HARRIS SEMICONDUCTOR

HA-5101, HA-5111

10MHz and 100MHz, Low Noise, Operational Amplifiers

November 1996

Features

- Low Noise . . . . 3.0nV/√Hz at 1kHz
- Bandwidth. . . . . 10MHz (Compensated)
  100MHz (Uncompensated)
- Slew Rate . . . . 10V/μs (Compensated)
  50V/μs (Uncompensated)
- Low Offset Voltage Drift . . . . $3\mu V/^oC$
- High Gain . . . . $1 \times 10^6 V/V$
- High CMRR/PSRR 100dB
- High Output Drive Capability 30mA

Applications

- High Quality Audio Preamplifiers
- High Q Active Filters
- Low Noise Function Generators
- Low Distortion Oscillators
- Low Noise Comparators
- For Further Design Ideas, See Application Note AN554, Harris AnswerFAX (407-724-7800) Document #9554

Description

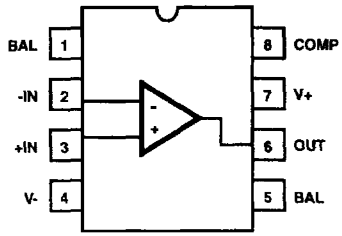
The HA-5101/5111 are dielectrically isolated operational amplifiers featuring low noise. Both amplifiers have an excellent noise voltage density of 3.0nV/√Hz at 1kHz. The uncompensated HA-5111 is stable at a minimum gain of 10 and has the same DC specifications as the unity gain stable HA-5101. The difference in compensation yields a 100MHz gain-bandwidth product and a 50V/μs slew rate for the HA-5111 versus a 10MHz unity gain bandwidth and a 10V/μs slew rate for the HA-5101.

DC characteristics of the HA-5101/5111 assure accurate performance. The 0.5mV offset voltage is externally adjustable and offset voltage drift is just $3\mu V/^oC$. An offset current of only 30nA reduces input current errors and an open loop voltage gain of $1 \times 10^6 V/V$ increases loop gain for low distortion amplification.

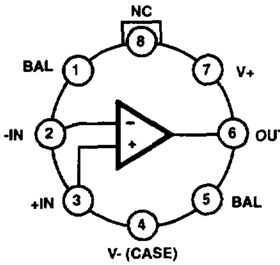
The HA-5101/5111 are ideal for audio applications, especially low-level signal amplifiers such as microphone, tape head and phono cartridge preamplifiers. Additionally, it is well suited for low distortion oscillators, low noise function generators and high Q filters.

Pinouts

HA-5101, HA-5111 (PDIP, CERDIP, SOIC)
TOP VIEW



HA-5101 (CAN)
TOP VIEW



Ordering Information

PART NUMBER (BRAND)	TEMP. RANGE (°C)	PACKAGE	PKG. NO.
HA2-5101-2	-55 to 125	8 Pin Can	T8.C
HA3-5101-5	0 to 75	8 Ld PDIP	E8.3
HA7-5101-2	-55 to 125	8 Ld CERDIP	F8.3A
HA9P5101-5 (H51015)	0 to 75	8 Ld SOIC	M8.15
HA9P5101-9 (H51019)	-40 to 85	8 Ld SOIC	M8.15
HA3-5111-5	0 to 75	8 Ld PDIP	E8.3
HA7-5111-2	-55 to 125	8 Ld CERDIP	F8.3A
HA9P5111-5 (H51115)	0 to 75	8 Ld SOIC	M8.15
HA9P5111-9 (H51119)	-40 to 85	8 Ld SOIC	M8.15

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

Absolute Maximum Ratings

Voltage Between V+ and V- Terminals 40V
Differential Input Voltage 7V
Input Voltage .... $\pm V_{SUPPLY}$
Output Current .... Full Short Circuit Protection

Operating Conditions

Temperature Range
HA-5101/5111-2 .... -55°C to 125°C
HA-5101/5111-5 .... 0°C to 75°C
HA-5101/5111-9 .... -40°C to 85°C

Thermal Information

Thermal Resistance (Typical, Note 2)	θ_{JA} (°C/W)	θ_{JC} (°C/W)
Can Package	165	80
PDIP Package	94	N/A
CERDIP Package	135	50
SOIC Package	157	N/A

Maximum Junction Temperature (Note 1) .... 175°C
Maximum Junction Temperature (Plastic Package) .... 150°C
Maximum Storage Temperature Range .... -65°C to 150°C
Maximum Lead Temperature (Soldering 10s) .... 300°C
(SOIC - Lead Tips Only)

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.

NOTES:

1. 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 the plastic packages.
2. θ_{JA} is measured with the component mounted on an evaluation PC board in free air.

