Low Noise High Performance Operational Amplifiers

Features

- **Low Noise** ..... **4.3nV$\sqrt{Hz}$**
- **Wide Bandwidth** ..... **8MHz (Compensated)**
  60MHz (Uncompensated)
- **High Slew Rate** ..... **3V/μs (Compensated)**
  20V/μs (Uncompensated)
- **Low Offset Voltage** **0.5mV**
- **Available in Duals or Quads**

Applications

- High Q, Active Filters
- Audio Amplifiers
- Instrumentation Amplifiers
- Integrators
- Signal Generators
- For Further Design Ideas, See App. Note 554.

Description

Low noise and high performance are key words describing HA-5102/04/12/14. These general purpose amplifiers offer an array of dynamic specifications ranging from a 3V/μs slew rate and 8MHz bandwidth (5102/04) to 20V/μs slew rate and 60MHz gain-bandwidth-product (HA-5112/14). Complementing these outstanding parameters is a very low noise specification of 4.3nV/$\sqrt{Hz}$ at 1kHz.

Fabricated using the Harris high frequency DI process, these operational amplifiers also offer excellent input specifications such as a 0.5mV offset voltage and 30nA offset current. Complementing these specifications are 108dB open loop gain and 108dB channel separation. Consuming a very modest amount of power (90mW/package for duals and 150mW/package for quads), HA-5102/04/12/14 also provide 15mA of output current.

This impressive combination of features make this series of amplifiers ideally suited for designs ranging from audio amplifiers and active filters to the most demanding signal conditioning and instrumentation circuits.

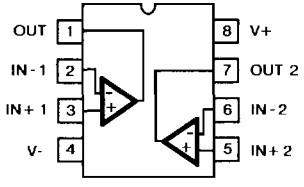
These operational amplifiers are available in dual or quad form with industry standard pinouts allowing for immediate inter-changeability with most other dual and quad operational amplifiers.

HA-5102	Dual, Compensated
HA-5112	Dual, Uncompensated
HA-5104	Quad, Compensated
HA-5114	Quad, Uncompensated

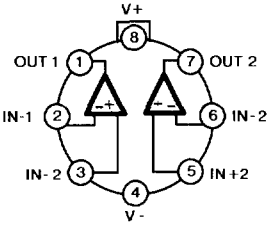
Each of these products are available in -2 (-55°C to +125°C), -5 and -7 (0°C to +75°C), or /883 grades. Refer to the /883 data sheet for military product.

Pinouts

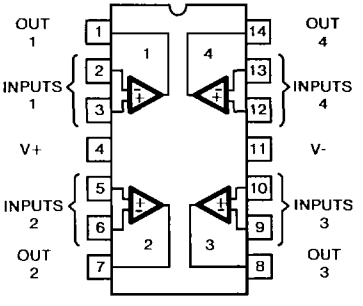
HA3-5102/5112 (PLASTIC MINI-DIP)
HA7-5102/5112 (CERAMIC MINI-DIP)
TOP VIEW



HA2-5102/5112 (TO-99 METAL CAN)
TOP VIEW



HA1-5104/5114 (CERAMIC DIP)
HA3-5104/5114 (PLASTIC DIP)
TOP VIEW



CAUTION: These devices are sensitive to electrostatic discharge. Proper I.C. handling procedures should be followed.

Absolute Maximum Ratings (Note 1)

T_A = +25°C Unless Otherwise Stated
Voltage Between V+ and V- Terminals 40.0V
Differential Input Voltage..... ±7V
Input Voltage (Note 2) ..... ±15.0V
Output Short Circuit Duration (Note 3)..... Indefinite
Power Dissipation (Note 4)..... 880mW

Operating Temperature Ranges

HA-5102/5104/5112/5114-2 ..... -55°C≤T_A≤+125°C
HA-5102/5104/5112/5114-5 ..... -0°C≤T_A≤+75°C
Storage Temperature Range ..... -65°C≤T_A≤+150°C

