HA-5102, HA-5104 HA-5112, HA-5114

Low Noise, High Performance Operational Amplifiers

April 1993

Features

- **Low Noise....................4.3nV/√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 Application 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/√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 60dB 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.

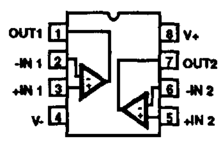
These operational amplifiers are available in dual or quad form with industry standard pinouts allowing for immediate inter-changeability with most other dual and quad operational amplifiers.

HA-5102	Dual, Comp.	HA-5104	Quad, Comp.
HA-5112	Dual, Uncomp.	HA-5114	Quad, Uncomp.

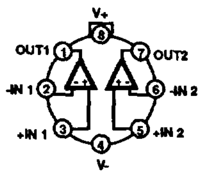
Refer to the /883 data sheet for military product.

Pinouts (See Ordering Information on Next Page)

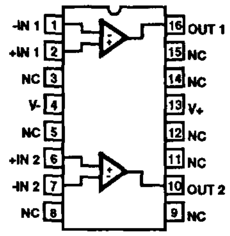
HA-5102/5112 (PDIP, CDIP) TOP VIEW



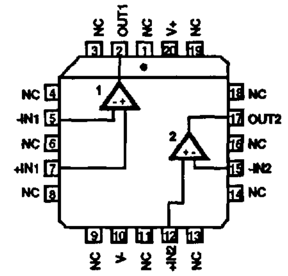
HA-5102/5112 (TO-99 METAL CAN) TOP VIEW



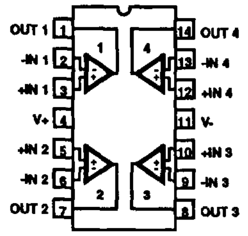
HA-5102/5112 (300 MIL SOIC) TOP VIEW



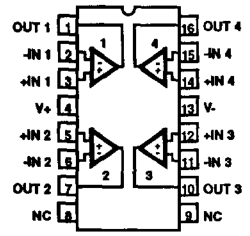
HA-5102 (PLCC) TOP VIEW



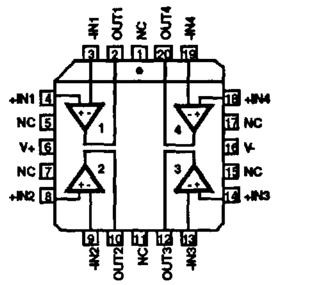
HA-5104/5114 (PDIP, CDIP) TOP VIEW



HA-5104/5114 (300 MIL SOIC) TOP VIEW



HA-5104/5114 (PLCC) TOP VIEW



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

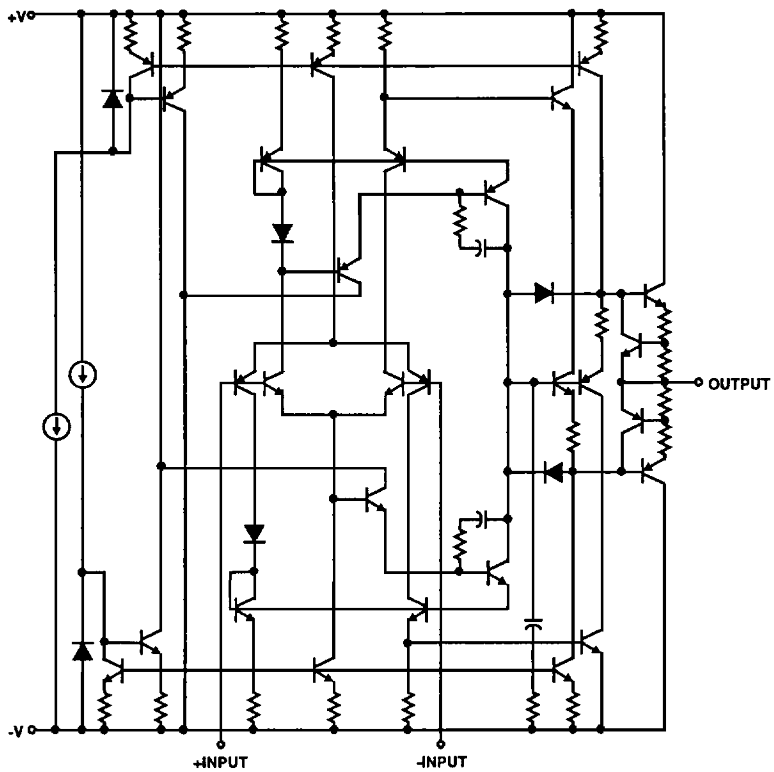
File Number **2925.1**

Ordering Information

PART NUMBER	TEMPERATURE RANGE	PACKAGE
HA2-5102-2	-55°C to +125°C	8 Pin Can
HA2-5102-5	0°C to +75°C	8 Pin Can
HA3-5102-5	0°C to +75°C	8 Lead Plastic DIP
HA4P5102-5	0°C to +75°C	20 Lead PLCC
HA7-5102-2	-55°C to +125°C	8 Lead Ceramic DIP
HA7-5102-5	0°C to +75°C	8 Lead Ceramic DIP
HA9P5102-5	0°C to +75°C	16 Lead Widebody SOIC
HA9P5102-9	-40°C to +85°C	16 Lead Widebody SOIC
HA1-5104-2	-55°C to +125°C	14 Lead Ceramic DIP
HA1-5104-5	0°C to +75°C	14 Lead Ceramic DIP
HA3-5104-5	0°C to +75°C	14 Lead Plastic DIP
HA4P5104-5	0°C to +75°C	20 Lead PLCC
HA9P5104-5	0°C to +75°C	16 Lead Widebody SOIC
HA9P5104-9	-40°C to +85°C	16 Lead Widebody SOIC

PART NUMBER	TEMPERATURE RANGE	PACKAGE
