Data Sheet | April 2002 | FN2905.4

10MHz, Low Noise, Operational Amplifiers

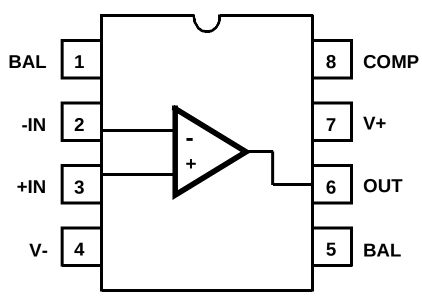
The HA-5101 is a dielectrically isolated operational amplifier featuring low noise, ($3.0nV/\sqrt{Hz}$ at 1kHz).

DC characteristics of the HA-5101 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 1×10^6V/V increases loop gain for low distortion amplification.

The HA-5101 is 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.

Pinout

HA-5101(SOIC)
TOP VIEW



Features

- Low Noise . . . . $3.0nV/\sqrt{Hz}$ at 1kHz
- Bandwidth 10MHz
- Slew Rate. . . . . $10V/\mu s$
- Low Offset Voltage Drift . . . . $3\mu V/^oC$
- High Gain . . . . 1×10^6V/V
- High CMRR/PSRR 100dB
- High Output Drive Capability 30mA

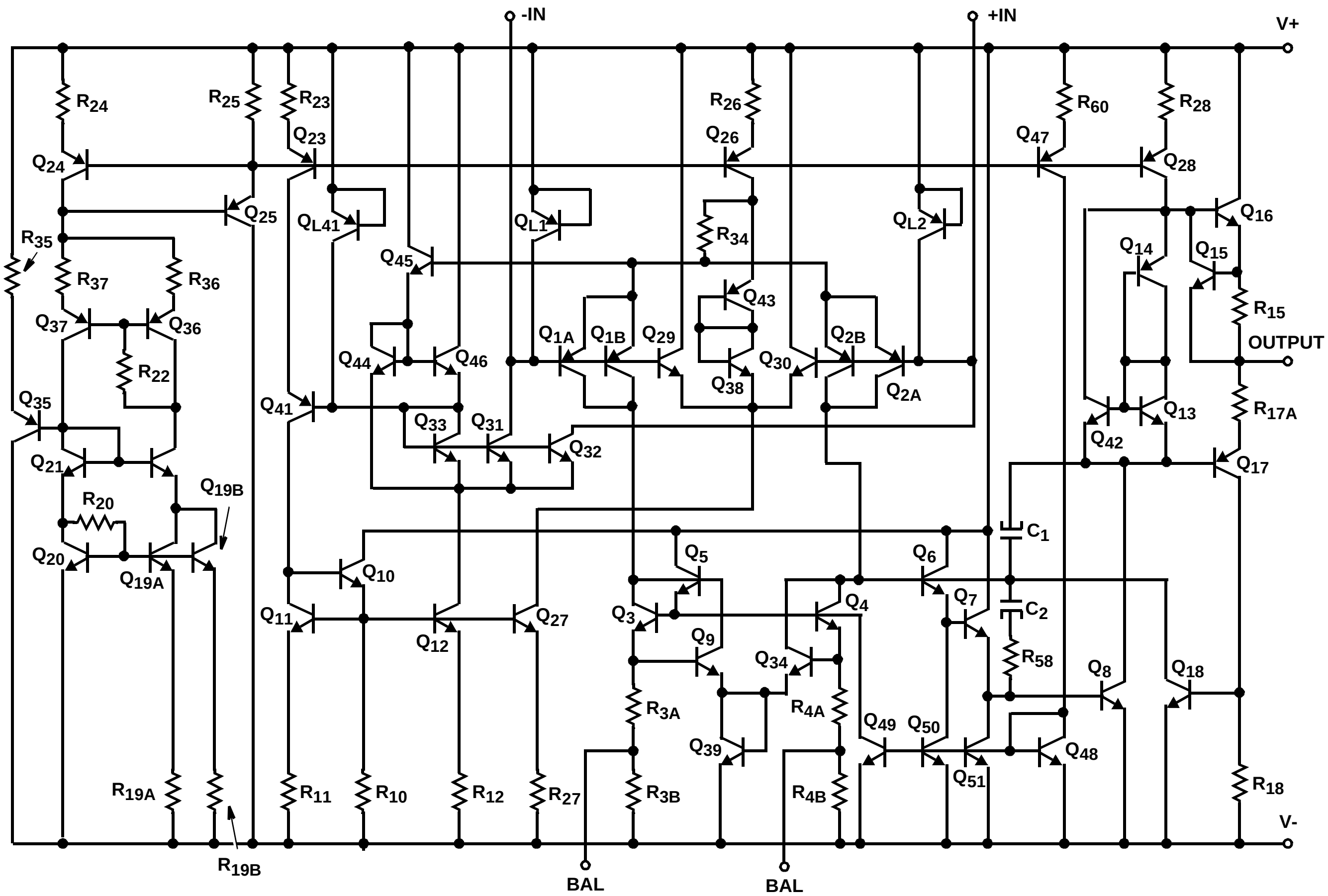
Applications

- 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

Ordering Information

PART NUMBER (BRAND)	TEMP. RANGE (^oC)	PACKAGE	PKG. NO.
HA9P5101-9 (H51019)	-40 to 85	8 Ld SOIC	M8.15

Schematic


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

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-5101-9 . . . . -40^oC to 85^oC

Thermal Information

Thermal Resistance (Typical, Note 2) θ_{JA} (^oC/W) θ_{JC} (^oC/W)
SOIC Package . . . . 160 N/A
Maximum Junction Temperature (Note 1) . . . . 150^oC
Maximum Storage Temperature Range . . . . -65^oC to 150^oC
Maximum Lead Temperature (Soldering 10s) . . . . 300^oC
(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 150^oC for the plastic packages.
2. θ_{JA} is measured with the component mounted on a low effective thermal conductivity test board in free air. See Tech Brief TB379 for details.

Electrical Specifications

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

PARAMETER	TEST CONDITIONS	TEMP (^oC)	MIN	TYP	MAX	UNITS