Electrical Specifications

V+ = 15V D.C., V- = -15V D.C., Unless Otherwise Specified

PARAMETER	TEMP	HA-5102-2 HA-5112-2 -55°C to +125°C			HA-5104-2 HA-5114-2 -55°C to +125°C			HA-5102-5 HA-5112-5 0°C to +75°C			HA-5104-5 HA-5114-5 0°C to 75°C			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
INPUT CHARACTERISTICS														
Offset Voltage	+25°C	-	0.5	2.0	-	0.5	2.5	-	0.5	2.0	-	0.5	2.5	mV
	Full	-	-	2.5	-	-	3.0	-	-	2.5	-	-	3.0	mV
Offset Voltage Average Drift	Full	-	3	-	-	3	-	-	3	-	-	3	-	µV/°C
Bias Current	+25°C	-	130	200	-	130	200	-	130	200	-	130	200	nA
	Full	-	-	325	-	-	325	-	-	325	-	-	325	nA
Offset Current	+25°C	-	30	75	-	30	75	-	30	75	-	30	75	nA
	Full	-	-	125	-	-	125	-	-	125	-	-	125	nA
Input Resistance	+25°C	-	500	-	-	500	-	-	500	-	-	500	-	kΩ
Common Mode Range	Full	±12	-	-	±12	-	-	±12	-	-	±12	-	-	V
TRANSFER CHARACTERISTICS														
Large Signal Voltage Gain	+25°C	-	250	-	-	250	-	-	250	-	-	250	-	kV/V
(Note 5)	Full	100	-	-	100	-	-	100	-	-	100	-	-	kV/V
Common Mode Rejection Ratio (Note 6)	Full	86	95	-	86	95	-	86	95	-	86	95	-	dB
Small Signal Bandwidth														
HA-5102/5104 (A_V = 1)	+25°C	-	8	-	-	8	-	-	8	-	-	8	-	MHz
Gain Bandwidth Product														
HA-5112/5114 (A_V = 10)	+25°C	-	60	-	60		-	-	60		-	60	-	MHz
Channel Separation (Note 7)	+25°C	-	108	-	108		-	-	108	-	-	108	-	dB
OUTPUT CHARACTERISTICS														
Output Voltage Swing														
(R_L = 10K)	Full	±12	±13	-	±12	±13	-	±12	±13	-	±12	±13	-	V
(R_L = 2K)	Full	±10	±12	-	±10	±12	-	±10	±12	-	±10	±12	-	V
Output Current (Note 8)	Full	±10	±15	-	±10	±15	-	±10	±15	-	±10	±15	-	mA
Full Power Bandwidth (Note 9)														
HA-5102/5104	+25°C	16	47	-	16	47	-	16	47	-	16	47	-	kHz
HA-5112/5114	+25°C	191	318	-	191	318	-	191	318	-	191	318	-	kHz
Output Resistance	+25°C	-	110	-	-	110	-	-	110	-	-	110	-	Ω
STABILITY														
Minimum Stable Closed Loop Gain														
HA-5102/5104	Full	1	-	-	1	-	-	1	-	-	1	-	-	V/V
HA-5112/5114	Full	10	-	-	10	-	-	10	-	-	10	-	-	V/V

Electrical Specifications **(Continued)** V+ =15V D.C., V- = -15V D.C., Unless Otherwise Specified

