 2. NORMALIZED AC PARAMETERS vs TEMPERATURE

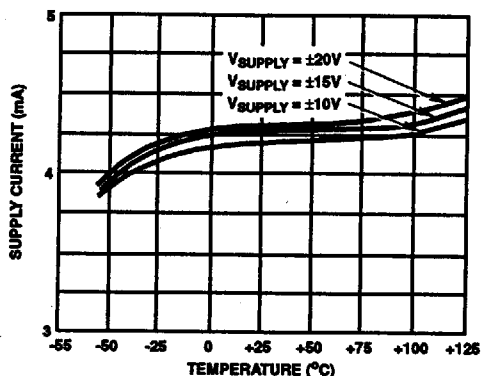


FIGURE 3. POWER SUPPLY CURRENT vs TEMPERATURE

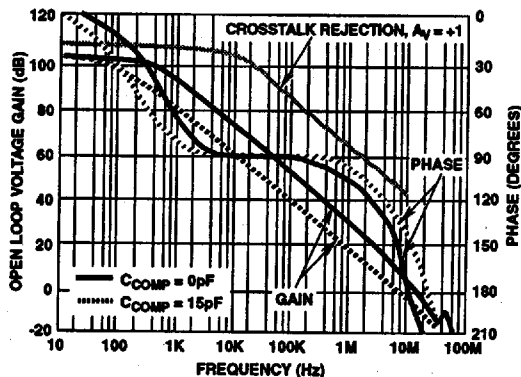


FIGURE 4. OPEN LOOP FREQUENCY AND PHASE RESPONSE

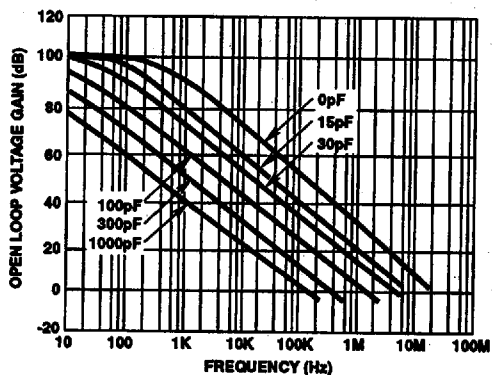


FIGURE 5. FREQUENCY RESPONSE vs C_{COMP}

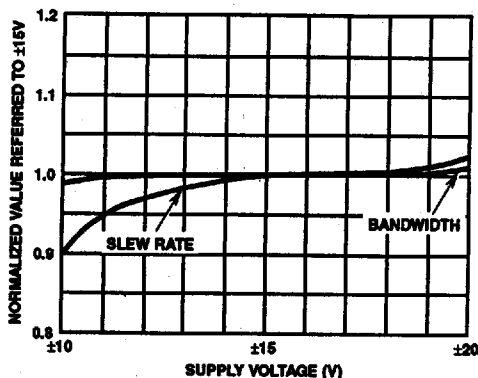


FIGURE 6. NORMALIZED AC PARAMETERS vs SUPPLY VOLTAGE

Typical Performance Curves (Continued)