INPUT CHARACTERISTICS						
Offset Voltage		25	-	0.5	3	mV
		Full	-	-	4	mV
Offset Voltage Drift		Full	-	3	-	$\mu V/^oC$
Bias Current		25	-	100	200	nA
		Full	-	-	325	nA
Offset Current		25	-	30	75	nA
		Full	-	-	125	nA
Input Resistance		25	-	500	-	kΩ
Common Mode Range		Full	±12	-	-	V
TRANSFER CHARACTERISTICS						
Large Signal Voltage Gain	$V_{OUT} = \pm10V$	25	-	1000	-	kV/V
		Full	100	250	-	kV/V
Common Mode Rejection Ratio	$V_{CM} = \pm10V$	Full	80	100	-	dB
Small Signal Bandwidth	$A_V = 1$	25	-	10	-	MHz
Minimum Stable Gain		Full	1	-	-	V/V
OUTPUT CHARACTERISTICS						
Output Voltage Swing	$R_L = 10k\Omega$	Full	±12	±13	-	V
	$R_L = 2k\Omega$	Full	±12	±13	-	V
	$V_S = \pm18V$, $R_L = 600\Omega$	25	±15	-	-	V
Output Current (Note 3)		25	25	30	-	mA
Full Power Bandwidth (Note 4)		25	95	160	-	kHz
Output Resistance		25	-	110	-	Ω
Maximum Load Capacitance		25	-	800	-	pF
TRANSIENT RESPONSE (Note 5)						
Rise Time		25	-	50	100	ns
Overshoot		25	-	20	35	%

Electrical Specifications V_{SUPPLY} = ±15V, R_S = 100Ω, R_L = 2kΩ, C_L = 50pF, Unless Otherwise Specified **(Continued)**

PARAMETER	TEST CONDITIONS	TEMP (°C)	MIN	TYP	MAX	UNITS
Slew Rate		25	6	10	-	V/µs
Settling Time (Note 6)	0.01%	-	-	2.6	-	µs
NOISE CHARACTERISTICS (Note 7)						
Input Noise Voltage	f = 10Hz	25	-	5	7	nV/√Hz
	f = 1kHz	25	-	3.0	4.0	nV/√Hz
Input Noise Current	f = 10Hz	25	-	4.0	9	pA/√Hz
	f = 1kHz		-	0.6	2.5	pA/√Hz
Broadband Noise Voltage	f = DC To 30kHz	25	-	0.870	-	μV_{RMS}
POWER SUPPLY CHARACTERISTICS						
Supply Current		Full	-	4	7	mA
Power Supply Rejection Ratio	ΔV_S = ±5V	Full	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 = -1.
7. The limits for these parameters are guaranteed based on lab characterization, and reflect lot-to-lot variation.