PARAMETER	TEMP	HA-5102-2 HA-5112-2 -55°C to +125°C			HA-5104-2 HA-5114-2 -55°C to +125°C			HA-5102-5 HA-5112-5 0°C to +75°C			HA-5104-5 HA-5114-5 0°C to +75°C			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
TRANSIENT RESPONSE (Note 10)														
Rise Time														
HA-5102/5104	+25°C	-	108	200	-	108	200	-	108	200	-	108	200	ns
HA-5112/5114	+25°C	-	48	100	-	48	100	-	48	100	-	48	100	ns
Overshoot														
HA-5102/5104	+25°C	-	20	35	-	20	35	-	20	35	-	20	35	%
HA-5112/5114	+25°C	-	30	40	-	30	40	-	30	40	-	30	40	%
Slew Rate														
HA-5102/5104	+25°C	±1	±3	-	±1	±3	-	±1	±3	-	±1	±3	-	V/µs
HA-5112/5114	+25°C	±12	±20	-	±12	±20	-	±12	±20	-	±12	±20	-	V/µs
Settling Time (Note 11)														
HA-5102/5104	+25°C	-	4.5	-	-	4.5	-	-	4.5	-	-	4.5	-	µs
HA-5112/5114	+25°C	-	0.6	-	-	0.6	-	-	0.6	-	-	0.6	-	µs
NOISE CHARACTERISTICS														
Input Noise Voltage (Note 12)														
f = 10Hz	+25°C	-	9	17	-	9	17	-	9	17	-	9	17	$nV/\sqrt{Hz}$
f = 1kHz	+25°C	-	4.3	6.0	-	4.3	6.0	-	4.3	6.0	-	4.3	6.0	$nV/\sqrt{Hz}$
Input Noise Current (Note 12)														
f = 10Hz	+25°C	-	5.1	12	-	5.1	12	-	5.1	12	-	5.1	12	$pA/\sqrt{Hz}$
f = 1kHz	+25°C	-	0.57	3	-	0.57	3	-	0.57	3	-	0.57	3	$pA/\sqrt{Hz}$
Broadband Noise Voltage														
f = DC to 30kHz	+25°C	-	870	-	-	870	-	-	870	-	-	870	-	nVrms
POWER SUPPLY CHARACTERISTICS														
Supply Current														
HA-5102/5112	+25°C	-	3.0	5.0	-	3.0	5.0	-	3.0	5.0	-	3.0	5.0	mA
HA-5104/5114	+25°C	-	5.0	6.5	-	5.0	6.5	-	5.0	6.5	-	5.0	6.5	mA
Power Supply Rejection Ratio (Note 6)	Full	86	100	-	86	100	-	86	100	-	86	100	-	dB

NOTES:

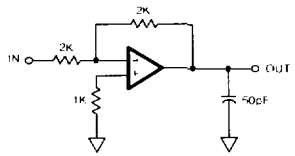
1. Absolute maximum ratings are limiting values, applied individually, beyond which the serviceability of the circuit may be impaired. Functional operability under any of these conditions is not necessarily implied.
2. For supply voltages < ±15V, the absolute maximum input voltage is equal to the supply voltage.
3. Any one amplifier may be shorted to ground indefinitely.
4. Derate 9.6mW/°C above T_A = +25°C.
5. V_{OUT} = ±10V, R_L = 2K
6. V_{CM} = ±5.0V
7. Channel separation value is referred to the input of the amplifier. Input test conditions are: f = 10kHz; V_{IN} = 200mV peak to peak; R_S = 1kΩ. (Refer to Channel Separation vs. Frequency Curve for test circuits.)
8. Output current is measured with V_{OUT} = ±5V.
9. Full power bandwidth is guaranteed by equation:

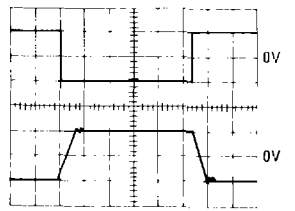
$$\text{Full power bandwidth} = \frac{\text{Slew Rate}}{2\pi\ V_{peak}}$$

10. Refer to Test Circuits section of the data sheet.
11. Settling time is measured to 0.1% of final value for a 1 volt input step, and A_V = -10 for HA-5112/5114, and a 10 volt input step, A_V = -1 for HA-5102/5104.
12. Sample tested.

