

**HARRIS**

HARRIS SEMICONDUCTOR

HA-5102/04/12/14**Low Noise High Performance
Operational Amplifiers****Features**

- Low Noise $4.3\text{nV}/\sqrt{\text{Hz}}$
- Wide Bandwidth 8MHz (Compensated)
60MHz (Uncompensated)
- High Slew Rate $3\text{V}/\mu\text{s}$ (Compensated)
 $20\text{V}/\mu\text{s}$ (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.

T-79-05-20
T-79-05-40

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 $3\text{V}/\mu\text{s}$ slew rate and 8MHz bandwidth (5102/04) to $20\text{V}/\mu\text{s}$ slew rate and 60MHz gain-bandwidth-product (HA-5112/14). Complementing these outstanding parameters is a very low noise specification of $4.3\text{nV}/\sqrt{\text{Hz}}$ 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.

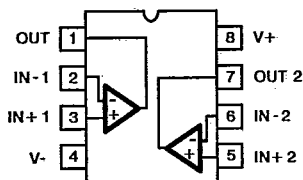
These operational amplifiers are available in dual or quad form with industry standard pinouts allowing for immediate inter-changeability with most other dual and quad operational amplifiers.

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

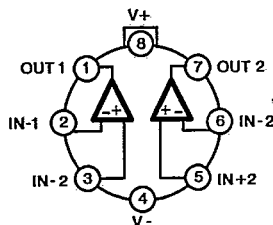
Each of these products are available in -2 (-55°C to +125°C), -5 and -7 (0°C to +75°C), or /883 grades. Refer to the /883 data sheet for military product.

Pinouts

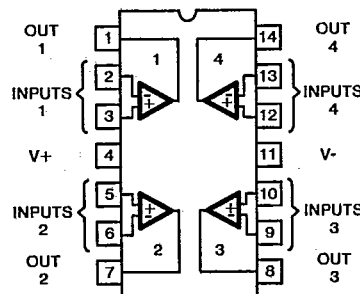
HA3-5102/5112 (PLASTIC MINI-DIP)
HA7-5102/5112 (CERAMIC MINI-DIP)
TOP VIEW



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.

Specifications HA-5102/04/12/14

HARRIS SEMICONDUCTOR

Absolute Maximum Ratings (Note 1)

$T_A = +25^\circ\text{C}$ Unless Otherwise Stated
 Voltage Between V_+ and V_- Terminals 40.0V
 Differential Input Voltage $\pm 7\text{V}$
 Input Voltage (Note 2) $\pm 15.0\text{V}$
 Output Short Circuit Duration (Note 3) Indefinite
 Power Dissipation (Note 4) 880mW

Operating Temperature Ranges

HA-5102/5104/5112/5114-2 $-55^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$
 HA-5102/5104/5112/5114-5 $-0^\circ\text{C} \leq T_A \leq +75^\circ\text{C}$
 Storage Temperature Range $-65^\circ\text{C} \leq T_A \leq +150^\circ\text{C}$

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Electrical Specifications $V_+ = 15\text{V D.C.}$, $V_- = -15\text{V D.C.}$, 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 (Note 5)	+25°C	-	250	-	-	250	-	-	250	-	-	250	-	kV/V
	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
	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

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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/√Hz
f = 1kHz	+25°C	-	4.3	6.0	-	4.3	6.0	-	4.3	6.0	-	4.3	6.0	nV/√Hz
Input Noise Current (Note 12)														
f = 10Hz	+25°C	-	5.1	12	-	5.1	12	-	5.1	12	-	5.1	12	pA/√Hz
f = 1kHz	+25°C	-	0.57	3	-	0.57	3	-	0.57	3	-	0.57	3	pA/√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 $< \pm 15V$, 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 $T_A = +25^\circ C$.
5. $V_{OUT} = \pm 10V$, $R_L = 2K$
6. $V_{CM} = \pm 5.0V$
7. Channel separation value is referred to the input of the amplifier. Input test conditions are: $f = 10kHz$; $V_{IN} = 200mV$ peak to peak; $R_S = 1k\Omega$.
8. Output current is measured with $V_{OUT} = \pm 5V$.
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 10 volt input step, $A_V = -1$ for HA-5102/5104.
12. Sample tested.