Electrical Specifications

$V_{SUPPLY} = \pm15V$, $R_S = 100\Omega$, $R_L = 2k\Omega$, $C_L = 50pF$, Unless Otherwise Specified

PARAMETER	TEST CONDITIONS	TEMP (°C)	HA-5101-2, -5; HA-5111-2, -5 MIN	TYP	MAX	HA-5101-9, HA-5111-9 MIN	TYP	MAX	UNITS
INPUT CHARACTERISTICS									
Offset Voltage		25	-	0.5	3	-	0.5	3	mV
		Full	-	-	4	-	-	4	mV
Offset Voltage Drift		Full	-	3	-	-	3	-	µV/°C
Bias Current		25	-	100	200	-	100	200	nA
		Full	-	-	325	-	-	325	nA
Offset Current		25	-	30	75	-	30	75	nA
		Full	-	-	125	-	-	125	nA
Input Resistance		25	-	500	-	-	500	-	kΩ
Common Mode Range		Full	±12	-	-	±12	-	-	V
TRANSFER CHARACTERISTICS									
Large Signal Voltage Gain	$V_{OUT} = \pm10V$	25	-	1000	-	-	1000	-	kV/V
		Full	100	250	-	100	250	-	kV/V
Common Mode Rejection Ratio	$V_{CM} = \pm10V$	Full	80	100	-	80	100	-	dB
Small Signal Bandwidth	HA-5101, $A_V = 1$	25	-	10	-	-	10	-	MHz
Gain Bandwidth Product	HA-5111, $A_V = 10$	25	-	100	-	-	100	-	MHz
Minimum Stable Gain	HA-5101	Full	1	-	-	1	-	-	V/V
	HA-5111	Full	10	-	-	10	-	-	V/V
OUTPUT CHARACTERISTICS									
Output Voltage Swing	$R_L = 10k\Omega$	Full	±12	±13	-	±12	±13	-	V
	$R_L = 2k\Omega$	Full	±12	±13	-	±12	±13	-	V
	$V_S = \pm18V$, $R_L = 600\Omega$	25	±15	-	-	±15	-	-	V
Output Current (Note 3)		25	25	30	-	25	30	-	mA

Electrical Specifications $V_{SUPPLY} = \pm 15V$, $R_S = 100\Omega$, $R_L = 2k\Omega$, $C_L = 50pF$, Unless Otherwise Specified **(Continued)**

PARAMETER	TEST CONDITIONS	TEMP (°C)	HA-5101-2, -5; HA-5111-2, -5			HA-5101-9, HA-5111-9			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
Full Power Bandwidth (Note 4)	HA-5101	25	95	160	-	95	160	-	kHz
	HA-5111	25	630	790	-	630	790	-	kHz
Output Resistance		25	-	110	-	-	110	-	Ω
Maximum Load Capacitance		25	-	800	-	-	800	-	pF
TRANSIENT RESPONSE (Note 5)									
Rise Time	HA-5101	25	-	50	100	-	50	100	ns
	HA-5111	25	-	30	60	-	30	60	ns
Overshoot	HA-5101	25	-	20	35	-	20	35	%
	HA-5111	25	-	20	40	-	20	40	%
Slew Rate	HA-5101	25	6	10	-	6	10	-	V/µs
	HA-5111	25	40	50	-	40	50	-	V/µs
Settling Time (Note 6)	HA-5101 0.01%	-	-	2.6	-	-	2.6	-	µs
	HA-5111 0.01%	-	-	0.5	-	-	0.5	-	µs
NOISE CHARACTERISTICS (Note 7)									
Input Noise Voltage	f = 10Hz	25	-	5	7	-	5	7	$nV/\sqrt{Hz}$
	f = 1kHz	25	-	3.0	4.0	-	3.0	4.0	$nV/\sqrt{Hz}$
Input Noise Current	f = 10Hz	25	-	4.0	9	-	4.0	9	$pA/\sqrt{Hz}$
	f = 1kHz		-	0.6	2.5	-	0.6	2.5	$pA/\sqrt{Hz}$
Broadband Noise Voltage	f = DC To 30kHz	25	-	0.870	-	-	0.870	-	μV_{RMS}
POWER SUPPLY CHARACTERISTICS									
Supply Current HA-5101/5111		Full	-	4	6	-	4	7	mA
Power Supply Rejection Ratio	$\Delta V_S = \pm 5V$	Full	80	100	-	80	100	-	dB

NOTES:

3. Output current is measured with $V_{OUT} = \pm 15V$ with $V_{SUPPLY} = \pm 18V$.
4. Full power bandwidth is guaranteed by equation: Full power bandwidth $= \frac{\text{Slew Rate}}{2\pi V_{PEAK}}$, $V_{PEAK} = 10V$.
5. Refer to Test Circuits section of the data sheet.
6. Settling time is measured to 0.01% of final value for a 10V output step, and $A_V = -10$ for HA-5111 and 0.01% of final value for a 10V output step, $A_V = -1$ for HA-5101.
7. The limits for these parameters are guaranteed based on lab characterization, and reflect lot-to-lot variation.

