OBSOLETE PRODUCT
HA-5101: See HA-5127A, HA-5221
HA-5111: See HA-5147A, HA-5221

September 1998 File Number 2905.3

10MHz and 100MHz, Low Noise, Operational Amplifiers

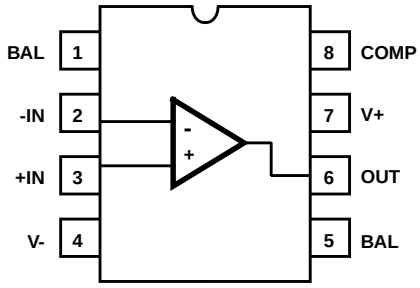
The HA-5101/5111 are dielectrically isolated operational amplifiers featuring low noise. Both amplifiers have an excellent noise voltage density of 3.0nV/$\sqrt{Hz}$ at 1kHz. The uncompensated HA-5111 is stable at a minimum gain of 10 and has the same DC specifications as the unity gain stable HA-5101. 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 3µV/^{o}C. An offset current of only 30nA reduces input current errors and an open loop voltage gain of 1 x 10^{6}V/V increases loop gain for low distortion amplification.

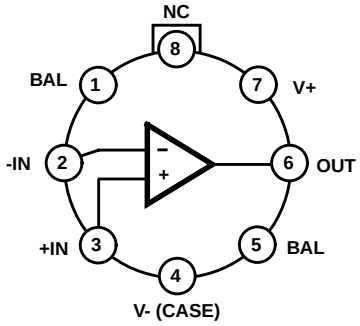
The HA-5101/5111 are ideal for audio applications, especially low-level signal amplifiers such as microphone, tape head and phono cartridge preamplifiers. Additionally, it is well suited for low distortion oscillators, low noise function generators and high Q filters.

Pinouts

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



HA-5101 (CAN)
TOP VIEW



Features

- Low Noise . . . . . 3.0nV/$\sqrt{Hz}$ at 1kHz
- Bandwidth . . . . . 10MHz (Compensated)
  100MHz (Uncompensated)
- Slew Rate . . . . . 10V/µs (Compensated)
  50V/µs (Uncompensated)
- Low Offset Voltage Drift . . . . . 3µV/^{o}C
- High Gain . . . . . 1 x 10^{6}V/V
- High CMRR/PSRR 100dB
- High Output Drive Capability 30mA

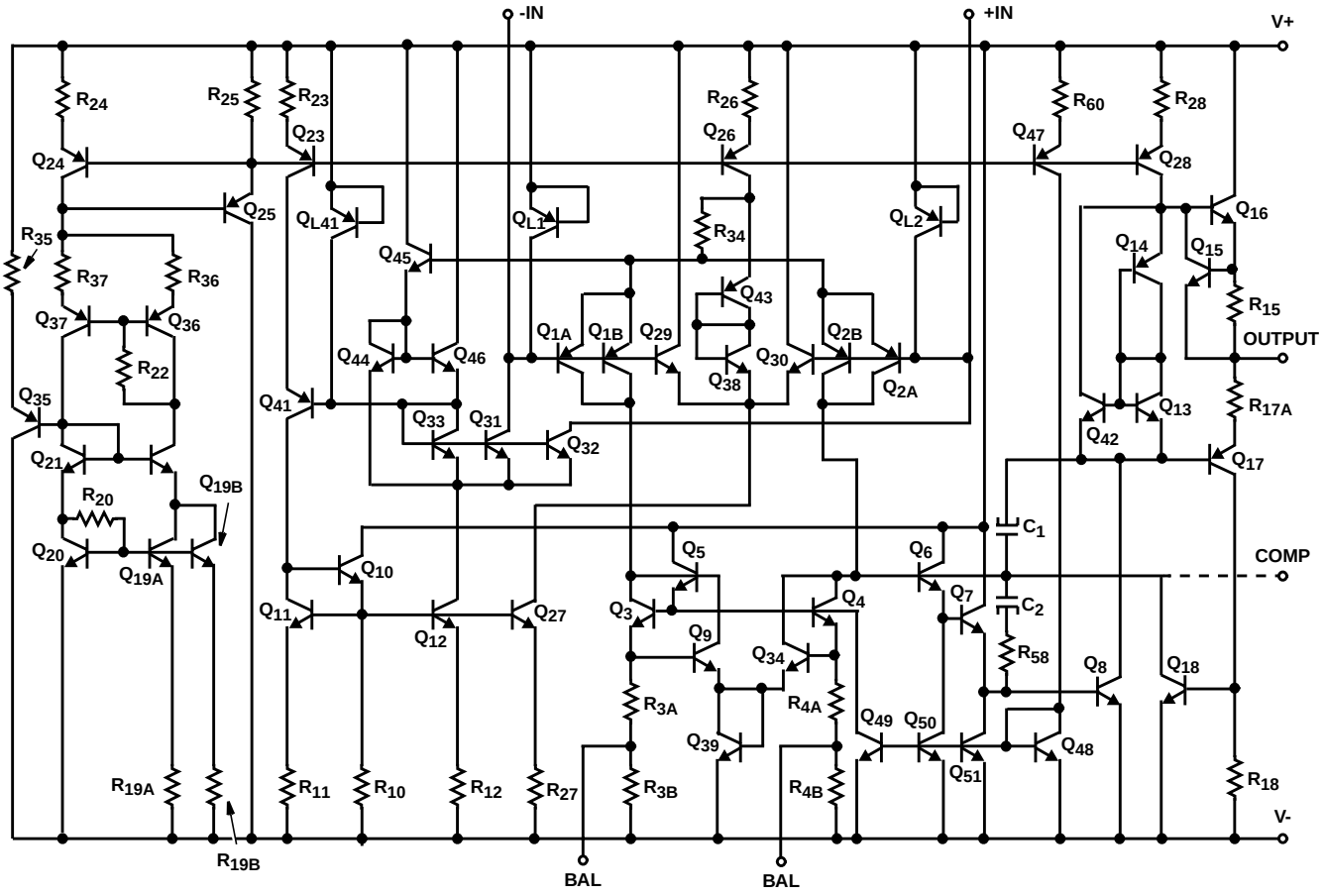
Applications

- 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

Part Number Information

PART NUMBER (BRAND)	TEMP. RANGE (^{o}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