HA-5102/04/12/14

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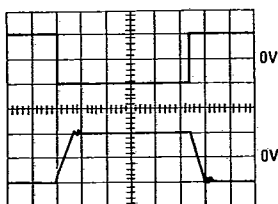
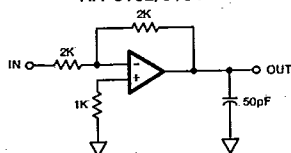
Test Circuits

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LARGE SIGNAL RESPONSE CIRCUIT

Volts: 5V/Div., Time: 5 μ s/Div. ($A_V = -1$)

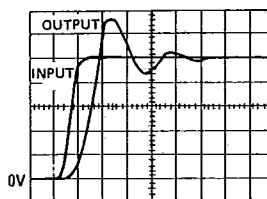
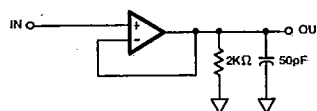
HA-5102/5104



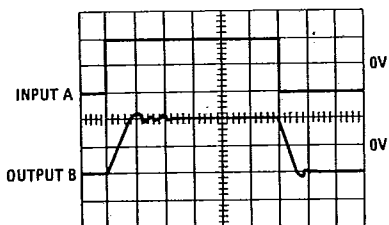
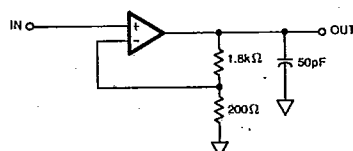
SMALL SIGNAL RESPONSE CIRCUIT

Volts: 40mV/Div., Time: 50ns/Div. ($A_V = +1$)

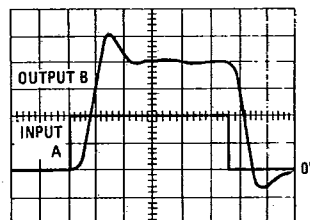
HA-5102/5104



LARGE AND SMALL SIGNAL RESPONSE CIRCUIT

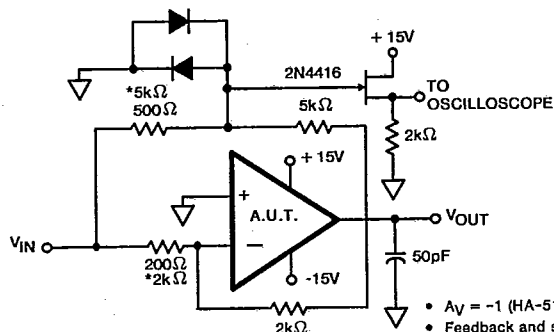
HA-5112/5114 ($A_V = +10$)

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.

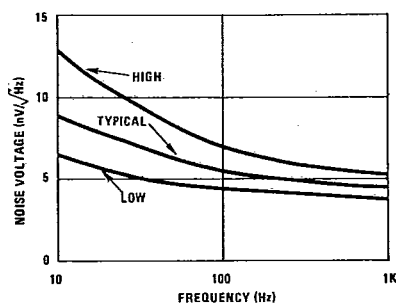
SETTLING TIME CIRCUIT



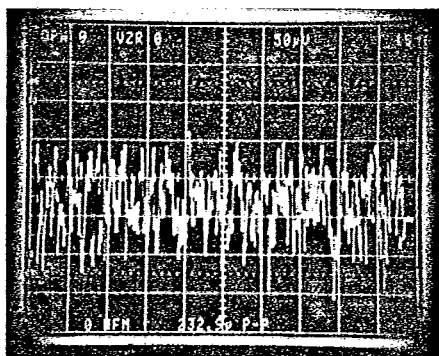
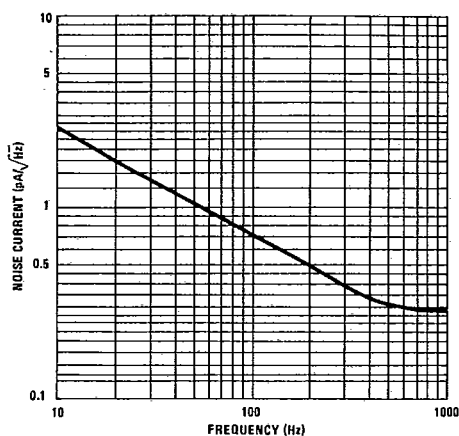
- $A_V = -1$ (HA-5102/5104), $*A_V = -10$ (HA-5112/5114)
- Feedback and summing resistors should be 0.1% matched.
- Clipping diodes are optional, HP5082-2810 recommended.

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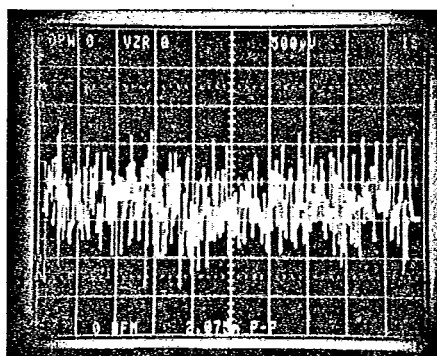
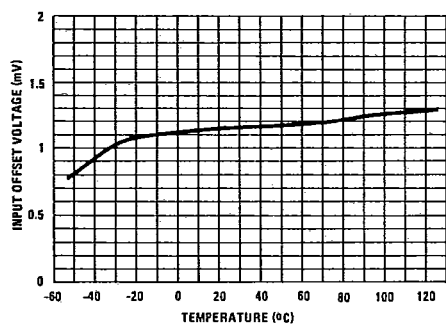
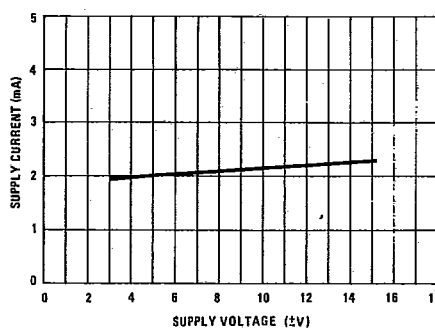
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Typical Performance Curves**INPUT NOISE VOLTAGE DENSITY**
 $V_{CC} = \pm 15V$, $T_A = +25^\circ C$ 