Test Circuits and Waveforms

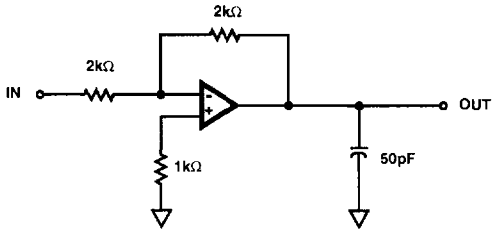


FIGURE 1. HA-5101 LARGE SIGNAL RESPONSE CIRCUIT

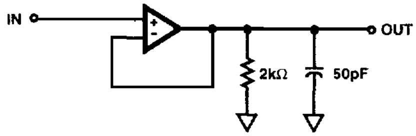
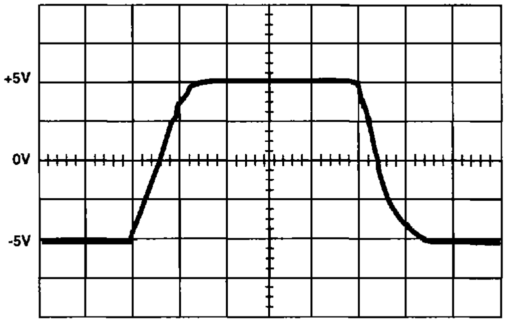
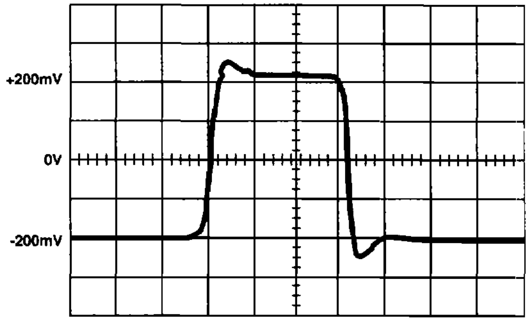


FIGURE 2. HA-5101 SMALL SIGNAL RESPONSE CIRCUIT



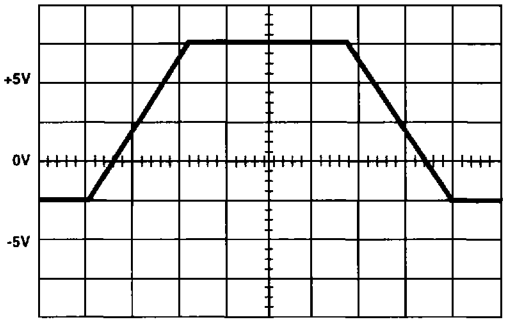
Ch. 1 = 2.5V/Div.
Timebase = 200ns/Div.

FIGURE 3. HA-5111 LARGE SIGNAL TRANSIENT RESPONSE



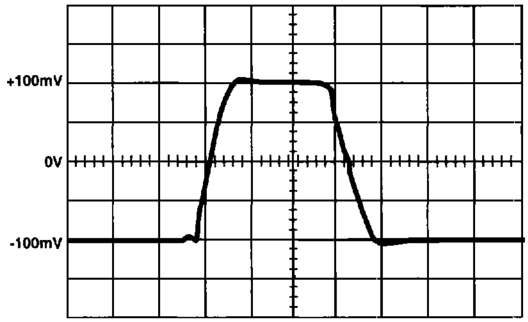
Ch. 1 = 100mV/Div.
Timebase = 100ns/Div.

FIGURE 4. HA-5111 SMALL SIGNAL TRANSIENT RESPONSE



Ch. 1 = 2.5V/Div.
Timebase = 1.00µs/Div.

FIGURE 5. HA-5101 LARGE SIGNAL TRANSIENT RESPONSE



Ch. 1 = 50mV/Div.
Timebase = 100ns/Div.

FIGURE 6. HA-5101 SMALL SIGNAL TRANSIENT RESPONSE

Test Circuits and Waveforms (Continued)

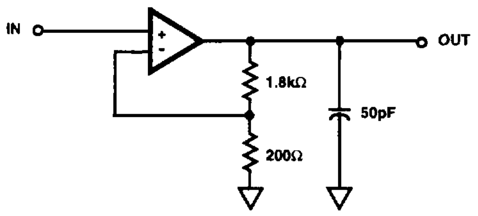
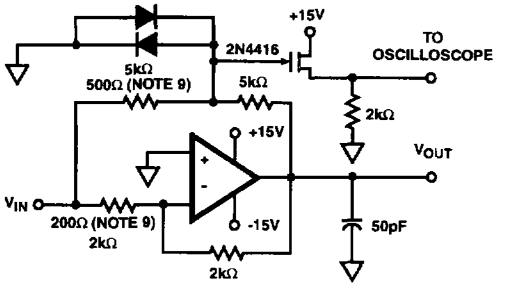