Test Circuits and Waveforms

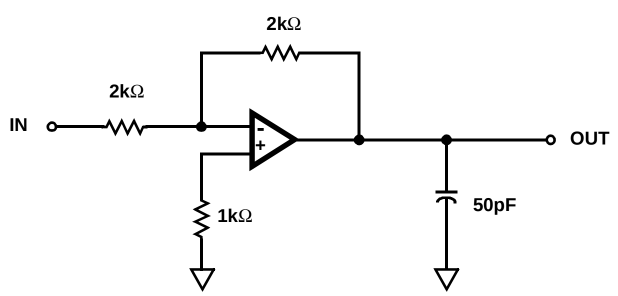


FIGURE 1. LARGE SIGNAL RESPONSE CIRCUIT

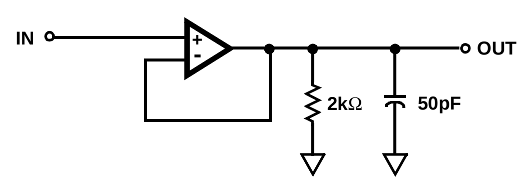
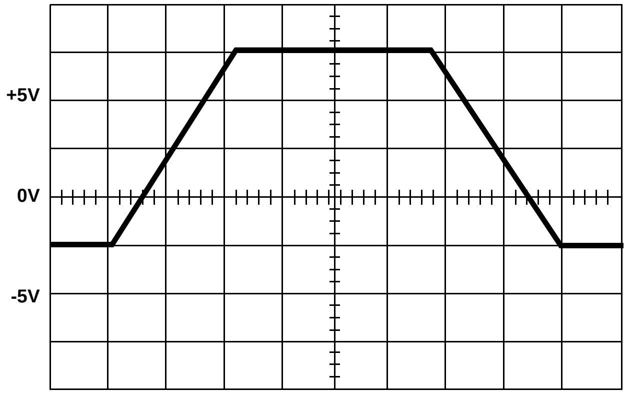
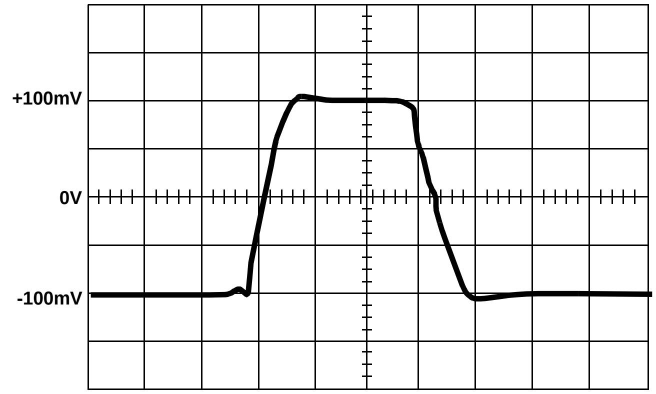


FIGURE 2. SMALL SIGNAL RESPONSE CIRCUIT



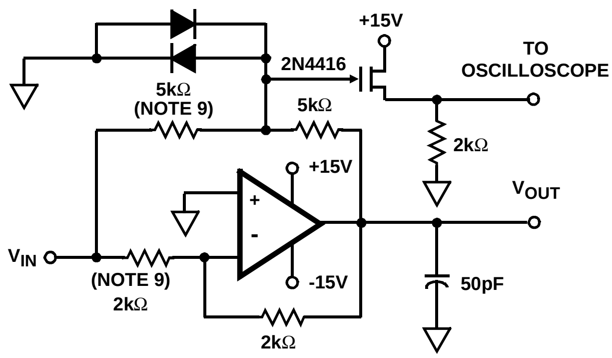
Ch. 1 = 2.5V/Div.
Timebase = 1.00µs/Div.

FIGURE 3. LARGE SIGNAL TRANSIENT RESPONSE



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

FIGURE 4. SMALL SIGNAL TRANSIENT RESPONSE



NOTES:

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

FIGURE 5. SETTLING TIME CIRCUIT

Application Information

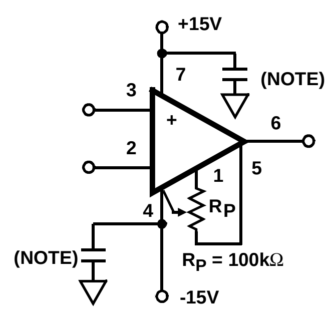
Operation At ±5V Supply

The HA-5101 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	10MHz
Slew Rate	7V/µs

Offset Adjustment

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



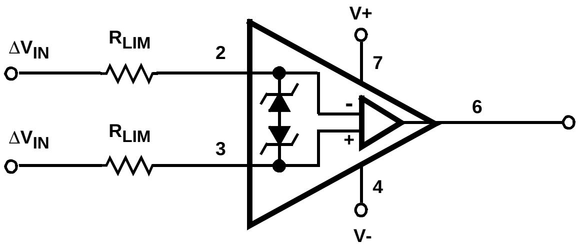
NOTE: Proper decoupling is always recommended, 0.1µF high quality capacitor should be at or very near the device's supply pins.