0.1Hz TO 10Hz NOISE
 $V_{CC} = \pm 15V$, $T_A = +25^\circ C$
 $50\mu V/Div.$, $1s/Div.$, $A_V = 1000 V/V$
 Input Noise = $0.232\mu V_{p-p}$

**INPUT NOISE CURRENT DENSITY**
 $V_{CC} = \pm 15V$, $T_A = +25^\circ C$ 

0.1Hz TO 1MHz NOISE
 $V_{CC} = \pm 15V$, $T_A = +25^\circ C$
 $500\mu V/Div.$, $1s/Div.$, $A_V = 1000 V/V$
 Total Output Noise = $2.075\mu V_{p-p}$

 **V_{IO} vs. TEMPERATURE**
 $V_{CC} = \pm 15V$  **V_{IO} vs. V_{CC}**
 $T_A = +25^\circ C$ 

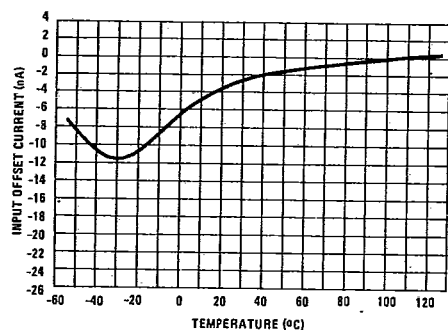
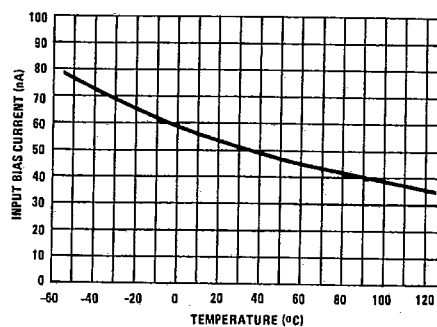
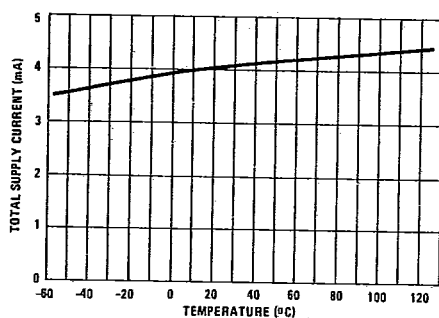
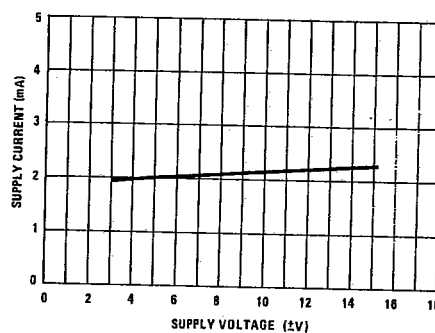
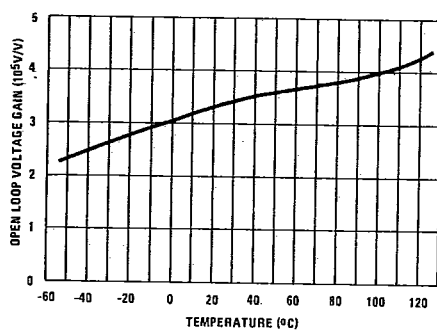
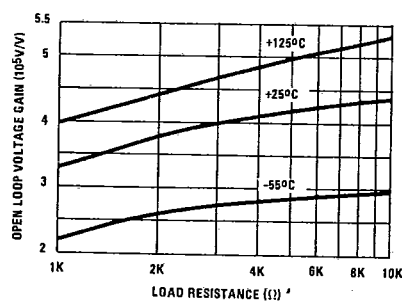
HA-5102/04/12/14