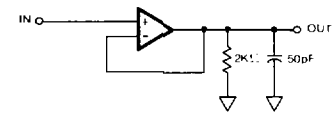
Test Circuits

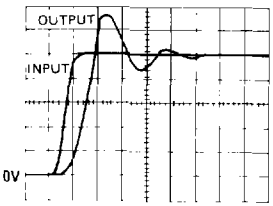
LARGE SIGNAL RESPONSE CIRCUIT
Volts: 5V/Div., Time: 5µs/Div. (A_V = -1)
HA-5102/5104



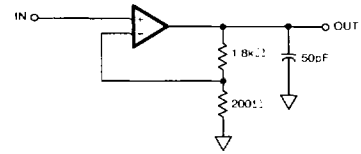


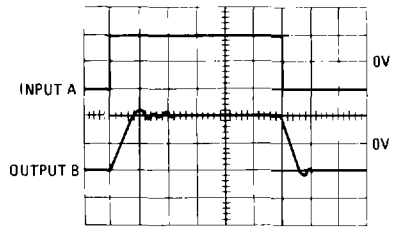
SMALL SIGNAL RESPONSE CIRCUIT
Volts: 40mV/Div., Time: 50ns/Div. (A_V = +1)
HA-5102/5104



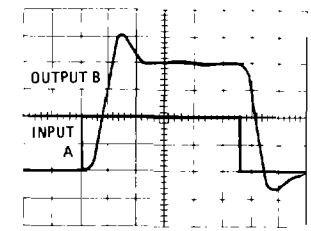


LARGE AND SMALL SIGNAL RESPONSE CIRCUIT
HA-5112/5114 (A_V = +10)



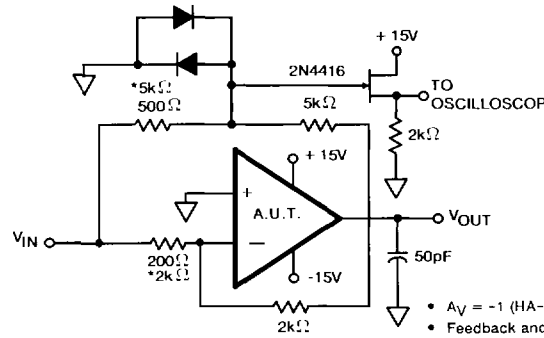


Volts: Input A: 0.5V/Div.. Output B: 5V/Div.
Time: 50ns/Div.



Volts: Input A: 0.01V/Div., Output B: 50mV/Div.
Time: 50ns/Div.

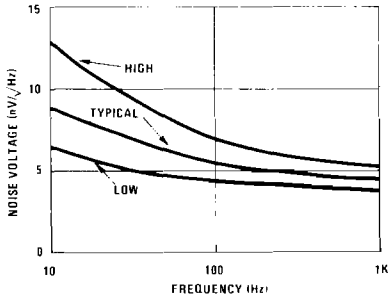
SETTLING TIME CIRCUIT



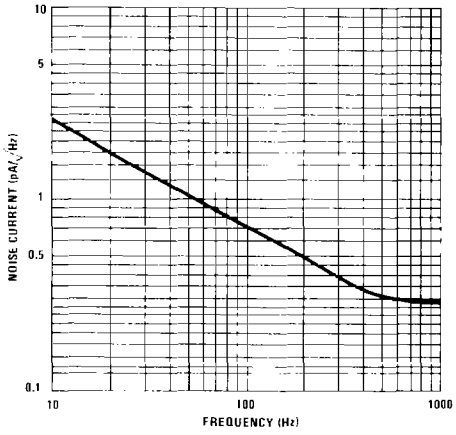
- A_V = -1 (HA-5102/5104). *A_V = -10 (HA-5112/5114)
- Feedback and summing resistors should be 0.1% matched.
- Clipping diodes are optional, HP5082-2810 recommended.