Input Protection

The HA-5101 has built-in back-to-back protection diodes which will limit the differential input voltage to approximately

7V. If the 5101 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's input.

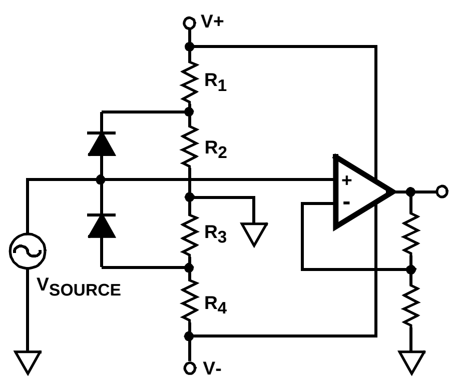
Comparator Circuit



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

Output Saturation

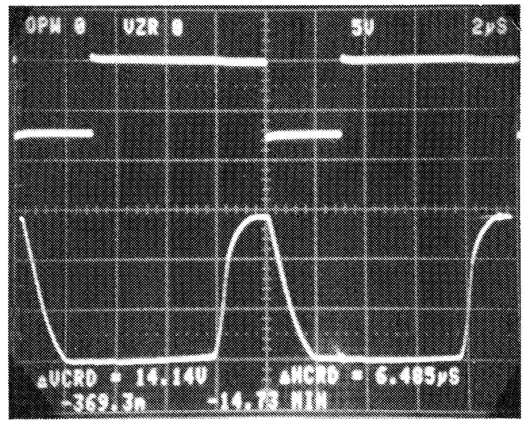
When an op amp is overdriven, output devices can saturate and sometimes take a long time to recover. Saturation can be avoided (sometimes) by using circuits such as:



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

IN

OUT



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

Typical Performance Curves

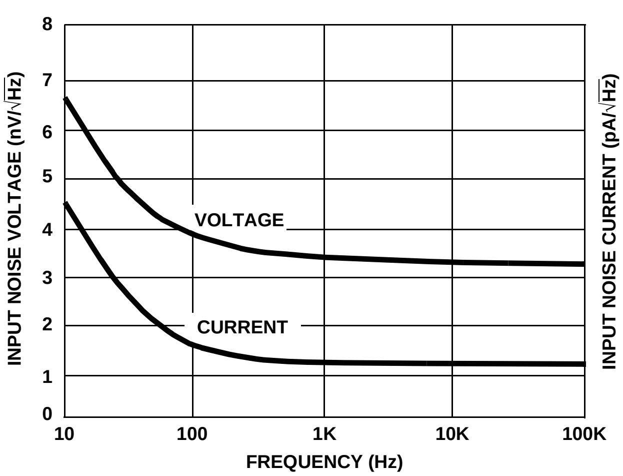


FIGURE 6. NOISE SPECTRUM

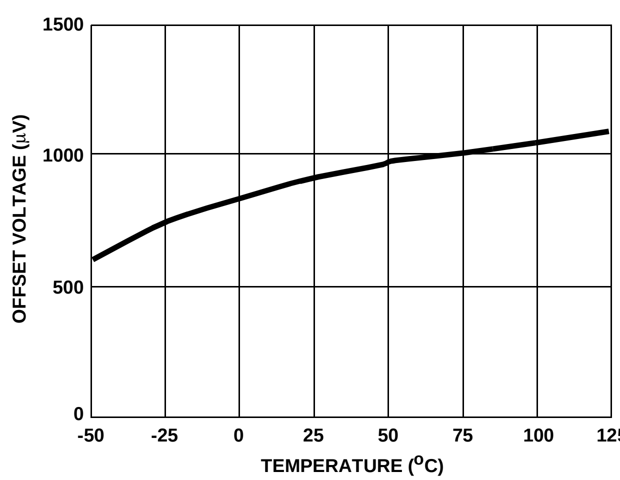
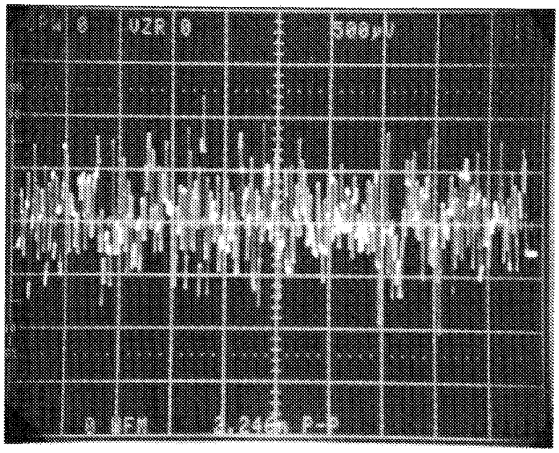
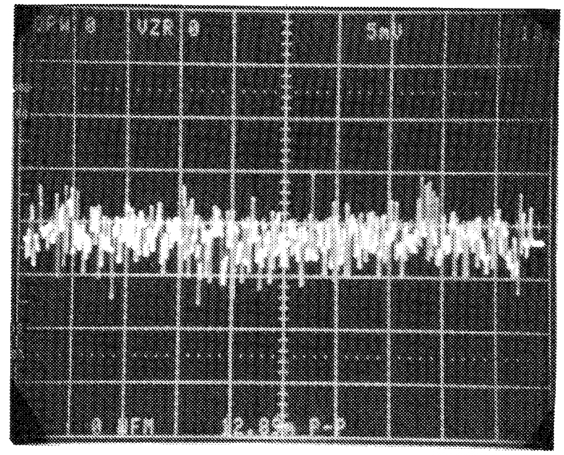