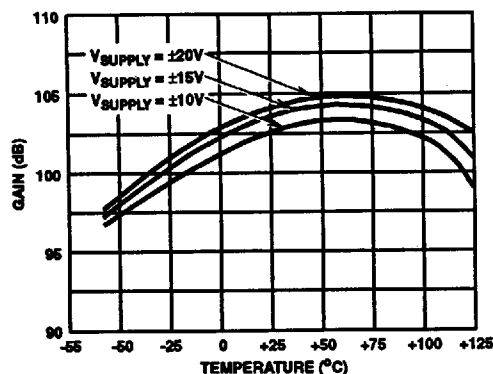


FIGURE 7. OPEN LOOP VOLTAGE GAIN vs TEMPERATURE

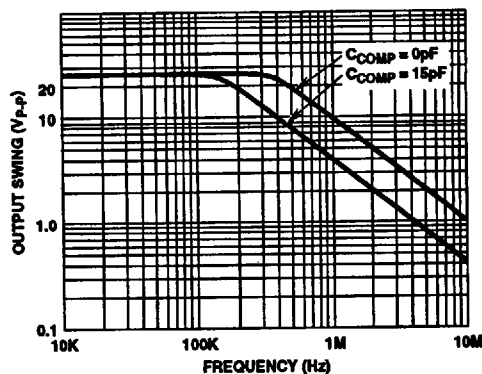


FIGURE 8. OUTPUT VOLTAGE SWING vs FREQUENCY

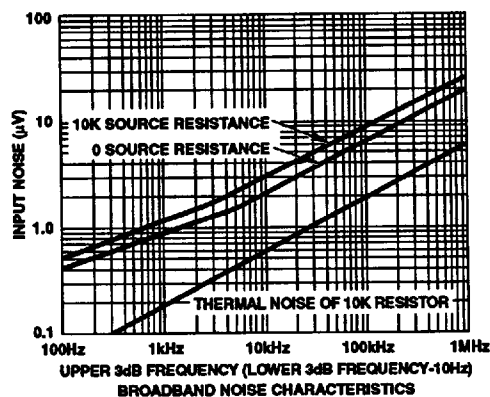


FIGURE 9. EQUIVALENT INPUT NOISE vs BANDWIDTH

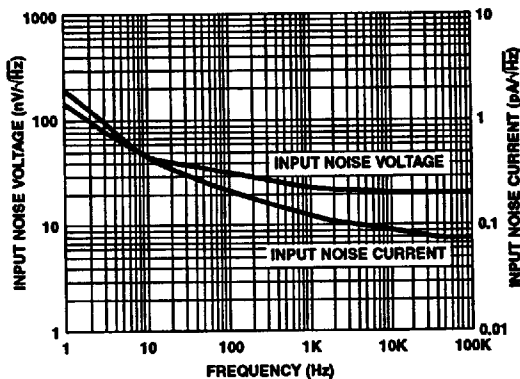


FIGURE 10. INPUT NOISE vs FREQUENCY

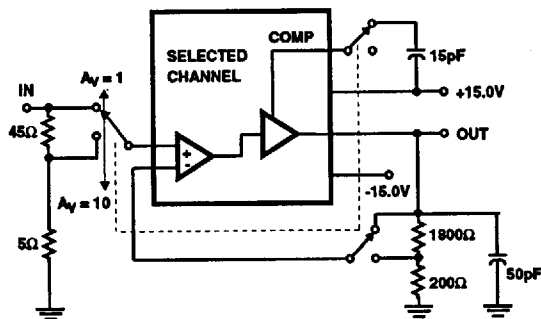


FIGURE 11. SLEW RATE AND TRANSIENT RESPONSE

HA-2400, HA-2404, HA-2405

Typical Applications

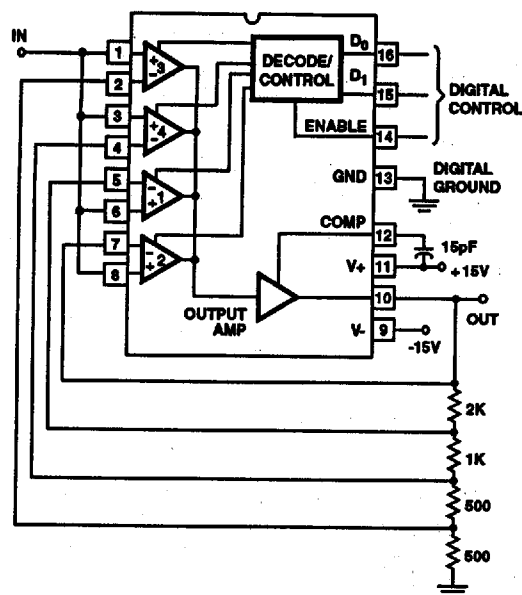
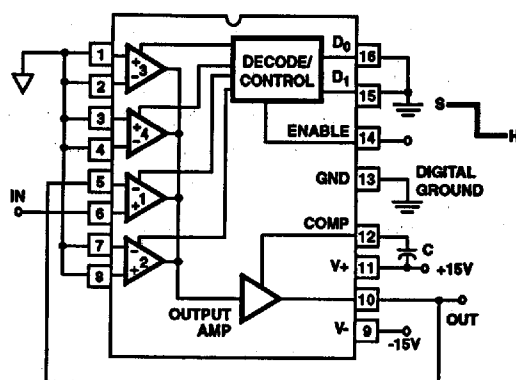


FIGURE 12. HA-2400 AMPLIFIER, NONINVERTING PROGRAMMABLE GAIN



$$\text{Sample Charging Rate} = \frac{I_1}{C} \text{ V/Sec}$$

$$\text{Hold Drift Rate} = \frac{I_2}{C} \text{ V/Sec}$$

$$\text{Switch Pedestal Error} = \frac{Q}{C} \text{ Volts}$$

$$I_1 \sim 150 \times 10^{-9} \text{ A}$$

$$I_2 \sim 200 \times 10^{-9} \text{ A at } +25^\circ\text{C}$$

$$\sim 600 \times 10^{-9} \text{ A at } -55^\circ\text{C}$$

$$\sim 100 \times 10^{-9} \text{ A at } +125^\circ\text{C}$$

$$Q \sim 2 \times 10^{-12} \text{ Coulomb}$$

FIGURE 13. HA-2400 SAMPLE AND HOLD

For more examples, see Harris Application Note 514