Typical Performance Curves

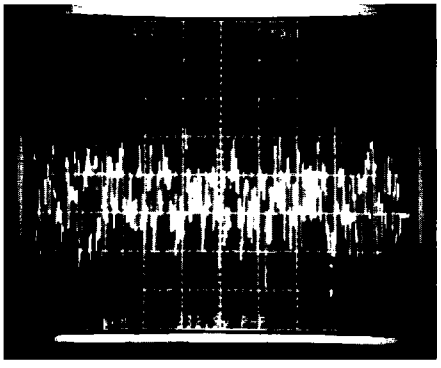
INPUT NOISE VOLTAGE DENSITY
V_{CC} = ±15V, T_A = +25°C



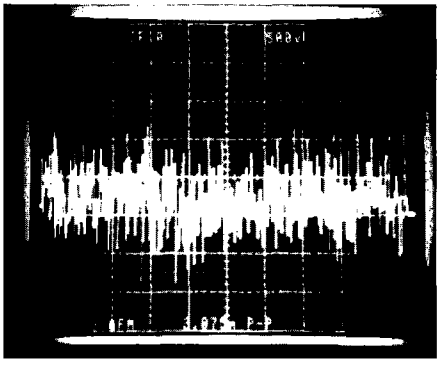
INPUT NOISE CURRENT DENSITY
V_{CC} = ±15V, T_A = +25°C



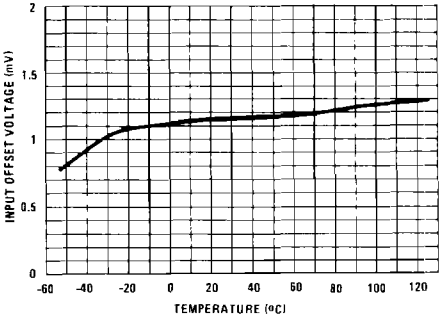
0.1Hz TO 10Hz NOISE
V_{CC} = ±15V, T_A = +25°C
50µV/Div., 1s/Div., A_V = 1000 V/V
Input Noise = 0.232µVp-p



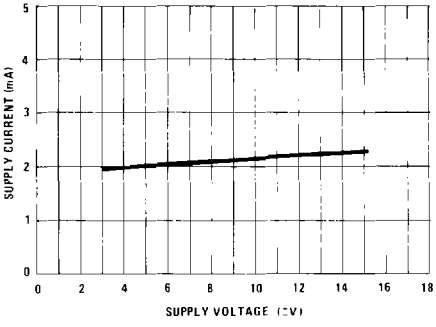
0.1Hz TO 1MHz NOISE
V_{CC} = ±15V, T_A = +25°C
500µV/Div., 1s/Div., A_V = 1000 V/V
Total Output Noise = 2.075µVp-p



V_{IO} vs. TEMPERATURE
V_{CC} = ±15V

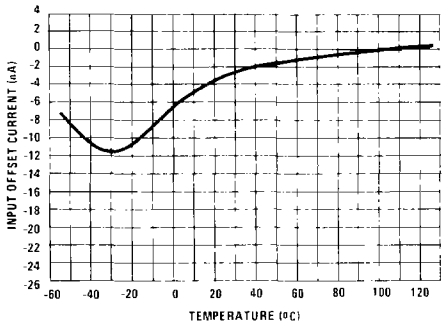


V_{IO} vs. V_{CC}
T_A = +25°C

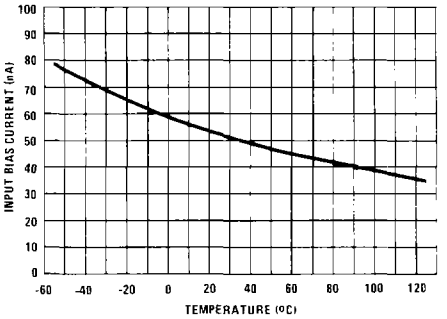


Typical Performance (Continued)