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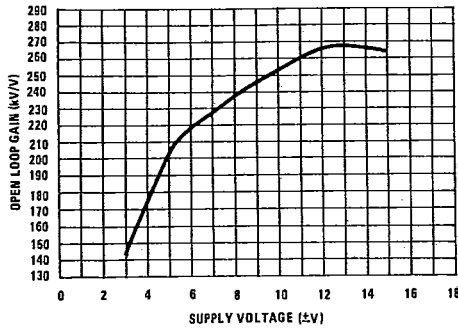
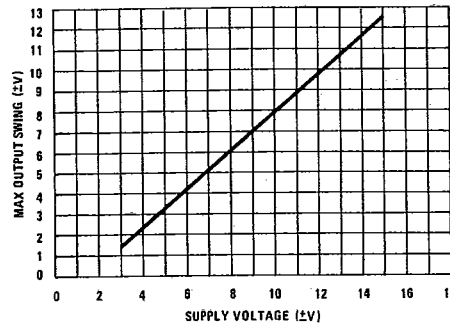
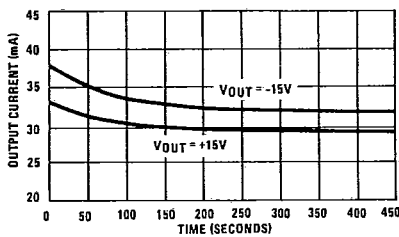
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Typical Performance (Continued) **I_{IO} vs. TEMPERATURE**
 $V_{CC} = \pm 15V$ **IBIAS vs. TEMPERATURE**
 $V_{CC} = \pm 15V$  **I_{CC} vs. TEMPERATURE**
 $V_{CC} = \pm 15V, I_{OUT} = 0$  **I_{CC} vs. V_{CC}**
 $T_A = +25^\circ C, I_{OUT} = 0$  **A_{VOL} vs. TEMPERATURE**
 $V_{CC} = \pm 15V, \Delta V_O = \pm 10V, R_L = 2K$  **A_{VOL} vs. LOAD RESISTANCE**
 $V_O = \pm 10V, V_{CC} = \pm 15V, T_A = +25^\circ C$ 

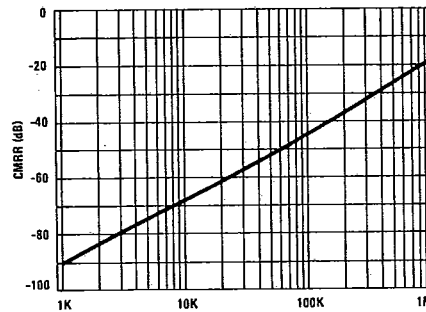
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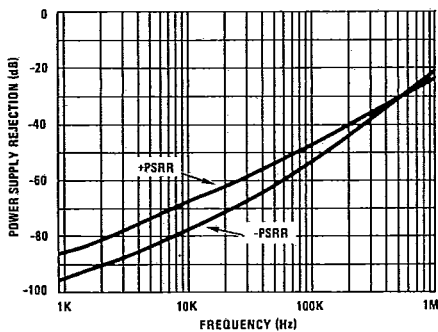
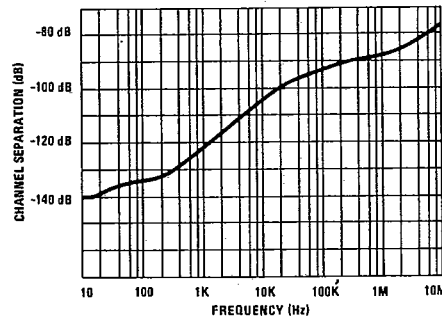
Typical Performance (Continued)

A_{OL} vs. V_{CC}
T_A = +25°C, R_L = 2KV_{OUT} vs. V_{CC}
T_A = +25°C, R_L = 2KOUTPUT SHORT-CIRCUIT CURRENT vs. TIME
V_{CC} = ±15V, T_A = +25°C

