September 1998 File Number 2901.3

150MHz, High Slew Rate, Precision Operational Amplifier

The HA-2548 is an op amp that offers a unique combination of bandwidth, slew rate, and precision specifications. These features can eliminate the need for composite op amp designs and external calibration circuitry.

Optimized for gains ≥5, the HA-2548 has a gain-bandwidth product of 150MHz and a slew rate of 120V/µs while maintaining extremely high open loop gain (130dB Typ) and low offset voltage (300µV Typ). These specifications are achieved through uniquely designed input circuitry and a single ultra-high gain stage that minimizes the AC signal path. Capable of delivering over 30mA of output current, the HA-2548 is ideal for precision, high speed applications such as signal conditioning, instrumentation, video/pulse amplifiers and buffers.

For information on the military version of this device please refer to the HA-2548/883 datasheet.

Features

- High Slew Rate 120V/µs
- Low Offset Voltage. 300µV
- High Open Loop Gain 130dB
- Gain Bandwidth Product 150MHz
- Low Noise Voltage at 1kHz . . . . 8.3nV/$\sqrt{Hz}$
- Minimum Gain Stability . . . . ≥5

Applications

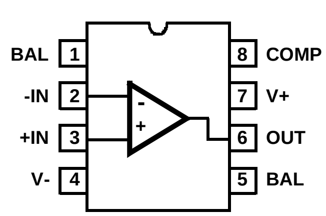
- High Speed Instrumentation
- Data Acquisition Systems
- Analog Signal Conditioning
- Precision, Wideband Amplifiers
  - Pulse/RF Amplifiers

Part Number Information

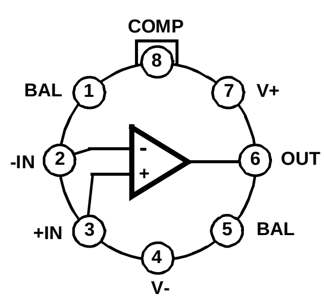
PART NUMBER	TEMP. RANGE (^{o}C)	PACKAGE	PKG. NO.
HA2-2548-5	0 to 75	8 Pin Metal Can	T8.C
HA2-2548-9	-40 to 85	8 Pin Metal Can	T8.C
HA3-2548-5	0 to 75	8 Ld PDIP	E8.3
HA7-2548-5	0 to 75	8 Ld SBDIP	D8.3
HA9P2548-5	0 to 75	16 Ld SOIC	M16.3

Pinouts

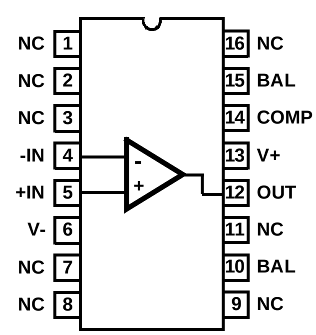
HA-2548
(PDIP, SBDIP)
TOP VIEW



HA-2548
(METAL CAN)
TOP VIEW



HA-2548
(SOIC)
TOP VIEW



Absolute Maximum Ratings

Supply Voltage Between V+ and V- Terminals 40V
Differential Input Voltage 5V
Output Current 40mA

Operating Conditions

Temperature Range
HA-2548-5 . . . . 0^oC to 75^oC
HA-2548-9 . . . . -40^oC to 85^oC

Thermal Information

Thermal Resistance (Typical, Note 1)	θ_{JA} (^oC/W)	θ_{JC} (^oC/W)
SBDIP Package	110	30
PDIP Package	92	N/A
SOIC Package	96	N/A
Metal Can Package	165	80

Maximum Junction Temperature (Hermetic Packages) . . . . . . 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.

NOTE:

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

Electrical Specifications

V_{SUPPLY} = ±15V, R_L = 1kΩ, C_L = 10pF, Unless Otherwise Specified

PARAMETER	TEST CONDITIONS	TEMP (^oC)	HA-2548-5, -9 MIN	TYP	MAX	UNITS
INPUT CHARACTERISTICS						
Input Offset Voltage		25	-	300	900	μV
		Full	-	400	1200	μV
Average Offset Voltage Drift (Note 5)		Full	-	4	9	μV/^oC
Input Bias Current		25	-	5	50	nA
		Full	-	20	100	nA
Input Offset Current		25	-	5	50	nA
		Full	-	20	100	nA
Common Mode Range		25	±7	±10	-	V
Differential Input Resistance		25	-	1	-	MΩ
Input Noise Voltage	f = 0.1Hz to 10Hz	25	-	0.2	-	μV_{RMS}
	f = 0.1Hz to 1MHz	25	-	0.8	-	μV_{RMS}
Input Noise Voltage Density (Note 2)	f = 10Hz	25	-	30	-	nV/√Hz
	f = 100Hz	25	-	12	-	nV/√Hz
	f = 1000Hz	25	-	8.3	-	nV/√Hz
Input Noise Current Density (Note 2)	f = 10Hz	25	-	1.9	-	pA/√Hz
	f = 100Hz	25	-	0.7	-	pA/√Hz
	f = 1000Hz	25	-	0.4	-	pA/√Hz
TRANSFER CHARACTERISTICS						
Large Signal Voltage Gain	V_{OUT} = ±10V	25	114	130	-	dB
		Full	108	125	-	dB
Common Mode Rejection Ratio	V_{CM} = ±2V	Full	80	90	-	dB
Gain Bandwidth Product (Note 5)	A_V = -100, f = 100kHz to 10MHz	25	130	150	-	MHz
		Full	110	125	-	MHz
Minimum Stable Gain		Full	5	-	-	V/V
OUTPUT CHARACTERISTICS						
Output Voltage Swing		Full	±11	±12	-	V
Output Current	R_L = 1kΩ, V_{OUT} ≥10V	Full	±30	±33	-	mA
Output Resistance		25	-	5	-	Ω
Full Power Bandwidth (Note 3)		25	-	1.91	-	MHz
TRANSIENT RESPONSE A_V = +5, Unless Otherwise Specified						

Electrical Specifications V_{SUPPLY} = ±15V, R_L = 1kΩ, C_L = 10pF, Unless Otherwise Specified **(Continued)**

PARAMETER	TEST CONDITIONS	TEMP (°C)	HA-2548-5, -9 MIN	TYP	MAX	UNITS
Slew Rate (Note 5) Positive	V_{OUT} = ±5V	25	80	120	-	V/µs
		Full	70	105	-	V/µs
Slew Rate (Note 5) Negative	V_{OUT} = ±5V	25	70	110	-	V/µs
		Full	60	105	-	V/µs
Rise Time (Note 5)	V_{OUT} = ±100mV	25	-	16.5	20	ns
		Full	-	19	23	ns
Fall Time (Note 5)	V_{OUT} = ±100mV	25	-	16	20	ns
		Full	-	18	23	ns
Overshoot (Note 5) Positive	V_{OUT} = ±100mV	25	-	15	25	%
		Full	-	25	35	%
Overshoot (Note 5) Negative	V_{OUT} = ±100mV	25	-	8	15	%
		Full	-	20	30	%
Settling Time	Notes 4, 5	25	-	200	260	ns
POWER SUPPLY						
Power Supply Rejection Ratio	V_S = ±10V to ±20V	Full	86	95	-	dB
I_{CC}		Full	-	12	18	mA

NOTES:

2. Refer to typical performance curve in data sheet.
3. Full Power Bandwidth is calculated by: $FPBW = \frac{\text{Slew Rate}}{2\pi V_{PEAK}}, V_{PEAK} = 10V$.
4. Settling time is specified to 0.01% with a 10V step and A_V = -5.
5. These parameters are not tested. The limits are guaranteed based on lab characterization and reflect lot to lot variation.

Test Circuits and Waveforms

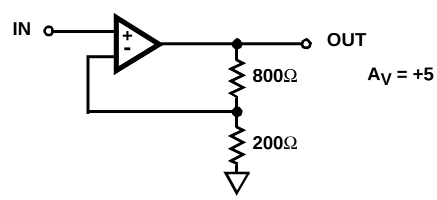
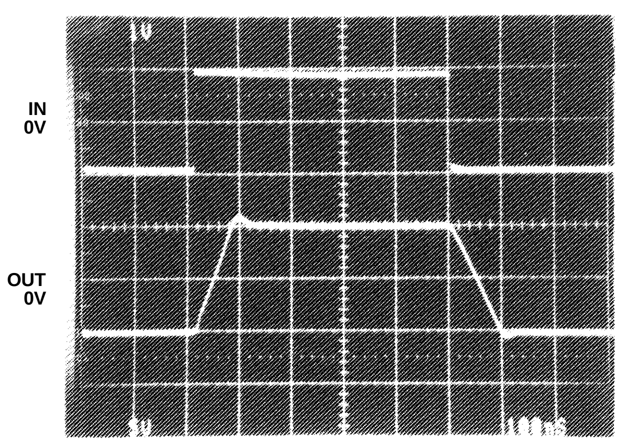
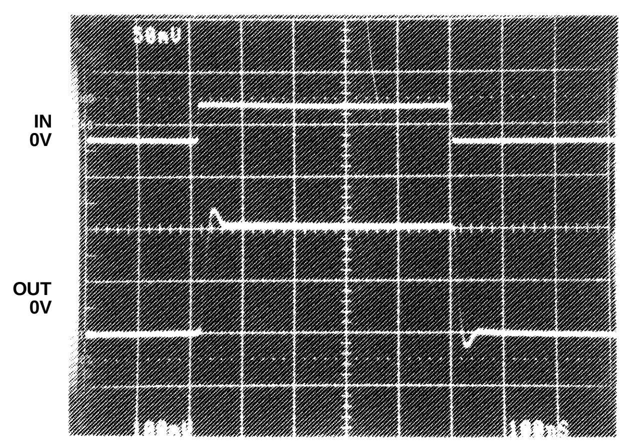