Schematic


-IN
+IN
V+
V-
OUTPUT
COMP
BAL
BAL
R24
R25
R23
Q23
Q24
Q25
QL41
QL1
R26
Q26
QL2
R60
R28
Q47
Q28
Q16
Q14
Q15
R15
R35
R37
R36
Q37
Q36
R22
Q45
R34
Q43
Q1A
Q1B
Q29
Q2B
Q30
Q38
Q2A
Q44
Q46
Q41
Q33
Q31
Q32
Q35
Q21
R20
Q20
Q19A
Q19B
Q13
Q42
R17A
Q17
C1
Q5
Q6
Q10
Q11
Q12
Q27
Q3
Q4
Q7
C2
Q9
Q34
R58
Q8
Q18
R3A
R4A
Q49
Q50
Q39
Q48
Q51
R19A
R11
R10
R12
R27
R3B
R4B
R18
R19B

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^oC to 125^oC
HA-5101/5111-5 . . . . . 0^oC to 75^oC
HA-5101/5111-9 . . . . . -40^oC to 85^oC

Thermal Information

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

Maximum Junction Temperature (Note 1) . . . . . 175^oC
Maximum Junction Temperature (Plastic Package) . . . . . 150^oC
Maximum Storage Temperature Range . . . . . -65^oC to 150^oC
Maximum Lead Temperature (Soldering 10s) . . . . . 300^oC
(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^oC for hermetic packages, and below 150^oC for the plastic packages.
2. θ_{JA} is measured with the component mounted on an evaluation PC board in free air.

Electrical Specifications

$V_{SUPPLY} = \pm 15V$, $R_S = 100\Omega$, $R_L = 2k\Omega$, $C_L = 50pF$, Unless Otherwise Specified

PARAMETER	TEST CONDITIONS	TEMP (^oC)	HA-5101-2, -5; HA-5111-2, -5			HA-5101-9, HA-5111-9			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
INPUT CHARACTERISTICS									
Offset Voltage		25	-	0.5	3	-	0.5	3	mV
		Full	-	-	4	-	-	4	mV
Offset Voltage Drift		Full	-	3	-	-	3	-	$\mu V/^oC$
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	-	$k\Omega$
Common Mode Range		Full	± 12	-	-	± 12	-	-	V
TRANSFER CHARACTERISTICS									
Large Signal Voltage Gain	$V_{OUT} = \pm 10V$	25	-	1000	-	-	1000	-	kV/V
		Full	100	250	-	100	250	-	kV/V
Common Mode Rejection Ratio	$V_{CM} = \pm 10V$	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
	$V_S = \pm 18V$, $R_L = 600\Omega$	25	± 15	-	-	± 15	-	-	V
Output Current (Note 3)		25	25	30	-	25	30	-	mA
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

Electrical Specifications V_{SUPPLY} = ±15V, R_S = 100Ω, R_L = 2kΩ, 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	
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	ΔV_S = ±5V	Full	80	100	-	80	100	-	dB

NOTES:

3. Output current is measured with V_{OUT} = ±15V with V_{SUPPLY} = ±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

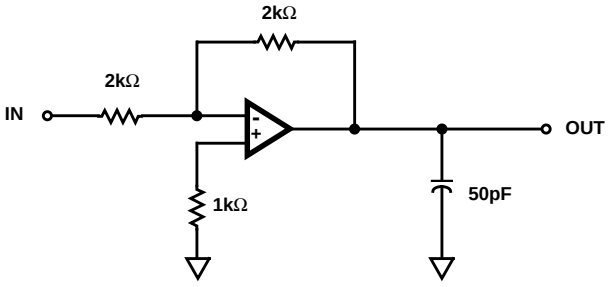


FIGURE 1. HA-5101 LARGE SIGNAL RESPONSE CIRCUIT

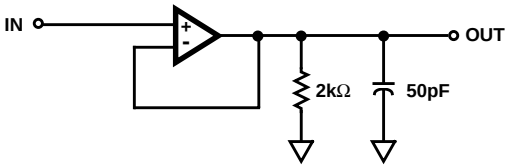
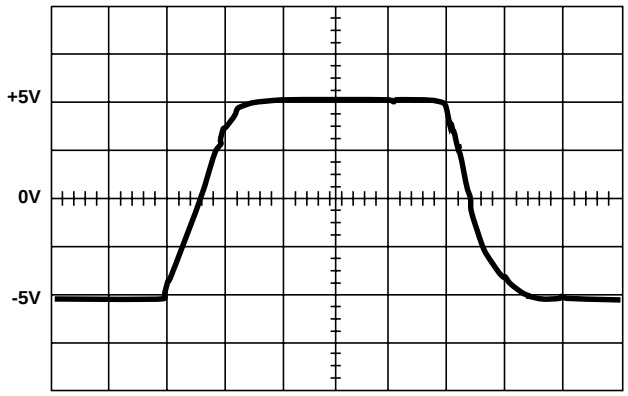