FIGURE 7. HA-5111 LARGE AND SMALL SIGNAL RESPONSE CIRCUIT

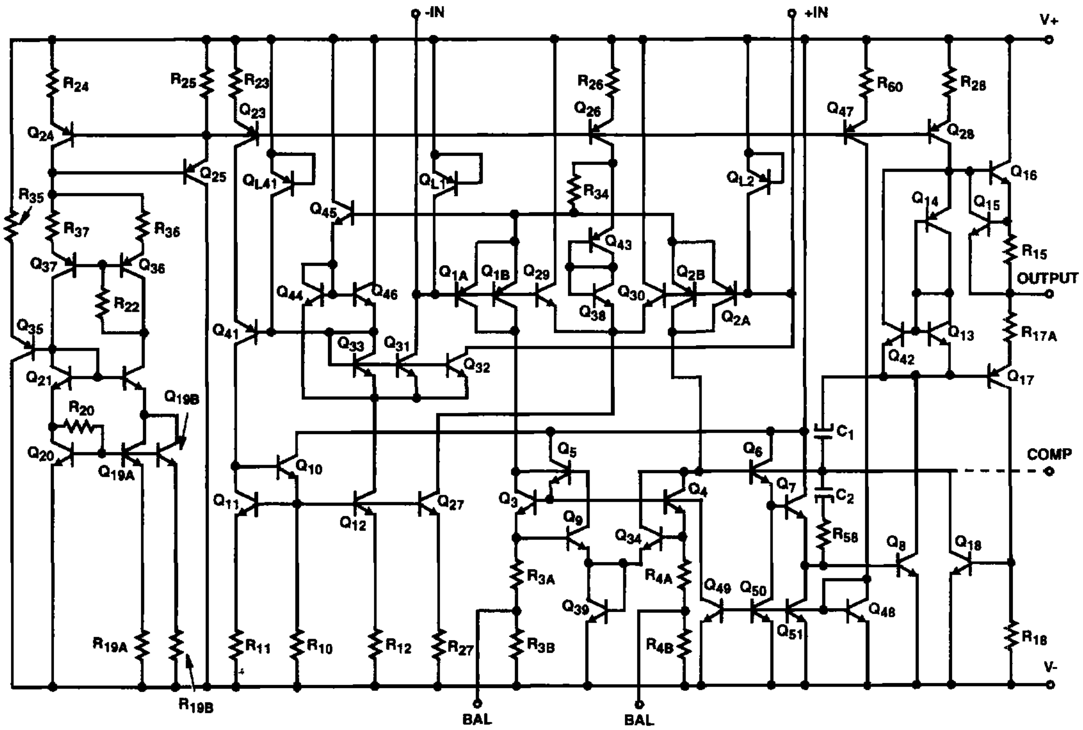


NOTES:

8. A_V = -1 (HA-5101), A_V = -10 (HA-5111).
9. Feedback and summing resistors should be 0.1% matched.
10. Clipping diodes are optional, HP5082-2810 recommended.

FIGURE 8. SETTLING TIME CIRCUIT

Schematic



Application Information

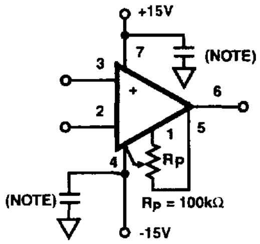
Operation At ±5V Supply

The HA-5101/11 performs well at V_S = ±5V exhibiting typical characteristics as listed below:

I_{CC}	3.7mA
V_{IO}	0.5mV
I_{BIAS}	56nA
A_{VOL} (V_O = ±3V)	106kV/V
V_{OUT}	3.7V
I_{OUT}	13mA
CMRR (ΔV_{CM} = ±2.5V)	90dB
PSRR (ΔV_S = 0.5V)	90dB
Unity Gain Bandwidth (5101)	10MHz
GBWP (5111)	100MHz
Slew Rate (5101)	7V/μs
Slew Rate (5111)	40V/μs

Offset Adjustment

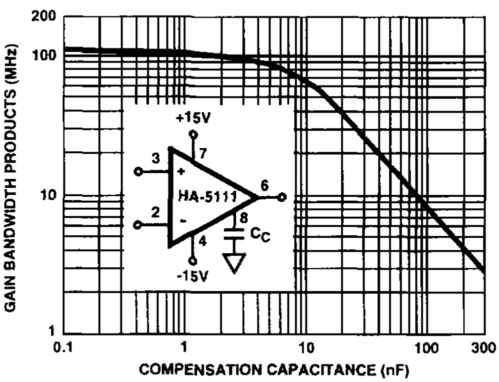
The following is the recommended V_{IO} adjust configuration:



NOTE: Proper decoupling is always recommended, 0.1μF high quality capacitor should be at or very near the device's supply pins.

Compensation

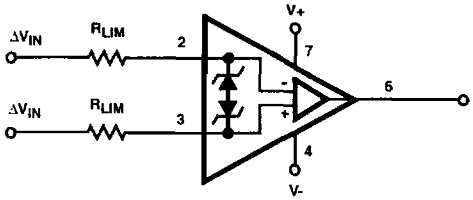
An external compensation capacitor can be used with the HA-5111 connected between pin 8 and ground (or V-, V+ not Recommended). A plot of gain bandwidth product vs compensation capacitor has been included as a design aid. The capacitor should be a high frequency type mounted near the device leads to minimize parasitics.