CMRR vs. FREQUENCY



PSRR vs. FREQUENCY

HA-5104 CHANNEL SEPARATION vs. FREQUENCY
10Hz ≤ f ≤ 10MHz

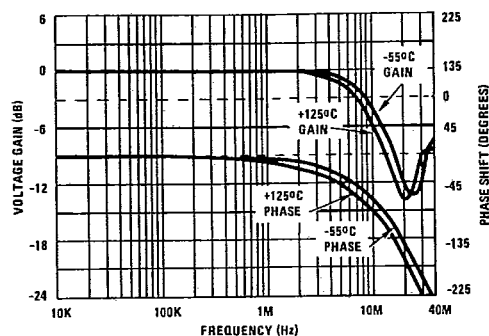
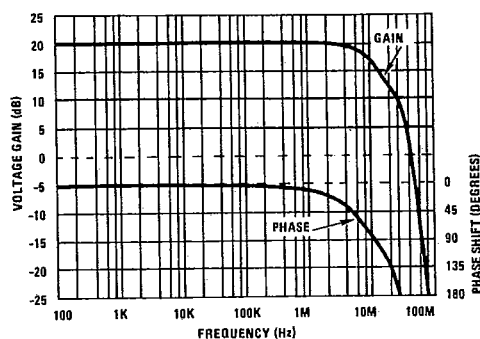
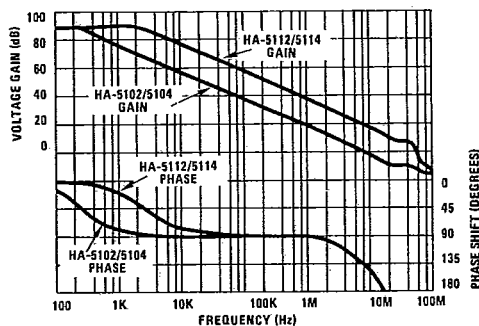
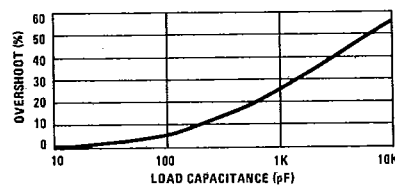
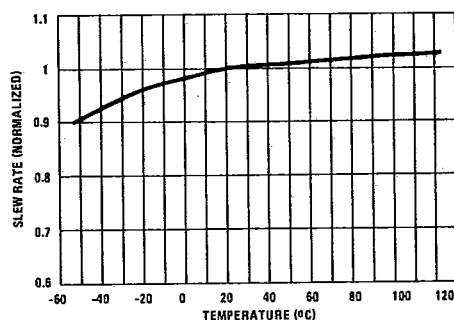
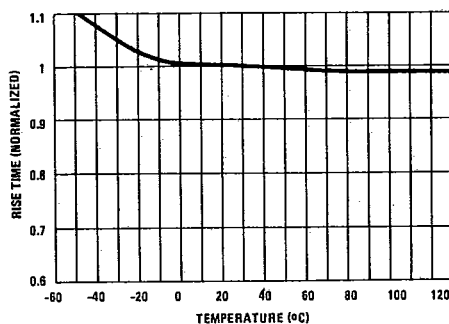
HA-5102/04/12/14

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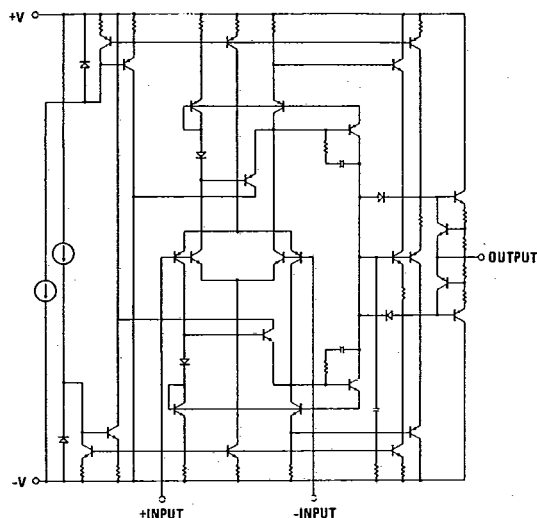
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Typical Performance (Continued)**HA-5104/02 UNITY GAIN FREQUENCY RESPONSE**
 $V_{CC} = \pm 15V$, $R_L = 2K$, $C_L = 50pF$ **HA-5112/14 FREQUENCY RESPONSE**
 $AV_{CL} = 10$, $T_A = +25^\circ C$, $R_L = 2K$, $C_L = 50pF$ **OPEN-LOOP GAIN vs. FREQUENCY**
 $V_{CC} = \pm 15V$, $R_L = 2K$, $C_L = 50pF$, $T_A = +25^\circ C$ **SMALL SIGNAL OVERSHOOT vs. CLOAD**
 $V_{CC} = \pm 15V$, $T_A = +25^\circ C$, $R_L = 2K$ **SLEW RATE vs. TEMPERATURE**
 $R_L = 2K$, $C_L = 50pF$, $V_{CC} = \pm 15V$ **RISE TIME vs. TEMPERATURE**
 $R_L = 2K$, $C_L = 50pF$, $V_{CC} = \pm 15V$ 

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Simplified Schematic**Die Characteristics**

Transistor Count	Thermal Constants (°C/W)	θ_{ja}	θ_{jc}
HA-5102/5112 93	HA1-5104 (-2, -5, -7)	103	35
HA-5104/5114 175	HA1-5104 (/883)	78	25
Die Dimensions	HA2-5102/5112 (-2, -5, -7)	174	48
HA-5102/5112 98.4 x 67.3 x 19 mils	HA2-5102/5112 (/883)	134	40
(2500 x 1710 x 480 μ m)	HA3-5102/5112 (-5)	80	20
HA-5104/5114 99.6 x 95.3 x 19 mils	HA3-5104/5114 (-5)	75	23
(2530 x 2420 x 480 μ m)	HA7-5102/5112 (-2, -5, -7)	163	82
Substrate Potential* V-	HA7-5102/5112 (/883)	124	47
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.