HA2-5112-2	-55°C to +125°C	8 Pin Can
HA2-5112-5	0°C to +75°C	8 Pin Can
HA3-5112-5	0°C to +75°C	8 Lead Plastic DIP
HA7-5112-2	-55°C to +125°C	8 Lead Ceramic DIP
HA7-5112-5	0°C to +75°C	8 Lead Ceramic DIP
HA9P5112-5	0°C to +75°C	16 Lead Widebody SOIC
HA9P5112-9	-40°C to +85°C	16 Lead Widebody SOIC
HA1-5114-2	-55°C to +125°C	14 Lead Ceramic DIP
HA1-5114-5	0°C to +75°C	14 Lead Ceramic DIP
HA3-5114-5	0°C to +75°C	14 Lead Plastic DIP
HA4P5114-5	0°C to +75°C	20 Lead PLCC
HA9P5114-5	0°C to +75°C	16 Lead Widebody SOIC
HA9P5114-9	-40°C to +85°C	16 Lead Widebody SOIC

Simplified Schematic



Absolute Maximum Ratings (Note 1)

T_A = +25°C, Unless Otherwise Stated

Supply Voltage Between V+ and V- Terminals 40.0V
Differential Input Voltage 7V
Input Voltage (Note 2) . . . . ±15V
Output Short Circuit Duration (Note 3) . . . . Indefinite
Junction Temperature (Note 4) . . . . +175°C
Junction Temperature (Plastic Package) . . . . +150°C
Lead Temperature (Soldering 10 Sec.) . . . . +300°C

Operating Conditions

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
HA-5102/5104/5112/5114-9 . . . . -40°C ≤ T_A ≤ +85°C
Storage Temperature Range . . . . -65°C ≤ T_A ≤ +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+ = 15V D.C., V- = -15V D.C., Unless Otherwise Specified

PARAMETER	TEMP	HA-5102-2, -5 HA-5112-2, -5			HA-5104-2, -5 HA-5114-2, -5			HA-5102-9 HA-5112-9			HA-5104-9 HA-5114-9			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	-	-	500	-	-	500	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 (Note 5)	+25°C	100	250	-	100	250	-	80	250	-	80	250	-	kV/V
	Full	100	-	-	100	-	-	80	-	-	80	-	-	kV/V
Common Mode Rejection Ratio (Note 6)	Full	86	95	-	86	95	-	80	95	-	80	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	-	60	-	-	60	-	-	60	-	-	60	-	dB
OUTPUT CHARACTERISTICS														
Output Voltage Swing (R_L = 10kΩ)	Full	±12	±13	-	±12	±13	-	±12	±13	-	±12	±13	-	V
(R_L = 2kΩ)	Full	±10	±12	-	±10	±12	-	±10	±12	-	±10	±12	-	V
Output Current (Note 8)	Full	±10	±15	-	±10	±15	-	±7	±15	-	±7	±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 V+ = 15V D.C., V- = -15V D.C., Unless Otherwise Specified **(Continued)**