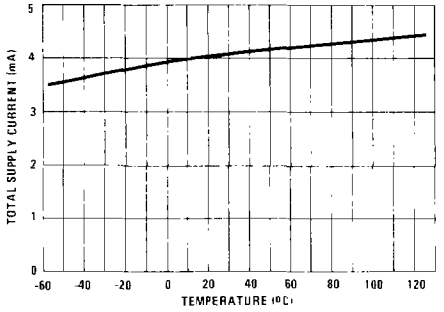
I_{IO} vs. TEMPERATURE
V_{CC} = ±15V



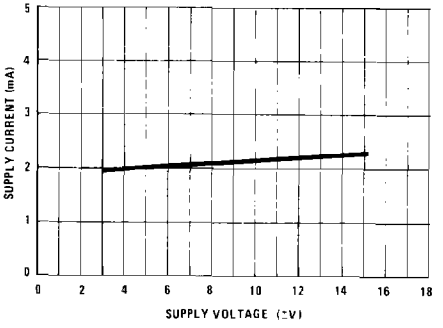
IBIAS vs. TEMPERATURE
V_{CC} = ±15V



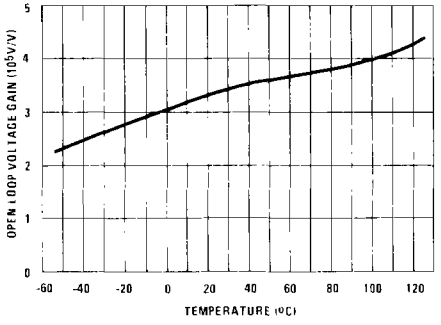
I_{CC} vs. TEMPERATURE
V_{CC} = ±15V, I_{OUT} = 0



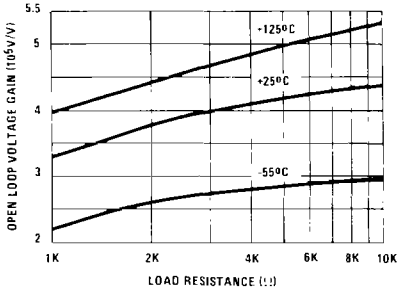
I_{CC} vs. V_{CC}
T_A = +25°C, I_{OUT} = 0



A_{VOL} vs. TEMPERATURE
V_{CC} = ±15V, ΔV_O = ±10V, R_L = 2K

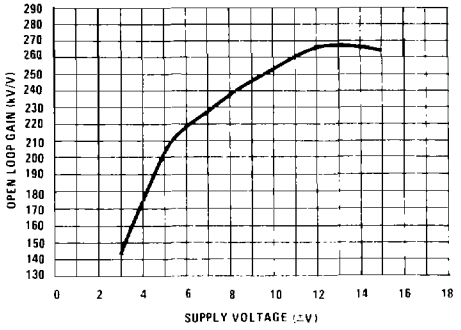


A_{VOL} vs. LOAD RESISTANCE
V_O = ±10V, V_{CC} = ±15V, T_A = +25°C

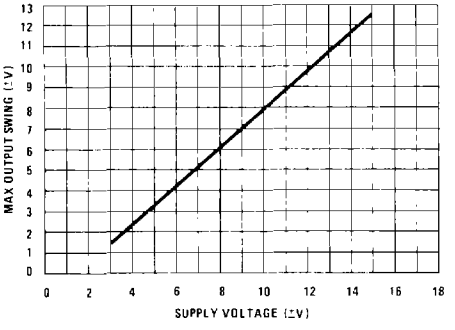


Typical Performance (Continued)

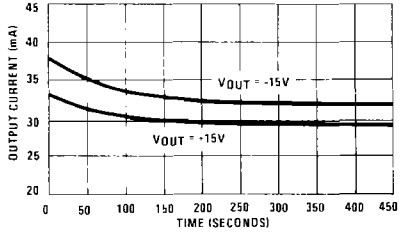
A_{VOL} vs. V_{CC}
$T_A = +25^oC$, $R_L = 2K$