Input Protection

The HA-5101/11 has built-in back-to-back protection diodes which will limit the differential input voltage to approximately 7V. If the 5101/11 will be used in conditions where that voltage may be exceeded, then current limiting resistors must be used. No more than 25mA should be allowed to flow in the HA-5101/11's input.

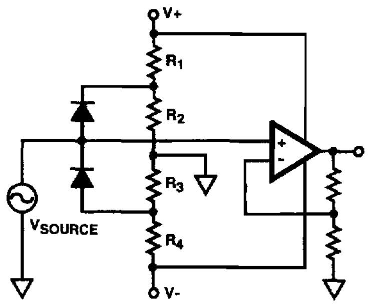
Comparator Circuit



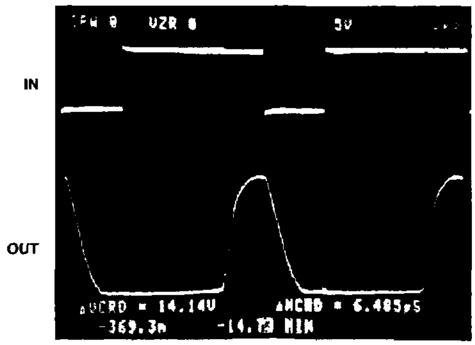
Choose R_{LIM} Such That: $\frac{(\Delta V_{INMAX} - 7V)}{25mA} \leq 2R_{LIM}$

Output Saturation

When an op amp is overdriven, output devices can saturate and sometimes take a long time to recover. Saturation can be avoided (sometimes) by using circuits such as:



If saturation cannot be avoided the HA-5101/11 recovers from a 25% overdrive in about 6.5μs (see photos).



Top: Input
Bottom: Output, 5V/Div., 2μs/Div.
Output is overdriven negative and recovers in 6μs.

Typical Performance Curves

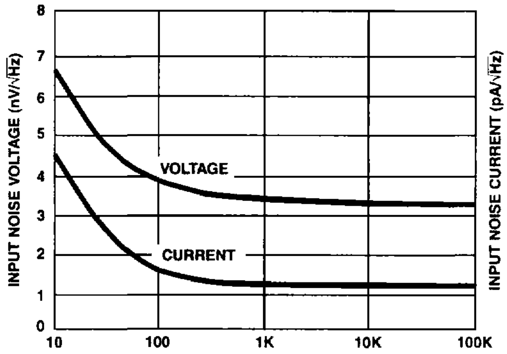


FIGURE 9. HA-5101/11 NOISE SPECTRUM

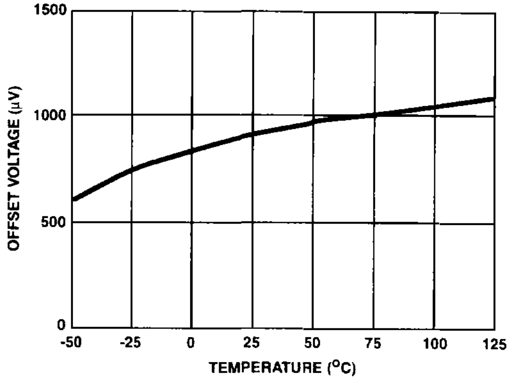
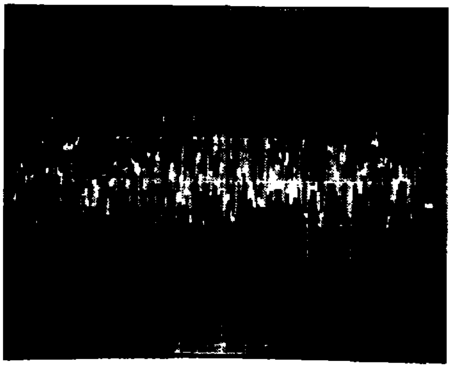
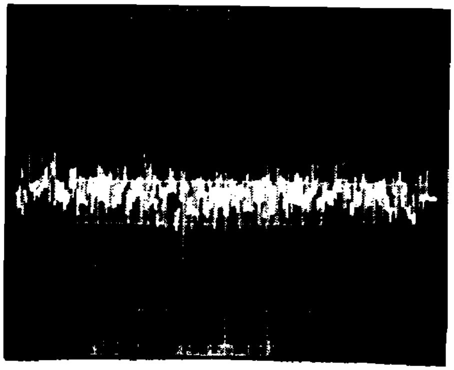


FIGURE 10. OFFSET VOLTAGE vs TEMPERATURE



A_V = 25000 V_S = ±15V (2.25μV_{P-P} RTO)

PEAK-TO-PEAK NOISE 0.1Hz TO 10Hz



A_V = 25000, V_S = ±15V (12.89mV_{P-P} RTO)