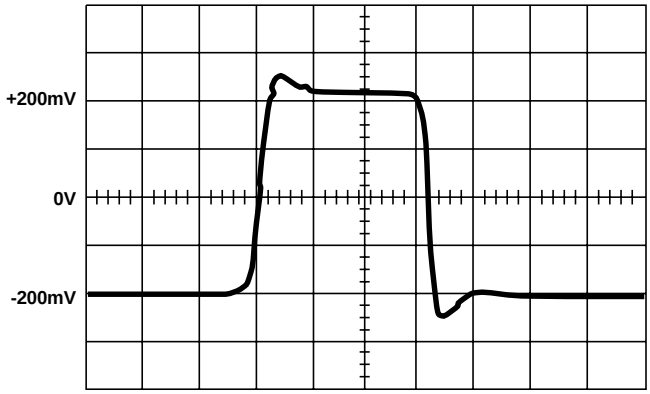
FIGURE 2. HA-5101 SMALL SIGNAL RESPONSE CIRCUIT

Test Circuits and Waveforms (Continued)



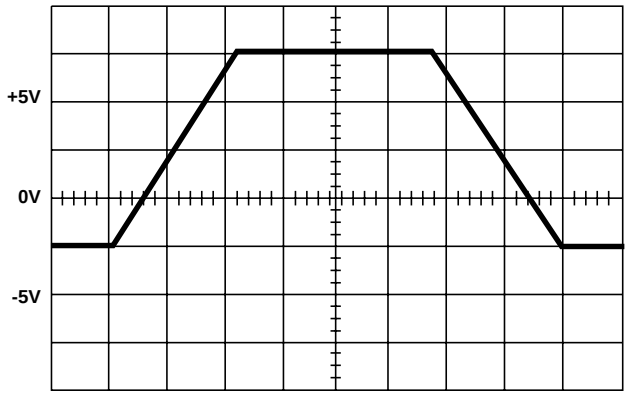
Ch. 1 = 2.5V/Div.
Timebase = 200ns/Div.

FIGURE 3. HA-5111 LARGE SIGNAL TRANSIENT RESPONSE



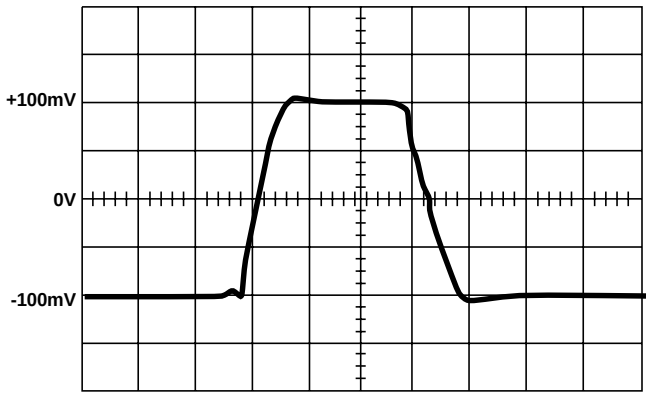
Ch. 1 = 100mV/Div.
Timebase = 100ns/Div.

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

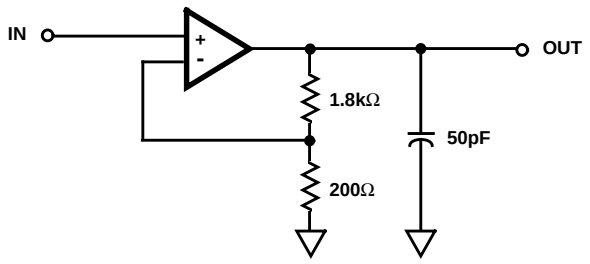
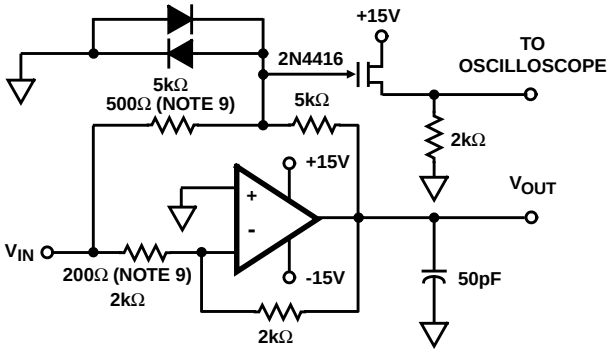


FIGURE 7. HA-5111 LARGE AND SMALL SIGNAL RESPONSE CIRCUIT



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

Application Information

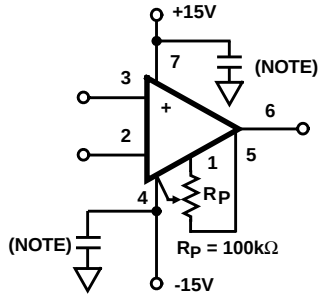
Operation At ±5V Supply

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

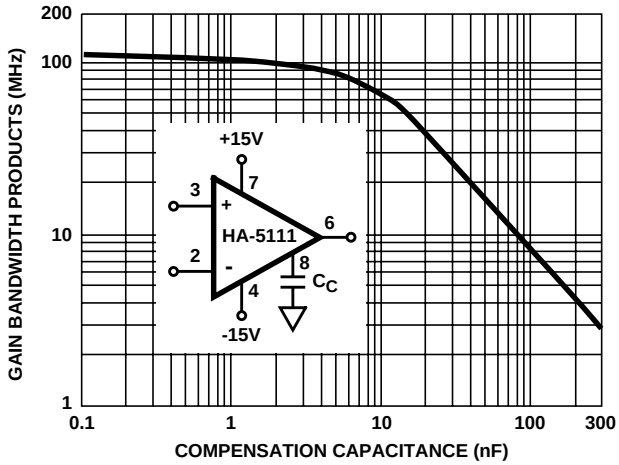
The following is the recommended V_{IO} adjust configuration:



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

Compensation

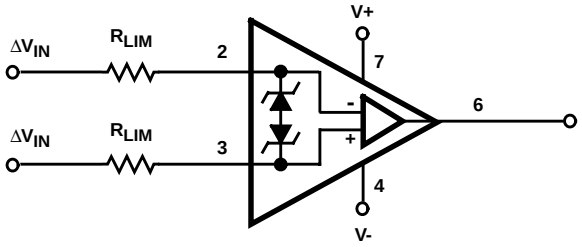
An external compensation capacitor can be used with the HA-5111 connected between pin 8 and ground (or V-, V+ not Recommended). A plot of gain bandwidth product vs compensation capacitor has been included as a design aid. The capacitor should be a high frequency type mounted near the device leads to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

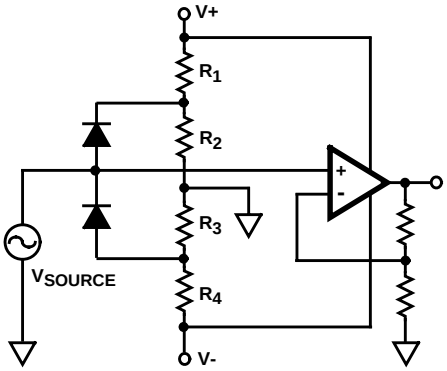
Comparator Circuit



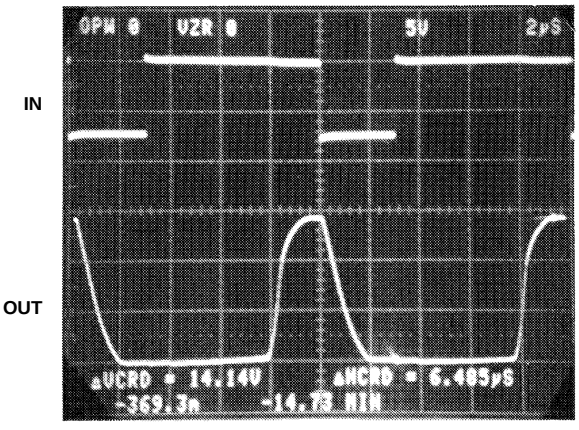
Choose R_{LIM} Such That: $\frac{(\Delta V_{INMAX} - 7V)}{25mA} \leq 2R_{LIM}$

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

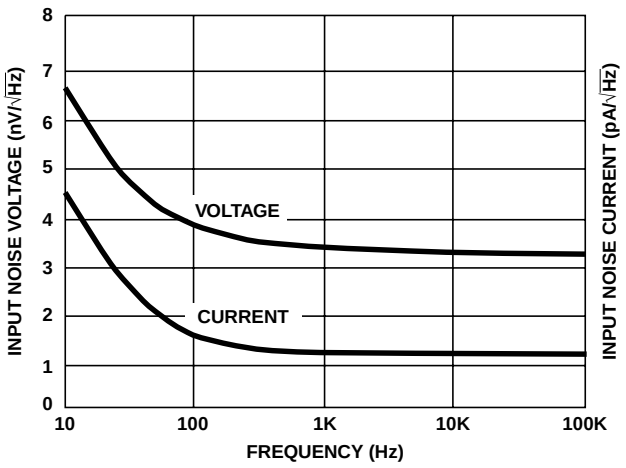


FIGURE 9. HA-5101/11 NOISE SPECTRUM

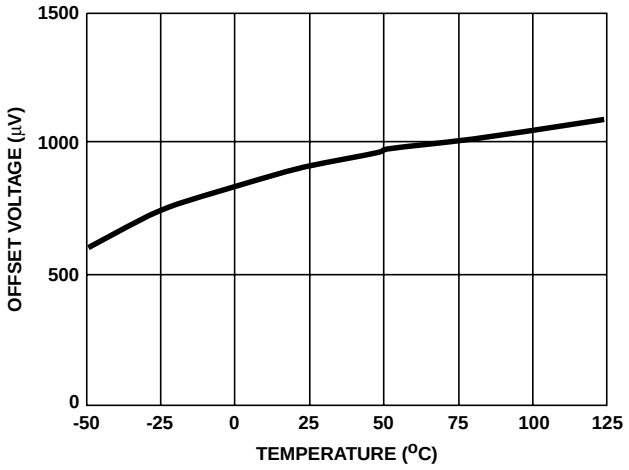
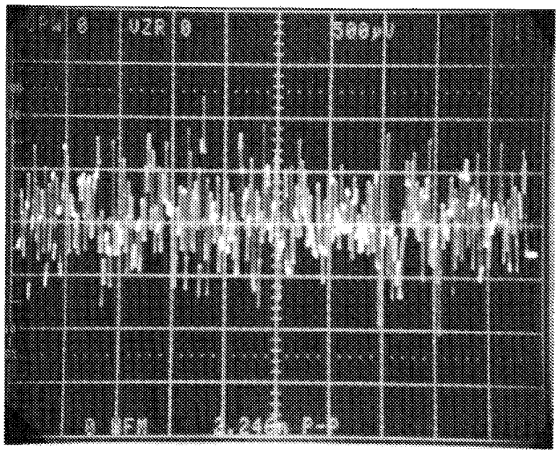
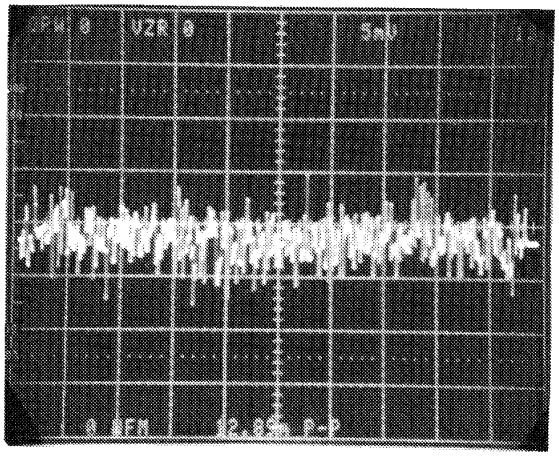