FIGURE 7. OFFSET VOLTAGE vs TEMPERATURE



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

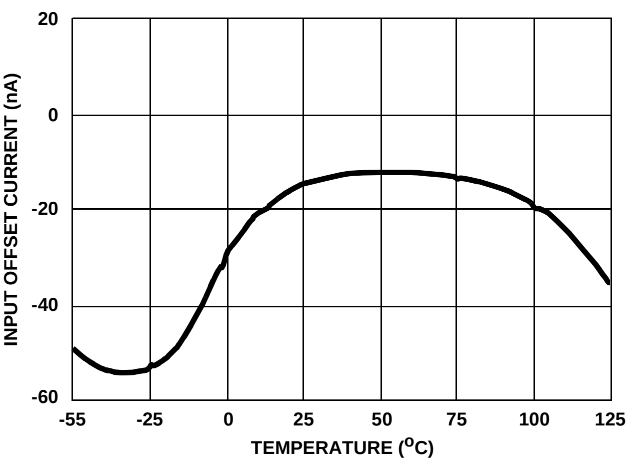


FIGURE 8. INPUT OFFSET CURRENT vs TEMPERATURE

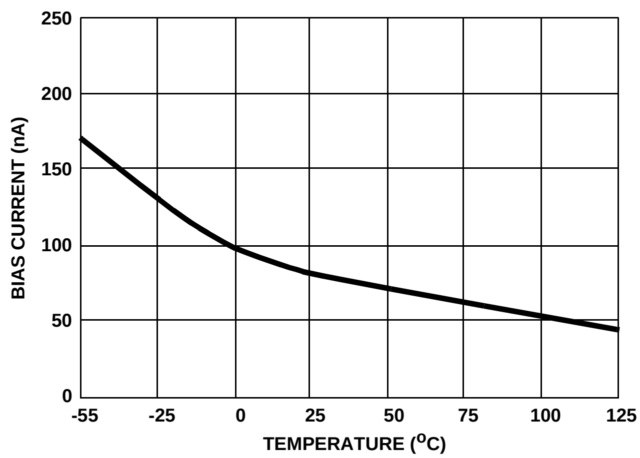


FIGURE 9. INPUT BIAS CURRENT vs TEMPERATURE

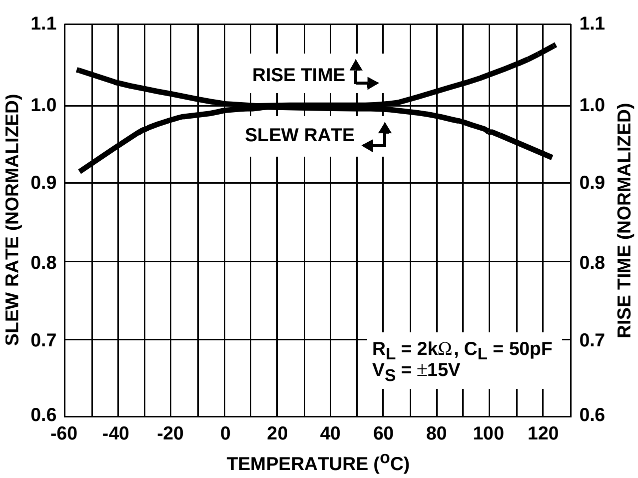


FIGURE 10. SLEW RATE/RISE TIME vs TEMPERATURE

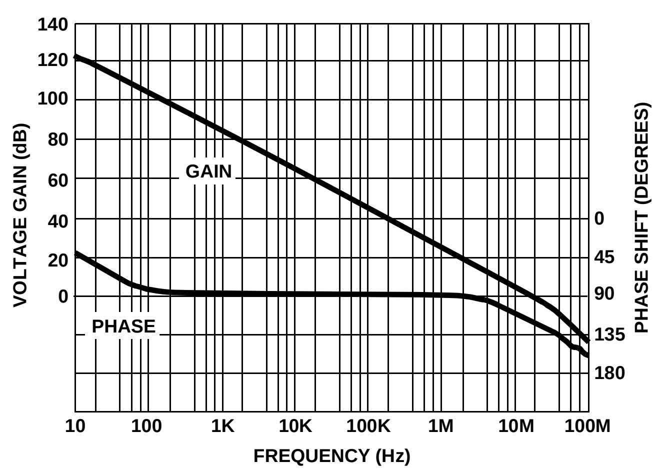


FIGURE 11. OPEN-LOOP GAIN/PHASE vs FREQUENCY

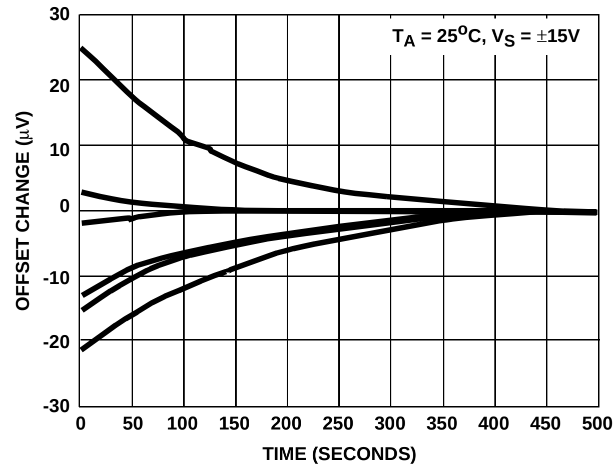


FIGURE 12. INPUT OFFSET WARMUP DRIFT vs TIME (NORMALIZED TO ZERO FINAL VALUE) (SIX REPRESENTATIVE UNITS)