HA-5102/04/12/14

2

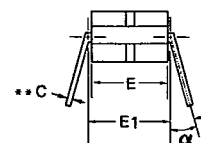
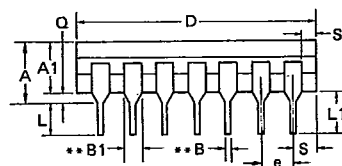
OP AMPS &
COMPARATORS

HARRIS SEMICONDUCTOR

Package Configuration

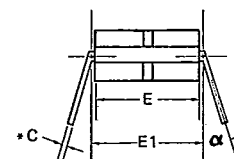
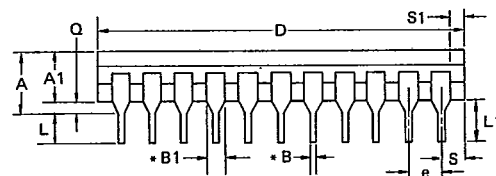
A**B****C****D****E****.300 CERAMIC DUAL-IN-LINE**

T-90-20



PKG. CODE	LEAD COUNT	DIM. A	DIM. A1	DIM. B	DIM. B1	DIM. C	DIM. D	DIM. E	DIM. E1	DIM. e	DIM. L	DIM. L1	DIM. S	DIM. S1	DIM. Q	DIM. α
A	8 SSI	—	.140 .160	.016 .023	.050 .065	.008 .015	.375 .395	.245 .265	.290 .310	.100 BSC	.125 .150	.150 —	— .055	.005 —	.015 .060	0° 15°
B1	14 MSI	—	.140 .170	.016 .023	.050 .065	.008 .015	.763 .785	.265 .285	.290 .310	.100 BSC	.125 .180	.150 —	— .098	.005 —	.015 .060	0° 15°
B2	14 LSI	—	.140 .170	.016 .023	.050 .065	.008 .015	.753 .785	.285 .305	.300 .320	.100 BSC	.125 .180	.150 —	— .098	.005 —	.015 .060	0° 15°
C1	16* MSI	—	.140 .170	.016 .023	.050* .065*	.008 .015	.753 .785	.265 .285	.290 .310	.100 BSC	.125 .180	.150 —	— .080	.005 —	.015 .060	0° 15°
C2	16* LSI	—	.140 .170	.016 .023	.050* .065*	.008 .015	.753 .785	.285 .305	.300 .320	.100 BSC	.125 .180	.150 —	— .080	.005 —	.015 .060	0° 15°
D	18 LSI	—	.140 .170	.016 .023	.050* .065*	.008 .015	.882 .915	.285 .305	.300 .320	.100 BSC	.125 .180	.150 —	— .098	.005 —	.015 .060	0° 15°
E	20 LSI	—	.140 .170	.016 .023	.050* .065*	.008 .015	.940 .970	.285 .305	.300 .320	.100 BSC	.125 .180	.150 —	— .080	.005 —	.015 .060	0° 15°

* End leads are half leads where B remains the same and B1 is 0.035
 ** Solder dip finish add +0.003 inches 0.045

F**.400 CERAMIC DUAL-IN-LINE****G****H****.600 CERAMIC DUAL-IN-LINE**

PKG. CODE	LEAD COUNT	DIM. A	DIM. A1	DIM. B	DIM. B1	DIM. C	DIM. D	DIM. E	DIM. E1	DIM. e	DIM. L	DIM. L1	DIM. S	DIM. S1	DIM. Q	DIM. α
F .400	22 LSI	—	.150 .180	.016 .023	.050 .065	.008 .015	1.055 1.085	.375 .395	.395 .415	.100 BSC	.125 .180	.150 —	— .080	.005 —	.015 .060	0° 15°
G .600	24 LSI	—	.150 .180	.016 .023	.050 .065	.008 .015	1.24 1.27	.515 .535	.595 .615	.100 BSC	.125 .180	.150 —	— .098	.005 —	.015 .060	0° 15°
H .600	26 LSI	—	.160 .190	.016 .023	.050 .065	.008 .015	1.44 1.47	.515 .535	.595 .615	.100 BSC	.125 .180	.150 —	— .098	.005 —	.015 .060	0° 15°

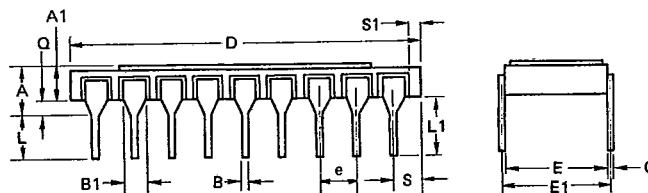
* Solder dip finish add +0.003 inches.

NOTE: Dimensions are $\frac{\text{Min}}{\text{Max}}$ Dimensions are in inches.

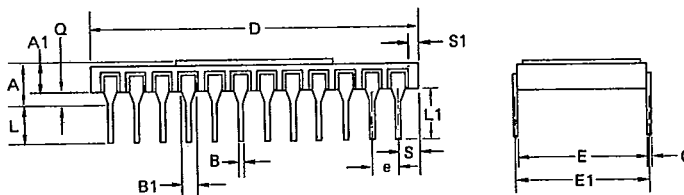
BSC means basic spacing between centerlines.