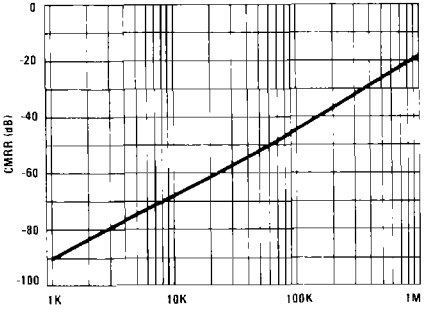
V_{OUT} vs. V_{CC}
$T_A = +25^oC$, $R_L = 2K$



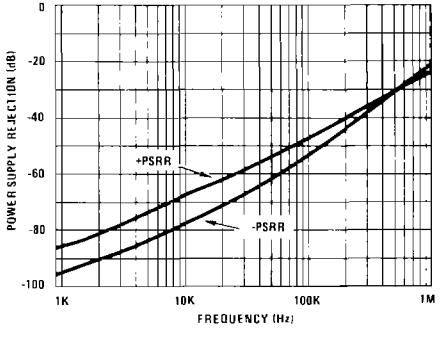
OUTPUT SHORT-CIRCUIT CURRENT vs. TIME
$V_{CC} = \pm 15V$, $T_A = +25^oC$



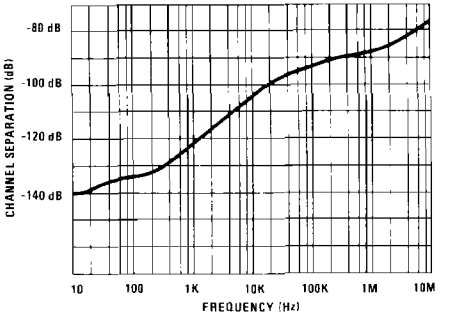
CMRR vs. FREQUENCY



PSRR vs. FREQUENCY

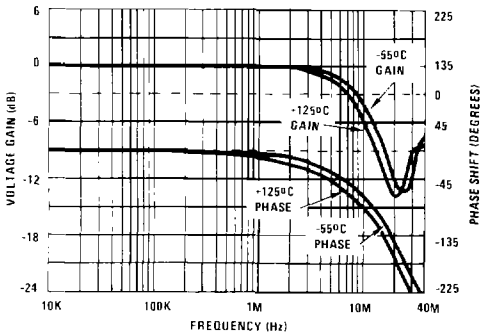


HA-5104 CHANNEL SEPARATION vs. FREQUENCY
$10Hz \leq f \leq 10MHz$

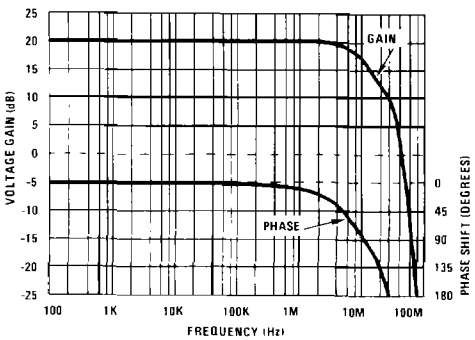


Typical Performance (Continued)

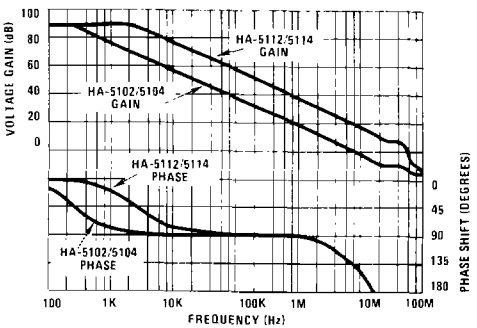
HA-5104/02 UNITY GAIN FREQUENCY RESPONSE
V_{CC} = ±15V, R_L = 2K, C_L = 50pF