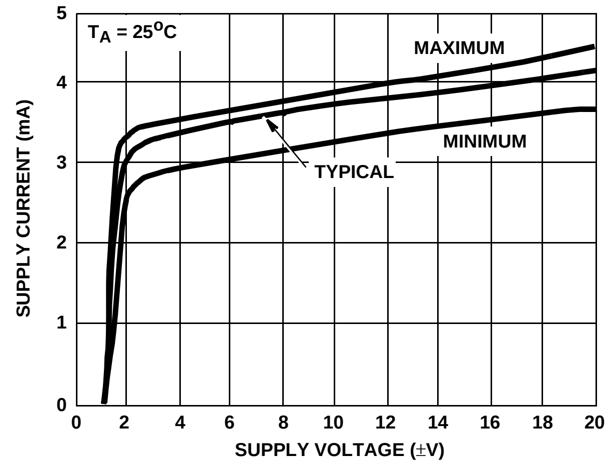


FIGURE 13. SUPPLY CURRENT vs SUPPLY VOLTAGE

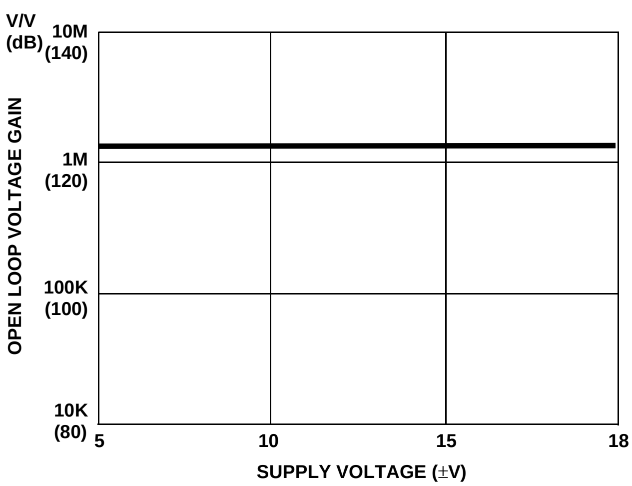


FIGURE 14. DC OPEN-LOOP VOLTAGE GAIN vs SUPPLY VOLTAGE

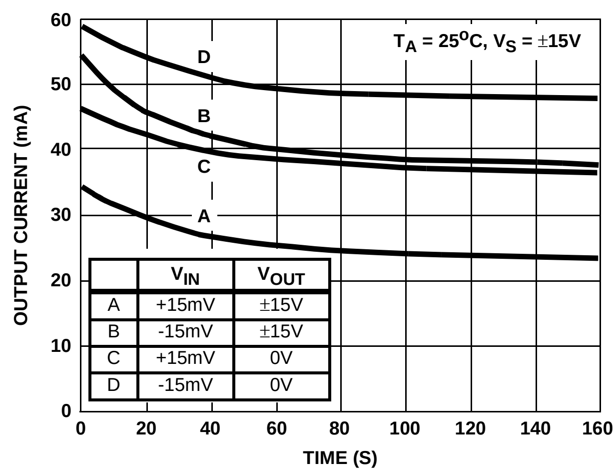


FIGURE 15. SHORT CIRCUIT CURRENT vs TIME

Typical Performance Curves (Continued)

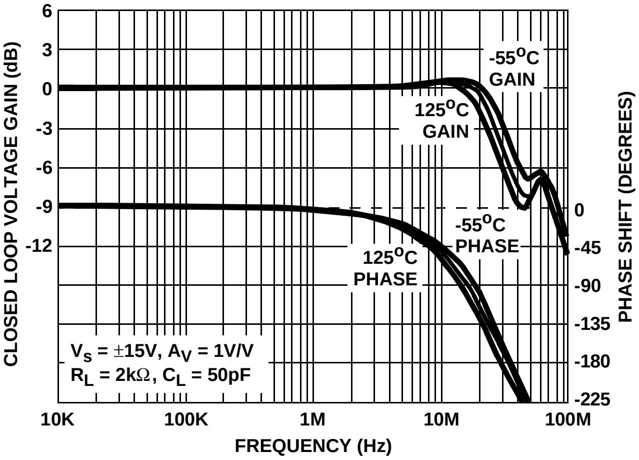


FIGURE 16. FREQUENCY RESPONSE

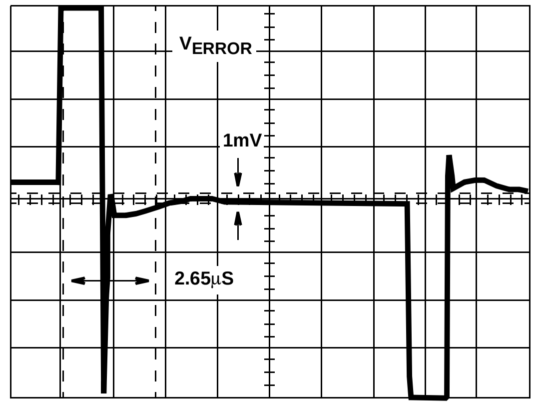


FIGURE 17. SETTLING WAVEFORM 1.5μs/DIV.