PARAMETER	TEMP	HA-5102-2, -5 HA-5112-2, -5			HA-5104-2, -5 HA-5114-2, -5			HA-5102-9 HA-5112-9			HA-5104-9 HA-5114-9			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 (Note 12)														
Input Noise Voltage														
f = 10Hz	+25°C	-	9	25	-	9	25	-	9	25	-	9	25	$nV/\sqrt{Hz}$
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														
f = 10Hz	+25°C	-	5.1	15	-	5.1	15	-	5.1	15	-	5.1	15	$pA/\sqrt{Hz}$
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	-	nV_{RMS}
POWER SUPPLY CHARACTERISTICS														
Supply Current	+25°C	-	3.0	5.0	-	5.0	6.5	-	3.0	5.0	-	5.0	6.5	mA
Power Supply Rejection Ratio (Note 6)	Full	86	100	-	86	100	-	80	100	-	80	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. See thermal constants in "Die Characteristics" section. Maximum power dissipation, including output load, must be designed to maintain the maximum junction temperature below +175°C for hermetic packages, and below +150°C for plastic packages.
5. $V_{OUT} = \pm10V$, $R_L = 2k\Omega$.
6. $V_{CM} = \pm5.0V$.
7. Channel separation value is referred to the input of the amplifier. Input test conditions are: f = 10kHz; V_{IN} = 100mV peak; $R_S = 1k\Omega$. (Refer to Channel Separation vs. Frequency Curve for test circuits.).
8. Output current is measured with $V_{OUT} = \pm5V$.
9. Full power bandwidth is guaranteed by equation: 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 10V input step, $A_V = -1$ for HA-5102/5104.
12. The limits for these parameters are guaranteed based on lab characterization, and reflect lot-to-lot variation.

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 (°C/W)	θ_{JA}	θ_{JC}
HA2-5102/5112 (CAN)	108	33
HA3-5102/5112 (PDIP)	92	30
HA4P5102 (PLCC)	74	33
HA7-5102/5112 (CDIP)	114	34
HA9P5102/5112 (SOIC)	112	35
HA1-5104/5114 (CDIP)	71	13
HA3-5104/5114 (PDIP)	86	25
HA4P5104/5114 (PLCC)	74	32
HA9P5104/5114 (SOIC)	96	26

Test Circuits

HA-5102, HA5104

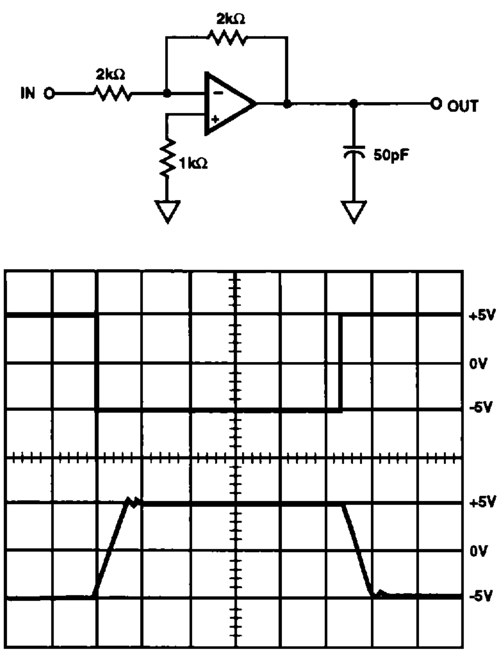


FIGURE 1. LARGE SIGNAL RESPONSE CIRCUIT
Volts: 5V/Div., Time: 5μs/Div. (A_V = -1)