PEAK-TO-PEAK TOTAL NOISE 0.1Hz TO 1MHz

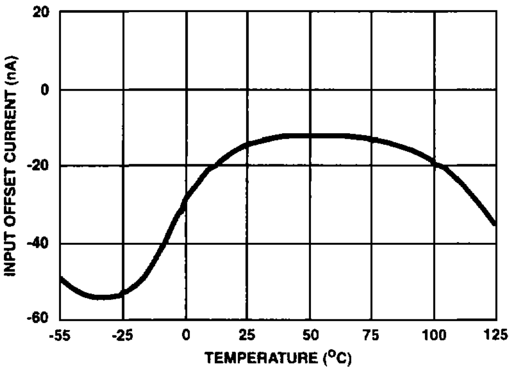


FIGURE 11. INPUT OFFSET CURRENT vs TEMPERATURE

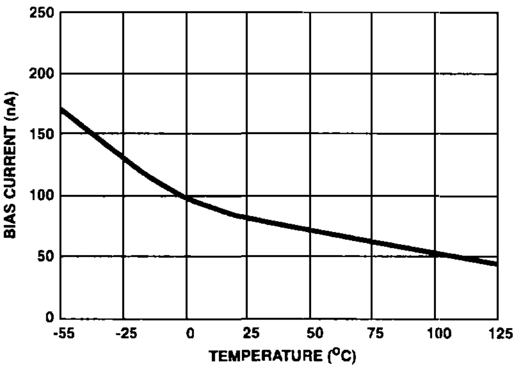


FIGURE 12. INPUT BIAS CURRENT vs TEMPERATURE

Typical Performance Curves (Continued)

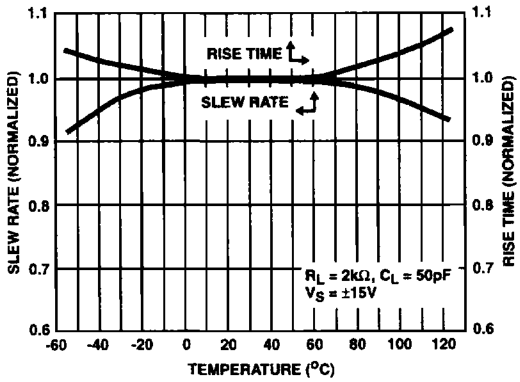


FIGURE 13. SLEW RATE/RISE TIME vs TEMPERATURE

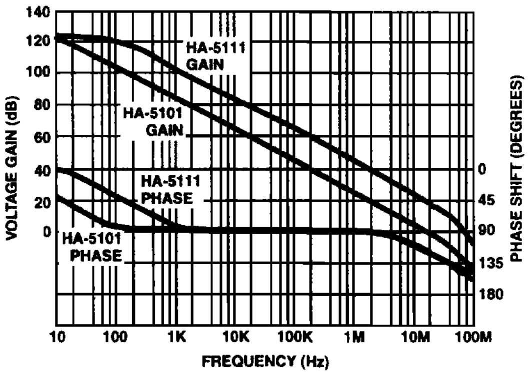


FIGURE 14. OPEN-LOOP GAIN/PHASE vs FREQUENCY

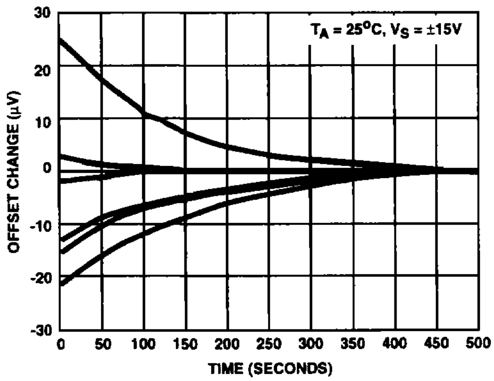


FIGURE 15. INPUT OFFSET WARMUP DRIFT vs TIME (NORMALIZED TO ZERO FINAL VALUE) (SIX REPRESENTATIVE UNITS)