FIGURE 10. OFFSET VOLTAGE vs TEMPERATURE



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

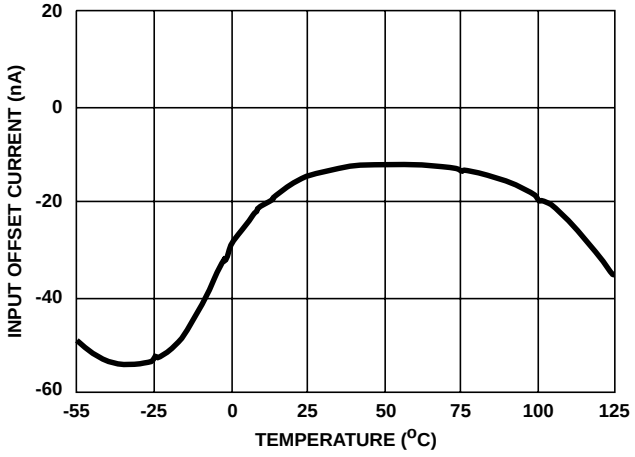


FIGURE 11. INPUT OFFSET CURRENT vs TEMPERATURE

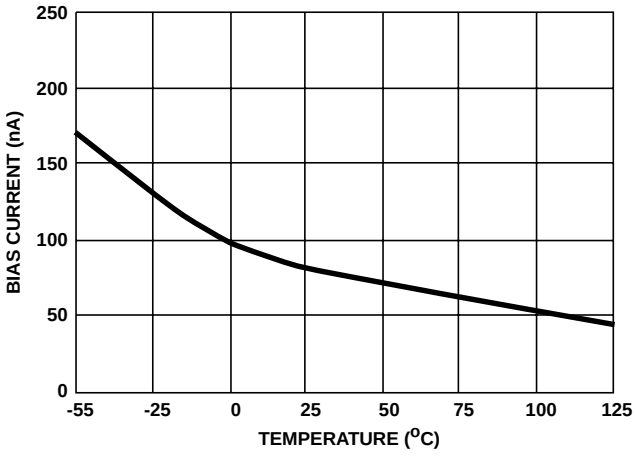


FIGURE 12. INPUT BIAS CURRENT vs TEMPERATURE

Typical Performance Curves (Continued)