FIGURE 1. LARGE AND SMALL SIGNAL RESPONSE CIRCUIT



V_{OUT} = ±5V, A_V = +5, R_L = 1K, C_L ≤ 10pF

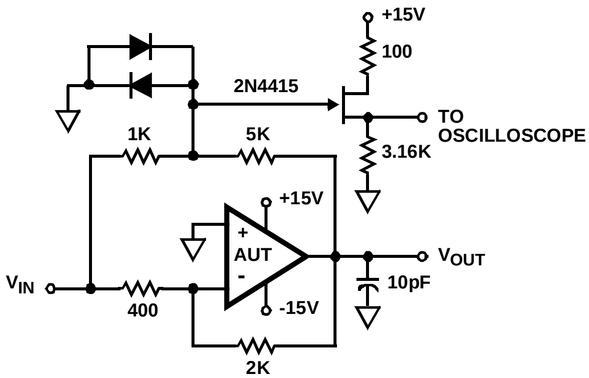
FIGURE 2. LARGE SIGNAL RESPONSE



V_{OUT} = ±100mV, A_V = +5, R_L = 1K, C_L ≤ 10pF

FIGURE 3. SMALL SIGNAL RESPONSE

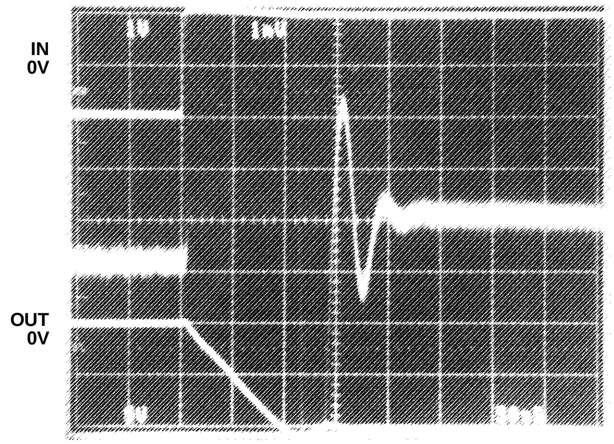
Test Circuits and Waveforms (Continued)



NOTES:

6. A_V = -5.
7. Feedback and summing resistors should be 0.1% matched.
8. Clipping diodes are optional. HP5082-2810 recommended.