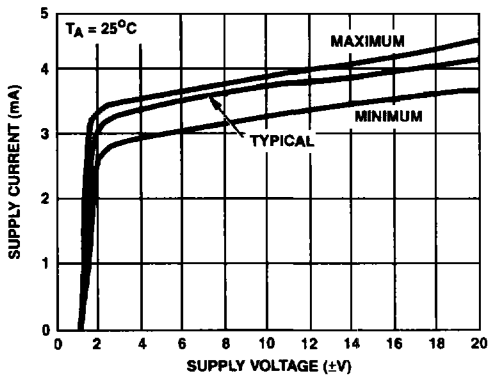


FIGURE 16. SUPPLY CURRENT vs SUPPLY VOLTAGE

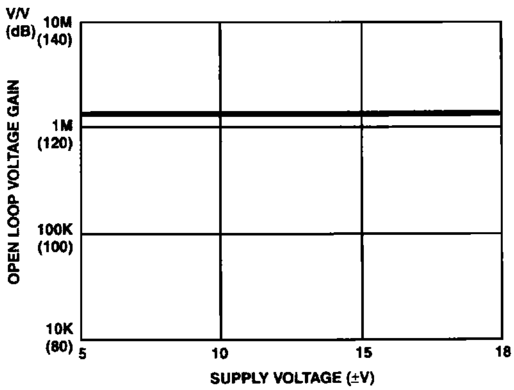


FIGURE 17. DC OPEN-LOOP VOLTAGE GAIN vs SUPPLY VOLTAGE

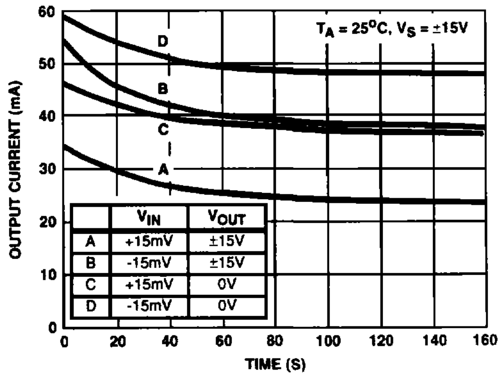


FIGURE 18. SHORT CIRCUIT CURRENT vs TIME

Typical Performance Curves (Continued)

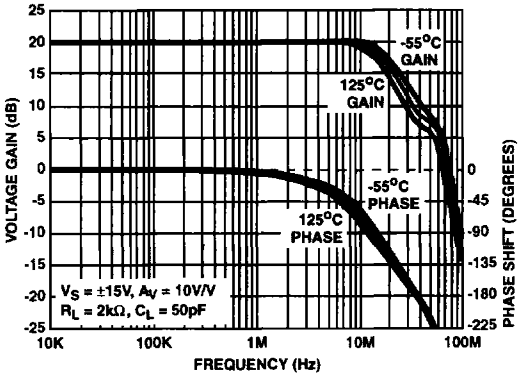


FIGURE 19. HA-5111 FREQUENCY RESPONSE

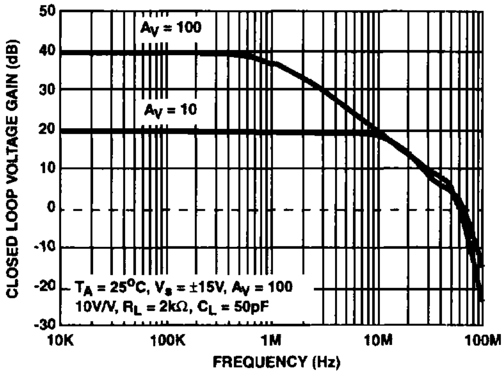


FIGURE 20. HA-5111 CLOSED-LOOP GAIN vs FREQUENCY

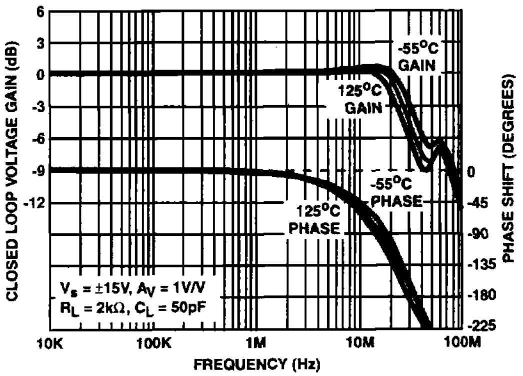


FIGURE 21. HA-5101 FREQUENCY RESPONSE

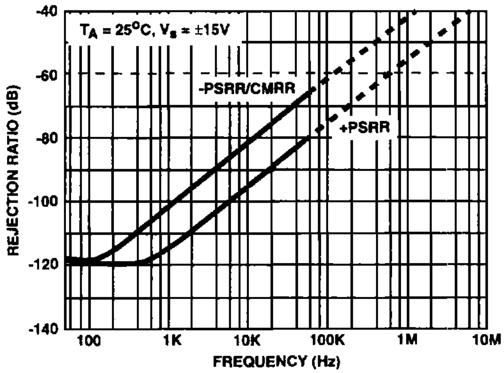


FIGURE 22. HA-5111 REJECTION RATIOS vs FREQUENCY

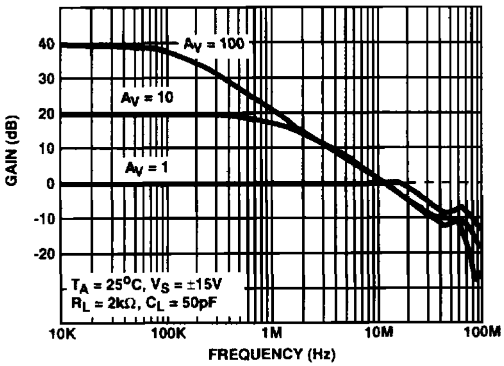


FIGURE 23. HA-5101 CLOSED-LOOP GAIN vs FREQUENCY

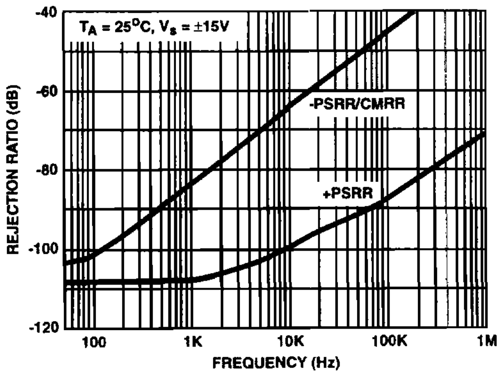


FIGURE 24. HA-5101 REJECTION RATIOS vs FREQUENCY

Typical Performance Curves (Continued)