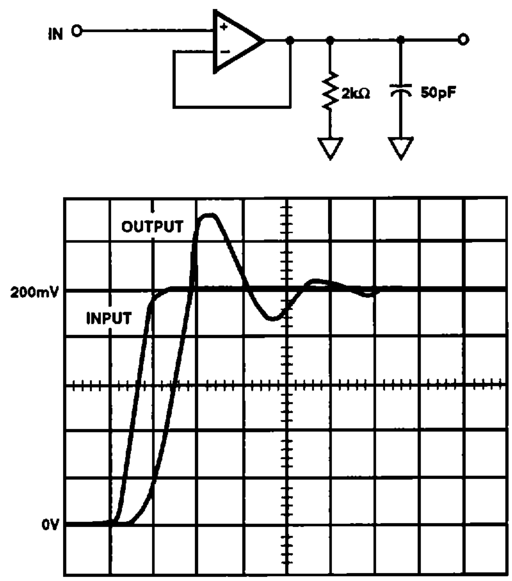
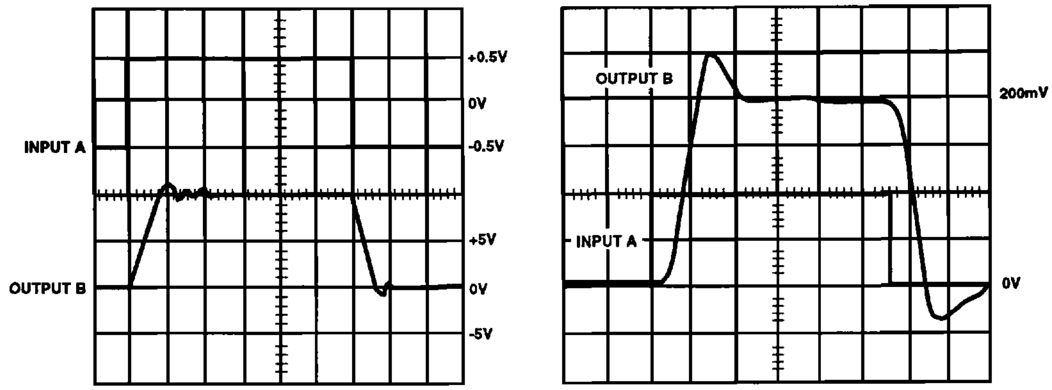


FIGURE 2. SMALL SIGNAL RESPONSE CIRCUIT
Volts: 40mV/Div., Time: 50ns/Div. (A_V = +1)

Test Circuits (Continued)

HA-5112, HA5114



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.

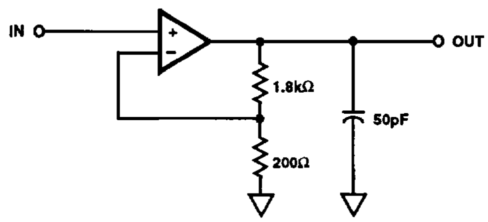
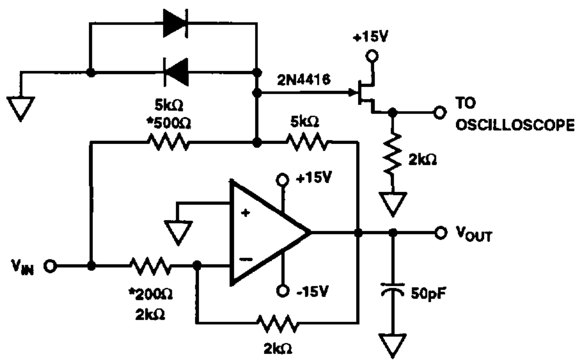


FIGURE 3. LARGE AND SMALL SIGNAL RESPONSE CIRCUIT
(A_V = +10)



- 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.