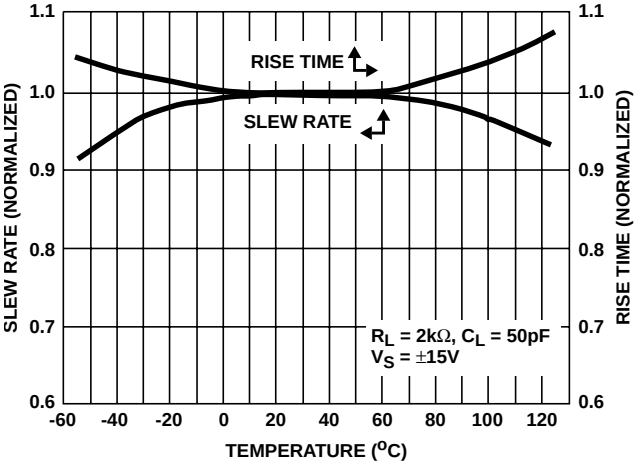


FIGURE 13. SLEW RATE/RISE TIME vs TEMPERATURE

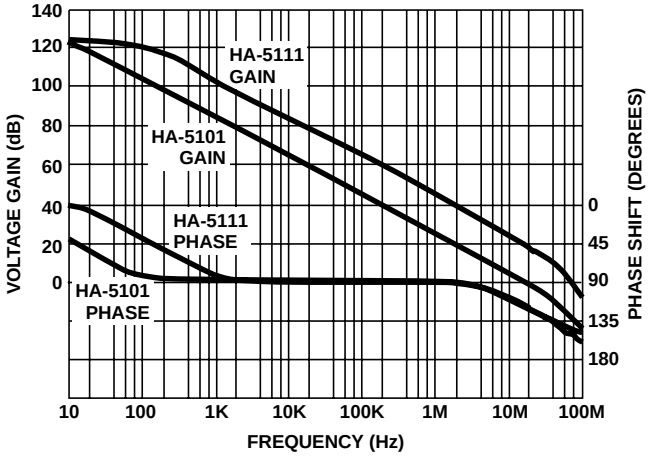


FIGURE 14. OPEN-LOOP GAIN/PHASE vs FREQUENCY

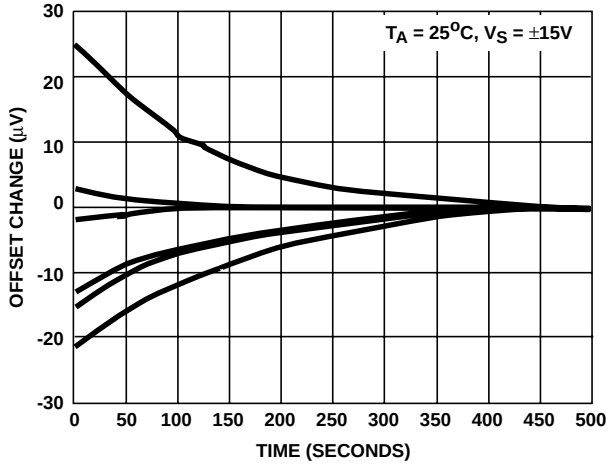


FIGURE 15. INPUT OFFSET WARMUP DRIFT vs TIME (NORMALIZED TO ZERO FINAL VALUE) (SIX REPRESENTATIVE UNITS)

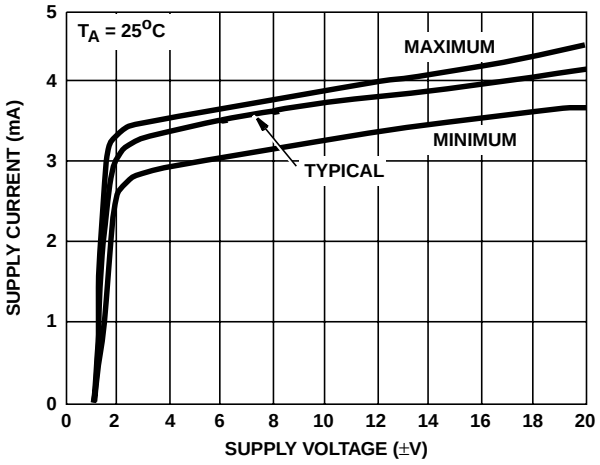


FIGURE 16. SUPPLY CURRENT vs SUPPLY VOLTAGE

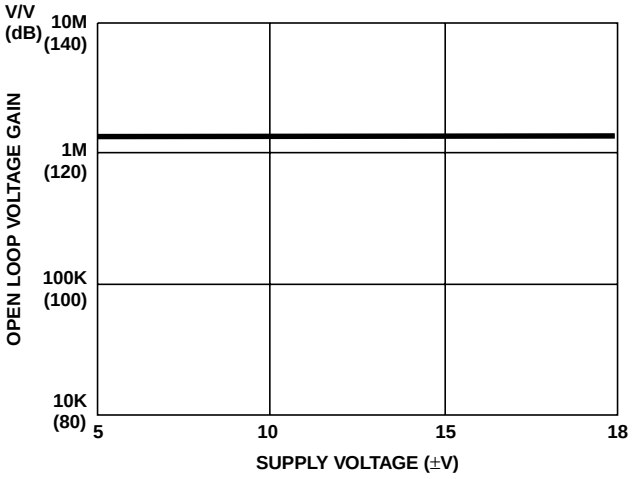
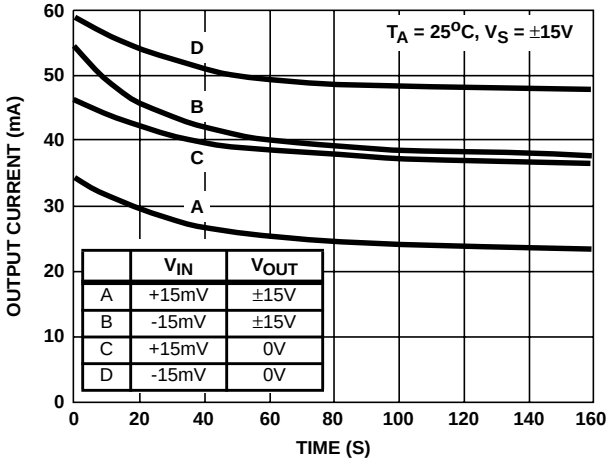


FIGURE 17. DC OPEN-LOOP VOLTAGE GAIN vs SUPPLY VOLTAGE



	V_{IN}	V_{OUT}
A	+15mV	±15V
B	-15mV	±15V
C	+15mV	0V
D	-15mV	0V

FIGURE 18. SHORT CIRCUIT CURRENT vs TIME

Typical Performance Curves (Continued)