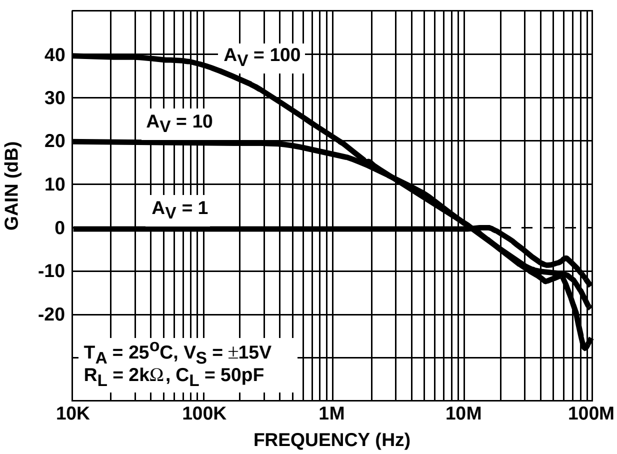


FIGURE 18. CLOSED-LOOP GAIN vs FREQUENCY

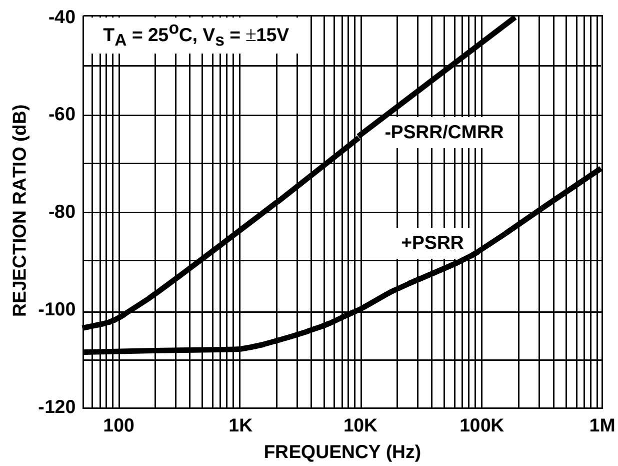


FIGURE 19. REJECTION RATIOS vs FREQUENCY

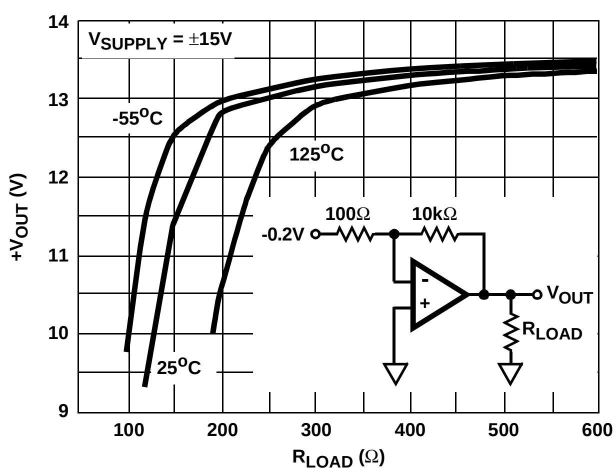


FIGURE 20. +V_{OUT} vs R_L

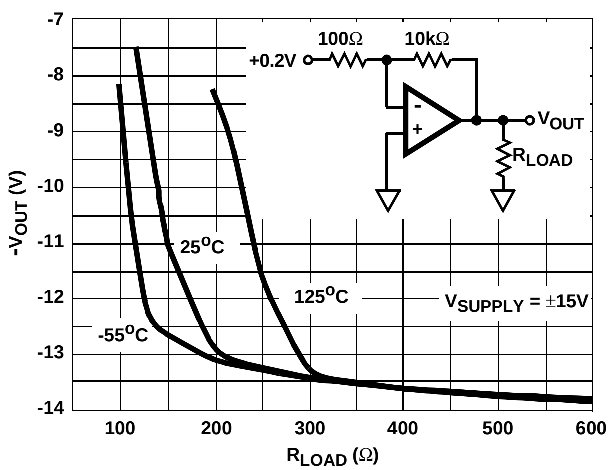