FIGURE 4. SETTLING TIME CIRCUIT

Typical Performance Curves

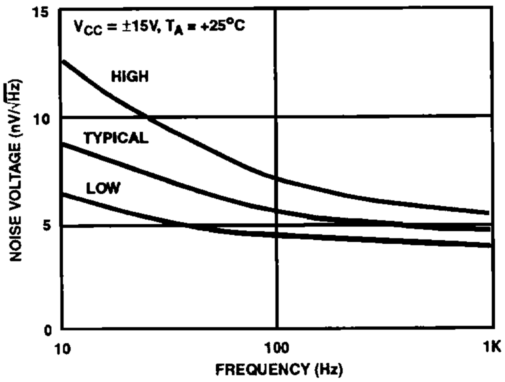


FIGURE 5. INPUT NOISE VOLTAGE DENSITY

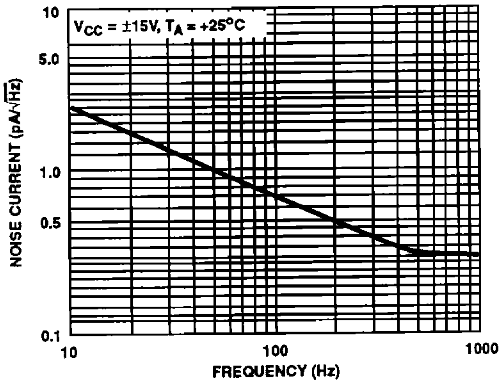


FIGURE 6. INPUT NOISE CURRENT DENSITY

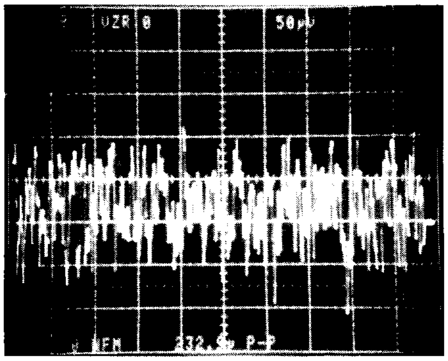


FIGURE 7. 0.1Hz TO 10Hz NOISE
V_{CC} = ±15V, T_A = +25°C, 50μV/Div., 1s/Div., A_V = 1000V/V
Input Noise = 0.232μV_{P-P}

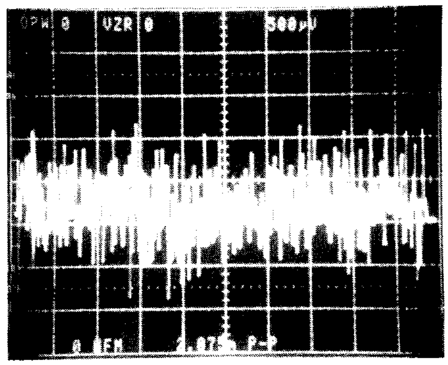


FIGURE 8. 0.1Hz TO 1MHz NOISE
V_{CC} = ±15V, T_A = +25°C, 500μV/Div., 1s/Div., A_V = 1000V/V
Total Output Noise = 2.075μV_{P-P}

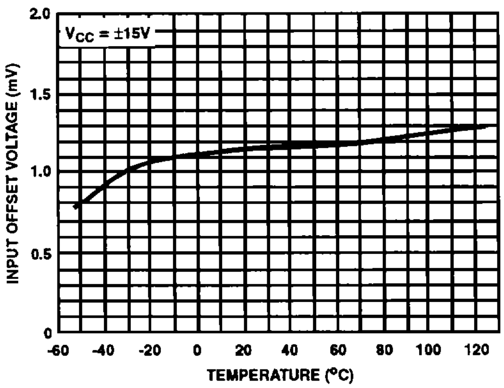


FIGURE 9. V_{IO} vs TEMPERATURE

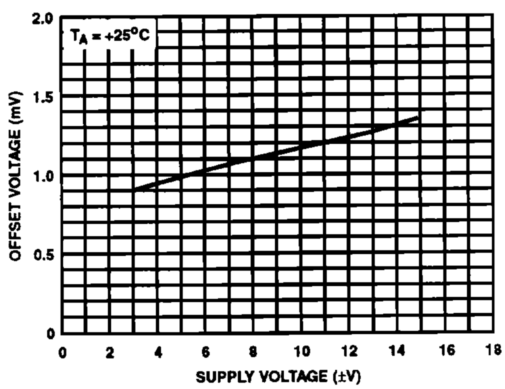


FIGURE 10. V_{IO} vs V_{CC}

Typical Performance Curves (Continued)