Package Configuration

T-90-20

I .300 SIDEBRAZE DUAL-IN-LINE

PKG. CODE	LEAD COUNT	DIM. A	DIM. A1	DIM. B	DIM. B1	DIM. C	DIM. D	DIM. E	DIM. E1	DIM. e	DIM. L	DIM. L1	DIM. S	DIM. S1	DIM. Q
I	18	— .200	.080 .110	.016 .023	.045 .060	.008 .015	.890 .910	.280 .300	.290 .310	.100 BSC	.125 .180	.150 —	— .098	.005 —	.025 .045

J K L .600 SIDEBRAZE DUAL-IN-LINE

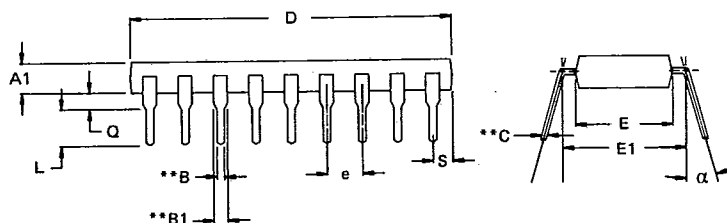
PKG. CODE	LEAD COUNT	DIM. A	DIM. A1	DIM. B	DIM. B1	DIM. C	DIM. D	DIM. E	DIM. E1	DIM. e	DIM. L	DIM. L1	DIM. S	DIM. S1	DIM. Q
J	24	— .225	.080 .110	.016 .023	.040 .054	.008 .015	1.185 1.215	.587 .603	.598 .612	.100 BSC	.125 .180	.150 —	— .080	.005 —	.040 .060
K	28	— .225	.080 .110	.016 .023	.040 .054	.008 .015	1.385 1.415	.587 .603	.598 .612	.100 BSC	.125 .180	.150 —	— .080	.005 —	.030 .060
L	40	— .225	.080 .110	.016 .023	.040 .054	.008 .015	1.980 2.020	.587 .603	.598 .612	.100 BSC	.125 .180	.150 —	— .080	.005 —	.040 .060

NOTE: Dimensions are $\frac{\text{Min.}}{\text{Max.}}$. Dimensions in inches.

BSC means basic spacing between centerlines.

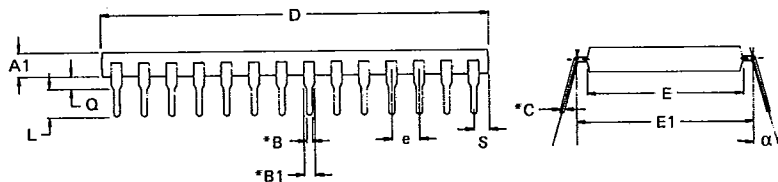
Package Configuration

T-90-20

M N O P Q .300 PLASTIC DUAL-IN-LINE

PKG. CODE	LEAD COUNT	DIM. A1	DIM. B	DIM. B1	DIM. C	DIM. D	DIM. E	DIM. E1	DIM. e	DIM. L	DIM. S	DIM. Q	DIM. α
M	8	.125 .140	.016 .023	.050 .070	.008 .015	.370 .390	.245 .265	.290 .310	.090 .110	.110 .150	.030 .050	.020 .040	0° 15°
N	14	.125 .140	.016 .023	.050 .070	.008 .015	.750 .770	.245 .265	.290 .310	.090 .110	.110 .150	.030 .050	.020 .040	0° 15°
O	16*	.125 .140	.016 .023	.050 .070	.008 .015	.750 .770	.245 .265	.290 .310	.090 .110	.110 .150	.025 .035	.020 .040	0° 15°
P	18	.125 .140	.016 .023	.050 .070	.008 .015	.900 .920	.245 .265	.290 .310	.090 .110	.110 .150	.040 .060	.020 .040	0° 15°
Q	20	.130 .145	.016 .023	.050 .070	.008 .015	1.030 1.050	.250 .270	.290 .310	.090 .110	.110 .150	.060 .080	.020 .040	0° 15°

* End leads are half leads where B remains the same and B1 is $\frac{0.035}{0.045}$
 ** Solder dip finish add 0.003 inches.

R S .600 PLASTIC DUAL-IN-LINE

PKG. CODE	LEAD COUNT	DIM. A1	DIM. B	DIM. B1	DIM. C	DIM. D	DIM. E	DIM. E1	DIM. e	DIM. L	DIM. S	DIM. Q	DIM. α
R	24	.145 .155	.016 .023	.050 .070	.008 .015	1.24 1.26	.540 .560	.590 .610	.090 .110	.110 .150	.045 .095	.020 .040	0° 15°
S	28	.145 .155	.016 .023	.050 .070	.008 .015	1.54 1.57	.540 .560	.590 .610	.090 .110	.110 .150	.110 .160	.020 .040	0° 15°

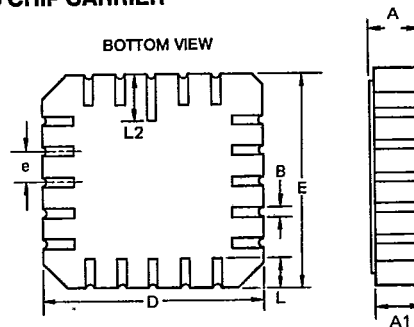
* Solder dip finish add 0.003 inches.