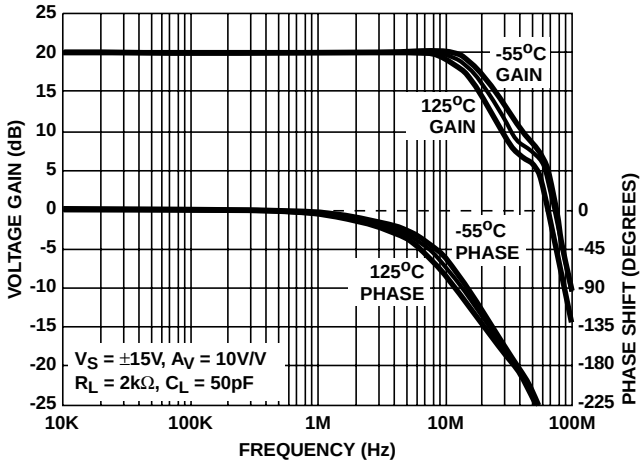


FIGURE 19. HA-5111 FREQUENCY RESPONSE

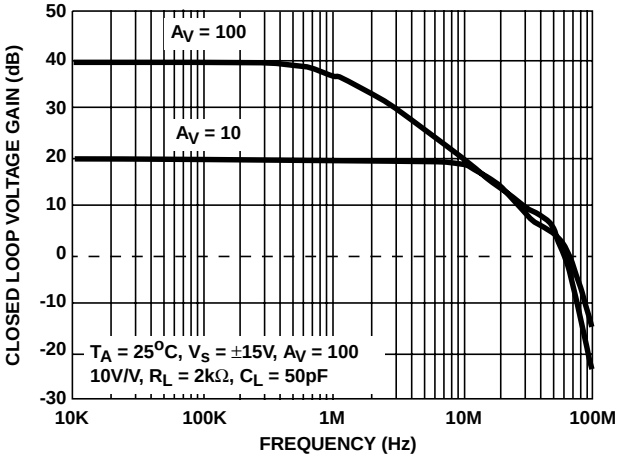


FIGURE 20. HA-5111 CLOSED-LOOP GAIN vs FREQUENCY

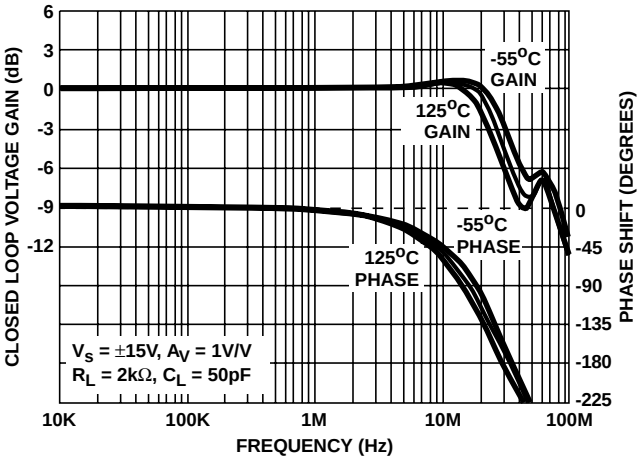


FIGURE 21. HA-5101 FREQUENCY RESPONSE

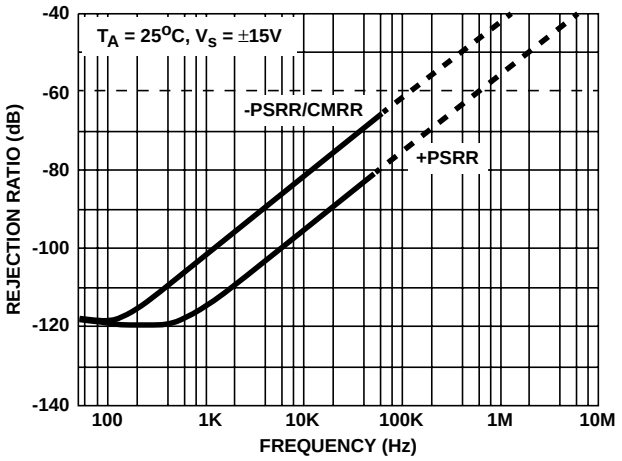


FIGURE 22. HA-5111 REJECTION RATIOS vs FREQUENCY

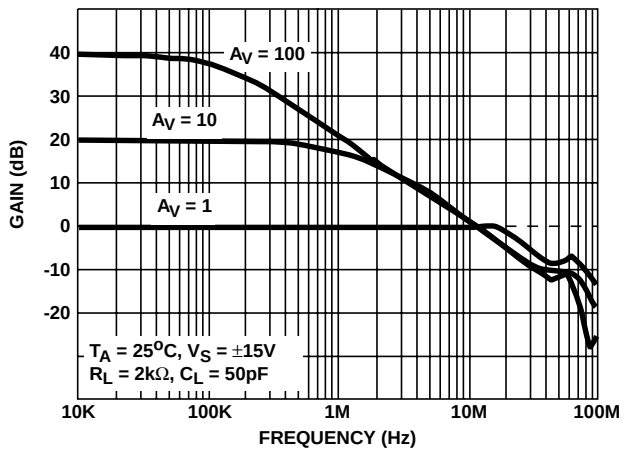


FIGURE 23. HA-5101 CLOSED-LOOP GAIN vs FREQUENCY

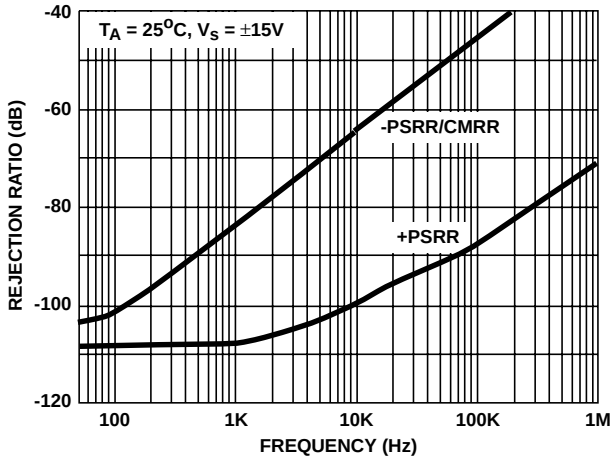


FIGURE 24. HA-5101 REJECTION RATIOS vs FREQUENCY

Typical Performance Curves (Continued)

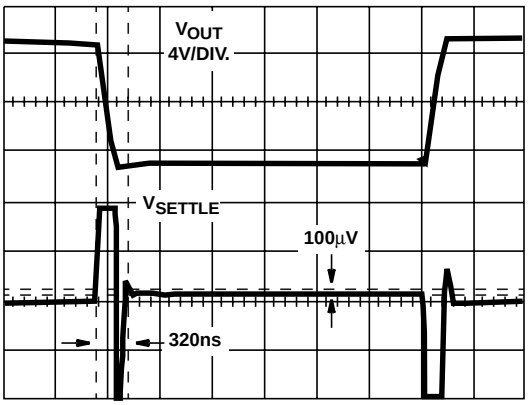


FIGURE 25. HA-5111 SETTLING WAVEFORM 500ns/DIV.