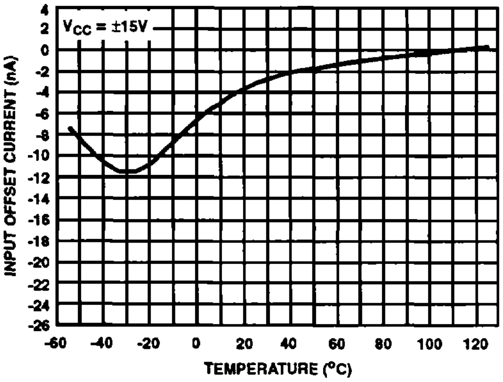


FIGURE 11. I_{IO} vs TEMPERATURE

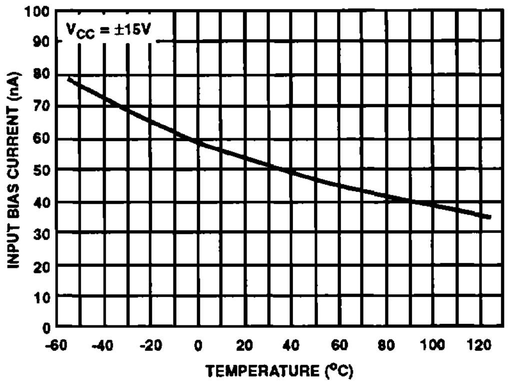


FIGURE 12. I_{BIAS} vs TEMPERATURE

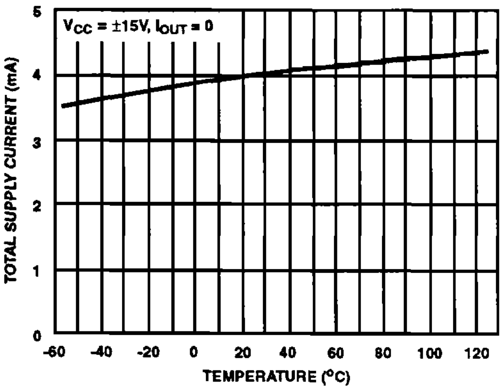


FIGURE 13. I_{CC} vs TEMPERATURE (HA-5104/14)

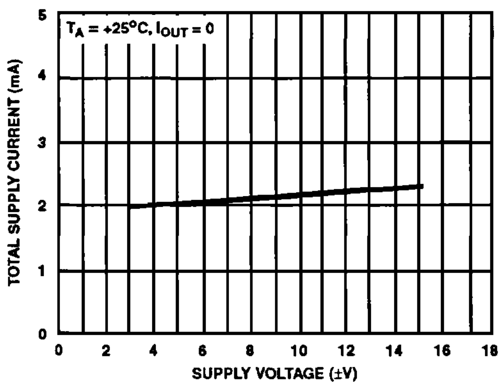


FIGURE 14. I_{CC} vs V_{CC} (HA-5102/12)

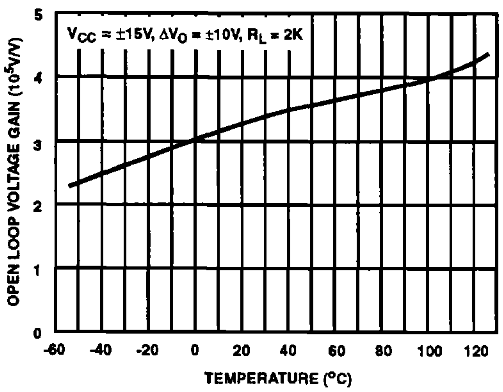


FIGURE 15. A_{VOL} vs TEMPERATURE

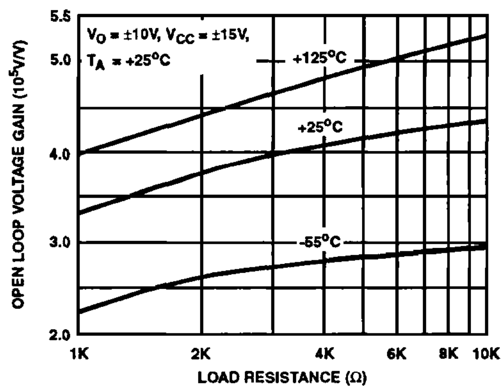


FIGURE 16. A_{VOL} vs LOAD RESISTANCE

Typical Performance Curves (Continued)