FIGURE 21. -V_{OUT} vs R_L

Die Characteristics

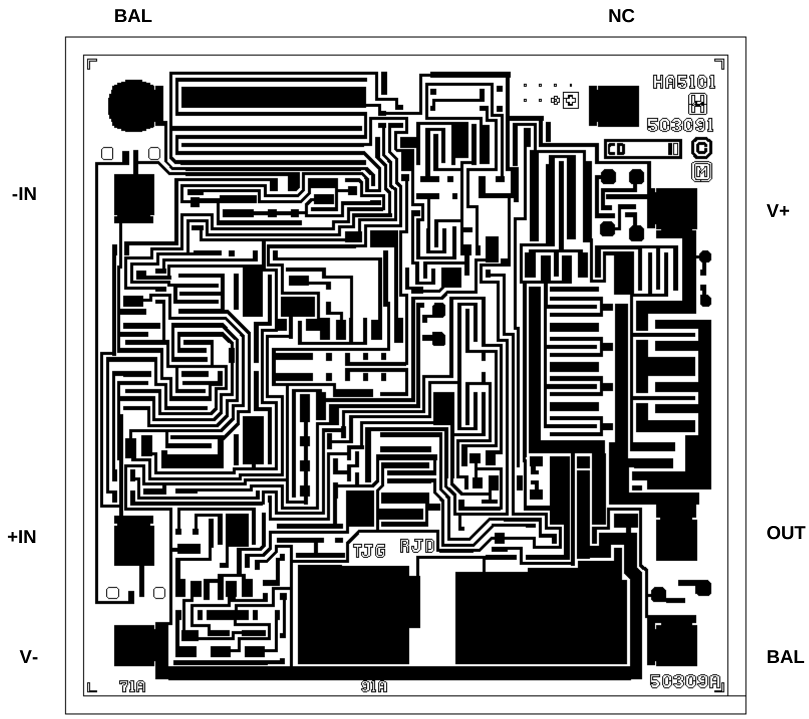
SUBSTRATE POTENTIAL (Powered Up): V-

TRANSISTOR COUNT: 54

PROCESS: Bipolar Dielectric Isolation

Metallization Mask Layout

HA-5101



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