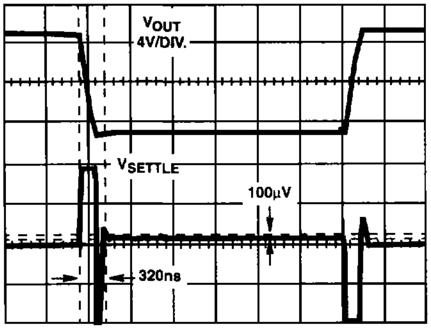


FIGURE 25. HA-5111 SETTLING WAVEFORM 500ns/DIV.

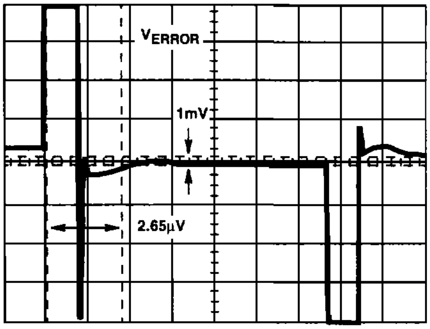


FIGURE 26. HA-5101 SETTLING WAVEFORM 1.5µs/DIV.

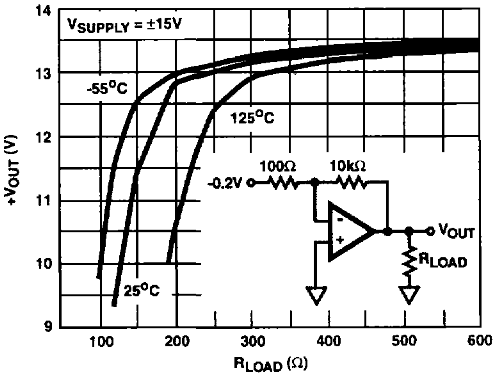


FIGURE 27. HA-5101 +V_{OUT} vs R_L

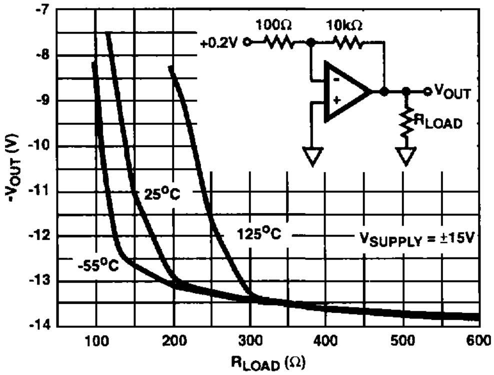


FIGURE 28. HA-5101 -V_{OUT} vs R_L

Die Characteristics

DIE DIMENSIONS:
70 mils x 70 mils x 19 mils
1790µm x 1780µm x 483µm

METALLIZATION:
Type: Al, 1% Cu
Thickness: 16kÅ ±2kÅ

PASSIVATION:
Type: Nitride (Si_3N_4) over Silox (SiO_2, 5% Phos.)
Silox Thickness: 12kÅ ±2kÅ
Nitride Thickness: 3.5kÅ ±1.5kÅ

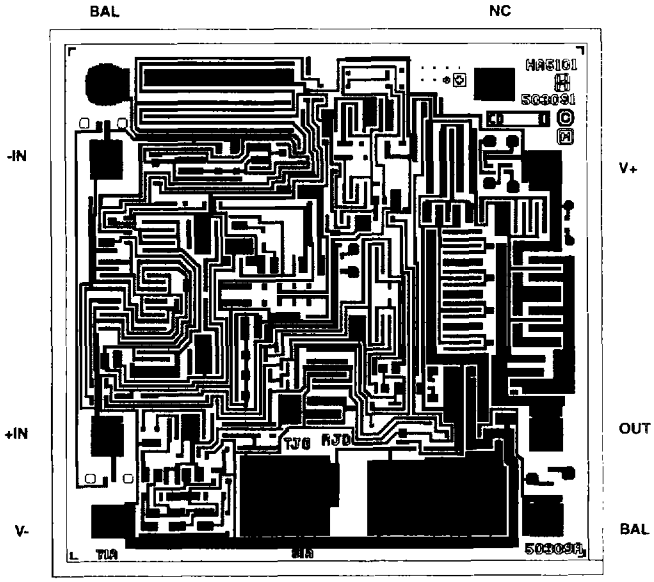
SUBSTRATE POTENTIAL (Powered Up): V-

TRANSISTOR COUNT: 54

PROCESS: Bipolar Dielectric Isolation

Metallization Mask Layout

HA-5101



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