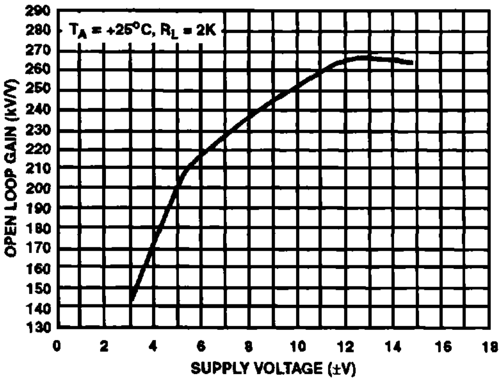


FIGURE 17. A_{VOL} vs V_{CC}

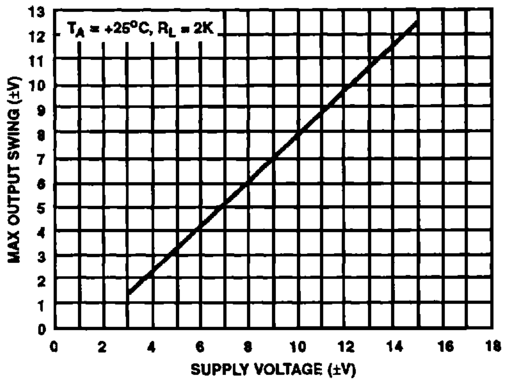


FIGURE 18. V_{OUT} vs V_{CC}

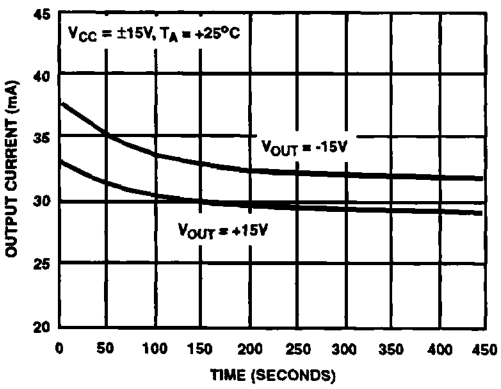


FIGURE 19. OUTPUT SHORT CIRCUIT CURRENT vs TIME

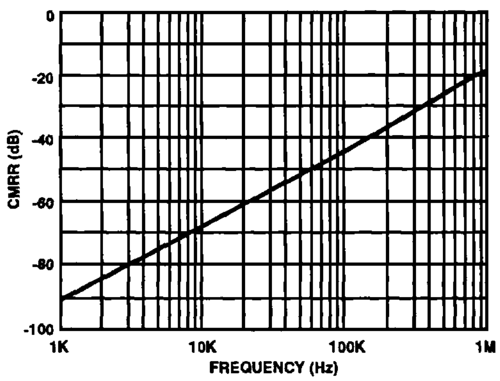


FIGURE 20. CMRR vs FREQUENCY

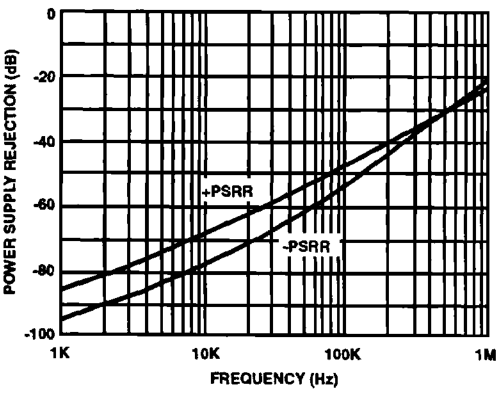


FIGURE 21. PSRR vs FREQUENCY

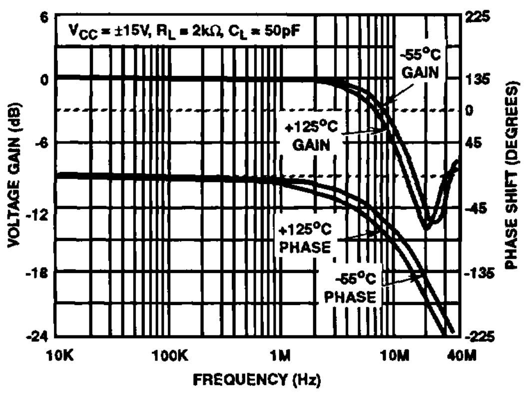


FIGURE 22. HA-5104/02 UNITY GAIN FREQUENCY RESPONSE

Typical Performance Curves (Continued)