NOTE: Dimensions are $\frac{\text{Min}}{\text{Max}}$. Dimensions are in inches.

BSC means basic spacing between centerlines.

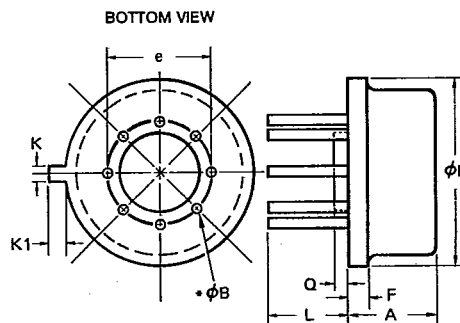
Package Configuration

T-90-20

T .350 CERAMIC LEADLESS CHIP CARRIER***U** .450 CERAMIC LEADLESS CHIP CARRIER***V** .650 CERAMIC LEADLESS CHIP CARRIER*

PKG. CODE	LEAD COUNT	DIM. A	DIM. A1	DIM. B	DIM. D	DIM. E	DIM. e	DIM. L	DIM. L2
T	20 .350 SQ	.073 .089	.063 .077	.022 .028	.342 .358	.342 .358	.050 BSC	.045 .055	.075 .095
U	28 .450 SQ	.074 .088	.064 .076	.022 .028	.442 .458	.442 .458	.050 BSC	.045 .055	.075 .095
V	44 .650 SQ	.073 .089	.063 .077	.022 .028	.643 .662	.643 .662	.050 BSC	.045 .055	.075 .095

* Solder dip finish for military parts conform to MIL-M-38510, Type A.

W TO-99 METAL CAN**X** TO-100 METAL CAN

PKG. CODE	LEAD COUNT	DIM. A	DIM. ϕB	DIM. ϕD	DIM. e	DIM. F	DIM. K	DIM. K1	DIM. L	DIM. Q
W	8 TO-99	.165 .185	.016 .018	.345 .365	.190 .210	.020 .040	.028 .034	.028 .040	.505 .550	.015 .040
X	10 TO-100	.165 .185	.016 .018	.345 .365	.220 .240	.020 .040	.028 .034	.028 .040	.505 .550	.015 .040

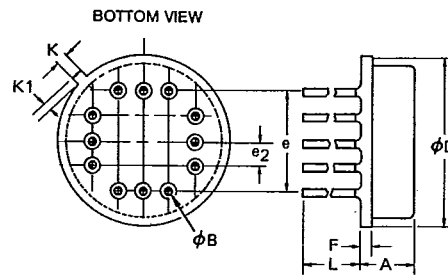
* Solder dip finish add +0.003 inches.

NOTE: Dimensions are $\frac{\text{Min}}{\text{Max}}$. Dimensions are in inches.

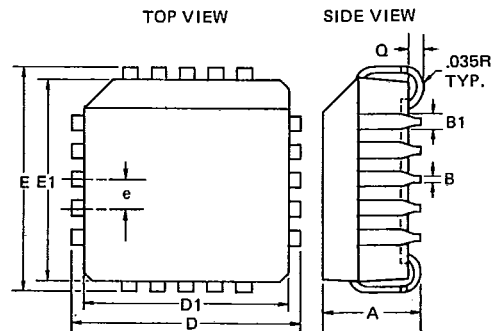
BSC means basic spacing between centerlines.

Package Configuration

T-90-20

Y TO-8 METAL CAN

PKG. CODE	LEAD COUNT	DIM. A	DIM. phi B	DIM. phi D	DIM. e	DIM. e2	DIM. F	DIM. K	DIM. K1	DIM. L
Y	12 TO-8	.130 .150	.016 .021	.585 .615	.400 BSC	.100 BSC	.020 .040	.027 .034	.027 .045	.500 .550

AA AB AC PLASTIC LEADED CHIP CARRIER

PKG. CODE	LEAD COUNT	DIM. A	DIM. B	DIM. B1	DIM. D/E	DIM. D1/E1	DIM. e	DIM. Q
AA	20	.165 .180	.013 .021	.026 .032	.385 .395	.350 .356	.050 BSC	.020 —
AB	28	.165 .180	.013 .021	.026 .032	.485 .495	.450 .456	.050 BSC	.020 —
AC	44	.165 .180	.013 .021	.026 .032	.685 .695	.650 .656	.050 BSC	.020 —

NOTE: Dimensions are $\frac{\text{Min}}{\text{Max}}$. Dimensions are in inches.

BSC means basic spacing between centerlines.