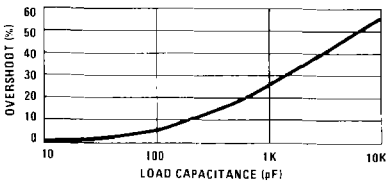
HA-5112/14 FREQUENCY RESPONSE
A_{VCL} = 10, T_A = +25°C, R_L = 2K, C_L = 50pF



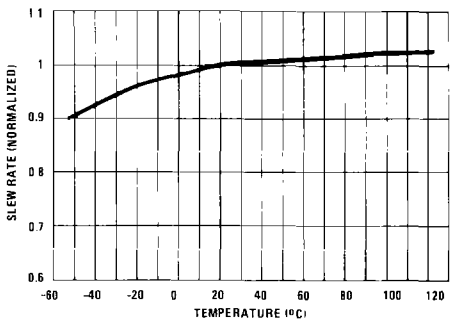
OPEN-LOOP GAIN vs. FREQUENCY
V_{CC} = ±15V, R_L = 2K, C_L = 50pF, T_A = +25°C



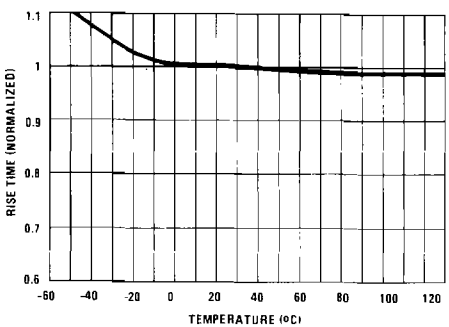
SMALL SIGNAL OVERSHOOT vs. CLOAD
V_{CC} = ±15V, T_A = +25°C, R_L = 2K



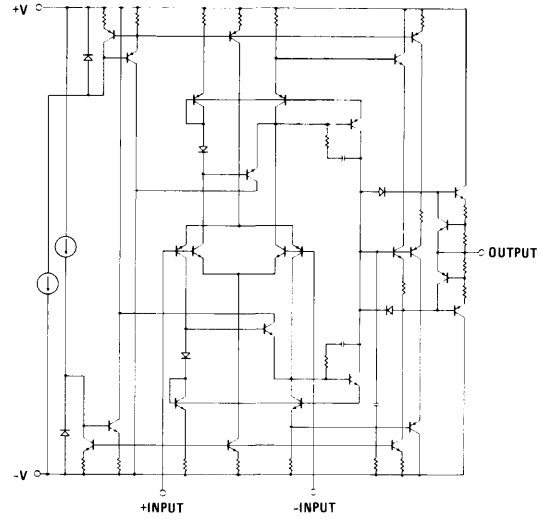
SLEW RATE vs. TEMPERATURE
R_L = 2K, C_L = 50pF, V_{CC} = ±15V



RISE TIME vs. TEMPERATURE
R_L = 2K, C_L = 50pF, V_{CC} = ±15V



Simplified Schematic



Die Characteristics

Transistor Count
- HA-5102/5112 93
- HA-5104/5114 175

Die Dimensions

HA-5102/5112 ..... 98.4 x 67.3 x 19 mils (2500 x 1710 x 480µm)

HA-5104/5114 ..... 99.6 x 95.3 x 19 mils (2530 x 2420 x 480µm)

Substrate Potential* ..... V-

Process ..... Bipolar-DI

Passivation ..... Nitride

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

Thermal Constants (oC/W)	θ_{ja}	θ_{jc}
HA1-5104 (-2, -5, -7)	103	35
HA1-5104 (/883)	78	25
HA2-5102/5112 (-2, -5, -7)	174	48
HA2-5102/5112 (/883)	134	40
HA3-5102/5112 (-5)	80	20
HA3-5104/5114 (-5)	75	23
HA7-5102/5112 (-2, -5, -7)	163	82
HA7-5102/5112 (/883)	124	47