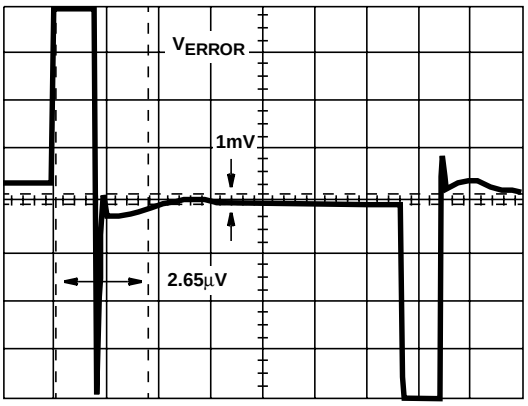


FIGURE 26. HA-5101 SETTLING WAVEFORM 1.5µs/DIV.

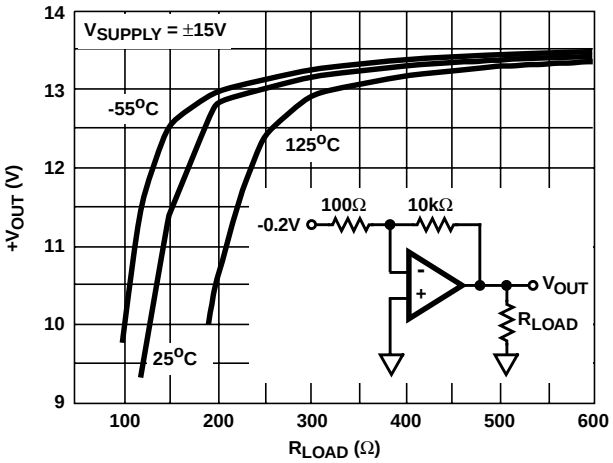


FIGURE 27. HA-5101 $+V_{OUT}$ vs R_L

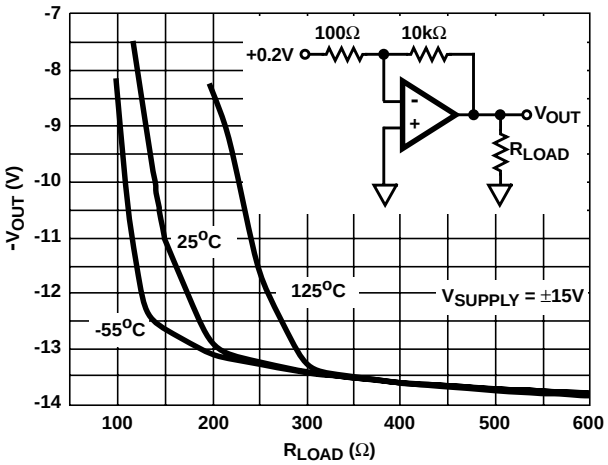


FIGURE 28. HA-5101 $-V_{OUT}$ vs R_L

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

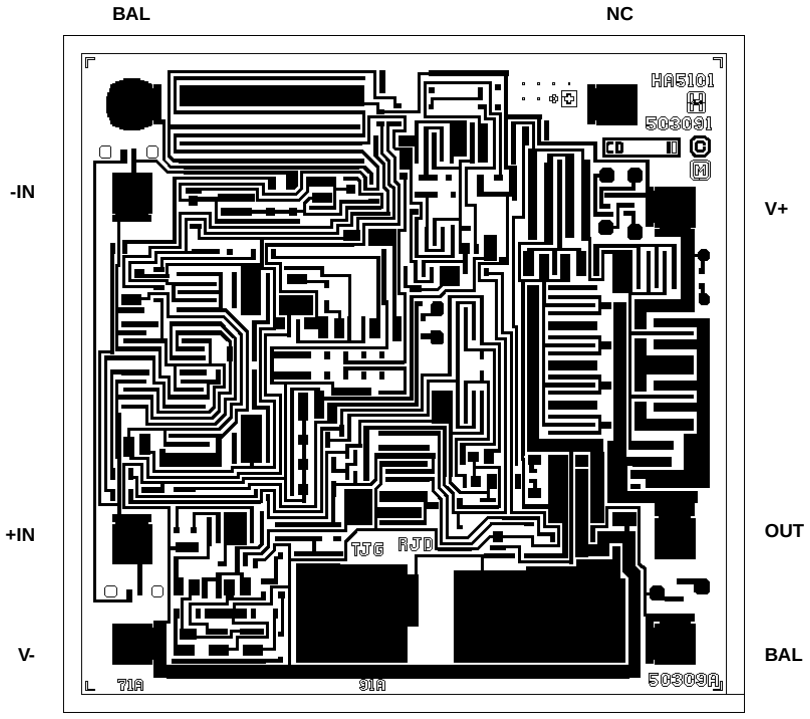
SUBSTRATE POTENTIAL (Powered Up): V-

TRANSISTOR COUNT: 54

PROCESS: Bipolar Dielectric Isolation

Metallization Mask Layout

HA-5101



HA-5111