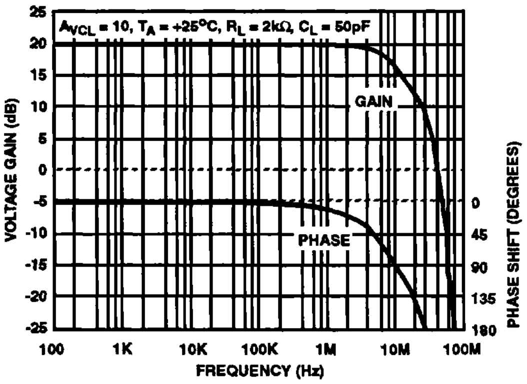


FIGURE 23. HA-5112/14 FREQUENCY RESPONSE

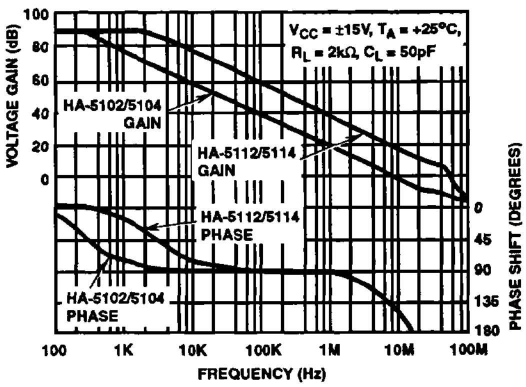


FIGURE 24. OPEN LOOP GAIN vs FREQUENCY

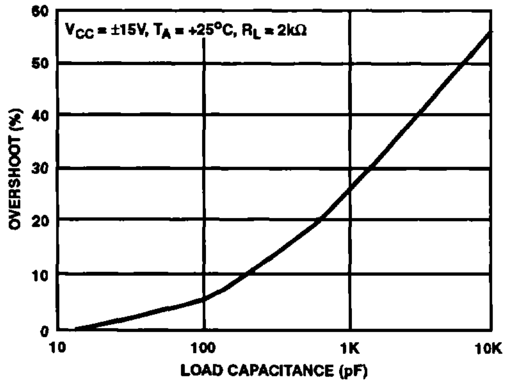


FIGURE 25. SMALL SIGNAL OVERSHOOT vs C_{LOAD}

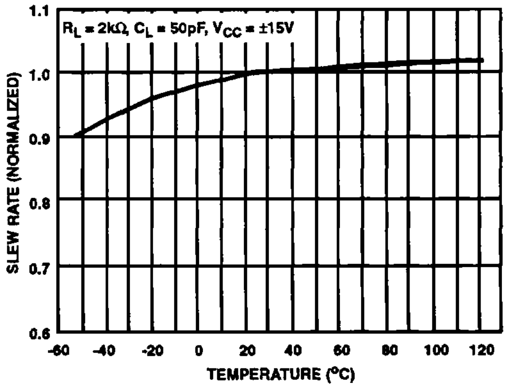


FIGURE 26. SLEW RATE vs TEMPERATURE

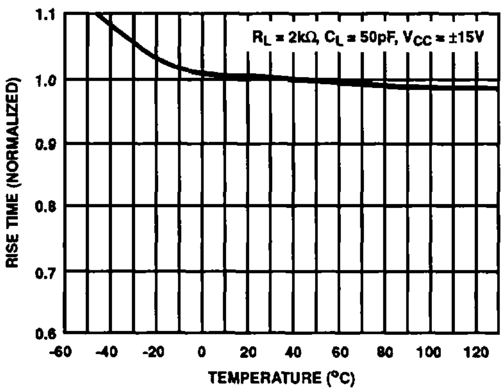


FIGURE 27. RISE TIME vs TEMPERATURE

2 OPERATIONAL AMPLIFIERS