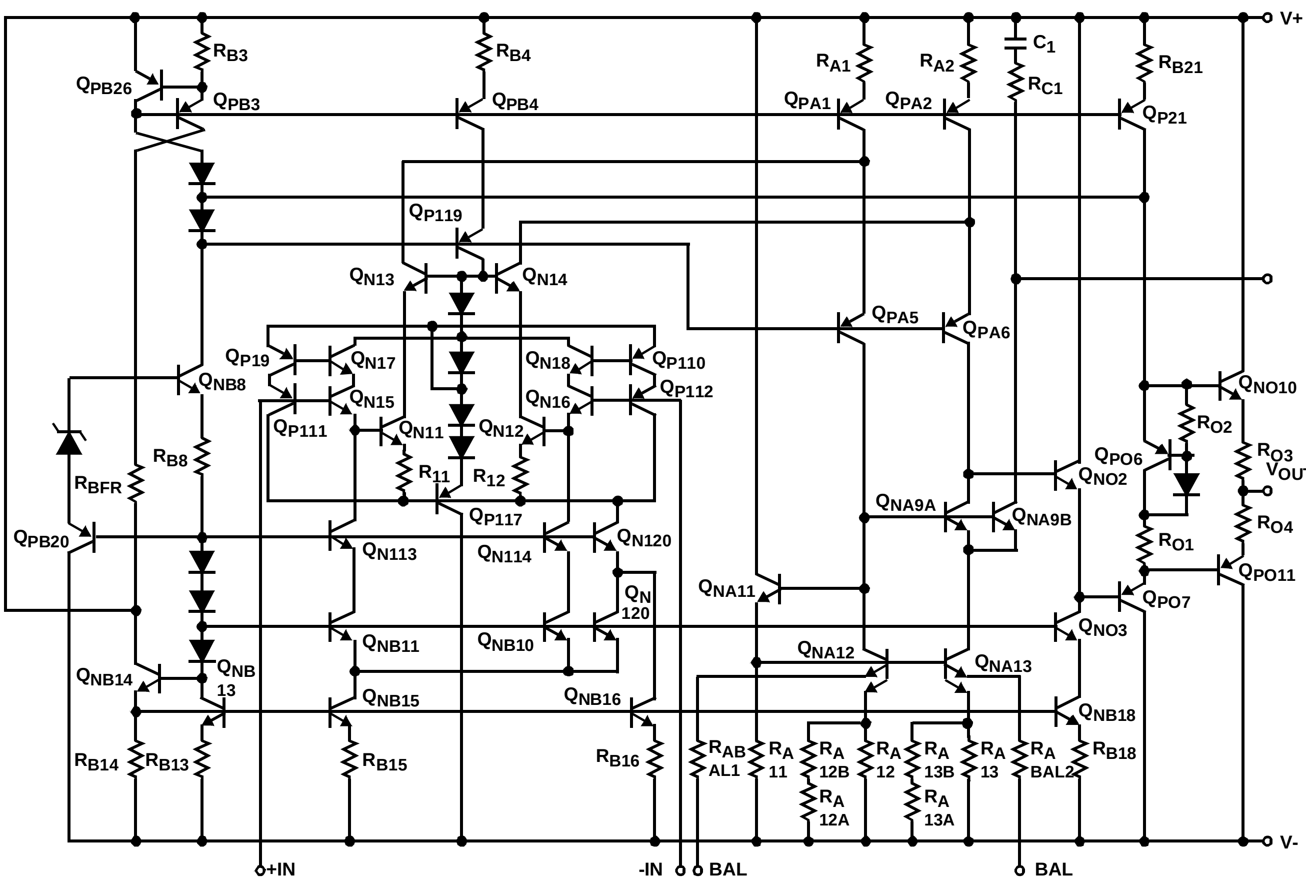
FIGURE 4. SETTLING TIME TEST CIRCUIT



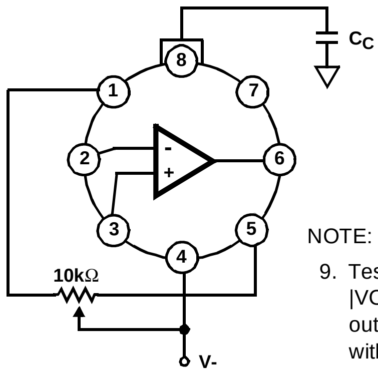
A_V = -5, Output = -10V Output Scale Vertical: 1mV/Div., Horizontal: 50ns/Div.

FIGURE 5. HA-2548 SETTLING TIME

Schematic Diagram



Application Information



NOTE:

9. Tested Offset Adjustment Range is |VOS +1mV| minimum referred to output. Typical range is ±20mV with R_T = 10kΩ.

FIGURE 6. SUGGESTED VOS ADJUSTMENT AND COMPENSATION HOOK UP

Typical Performance Curves $V_S = \pm15V$, $T_A = 25^oC$

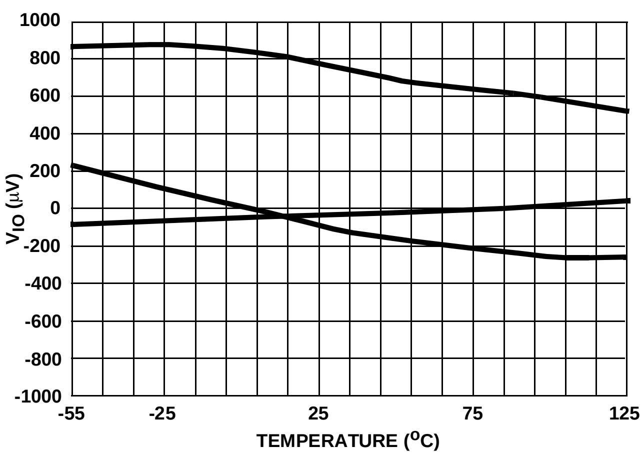


FIGURE 7. V_{IO} vs TEMPERATURE (3 REPRESENTATIVE UNITS)

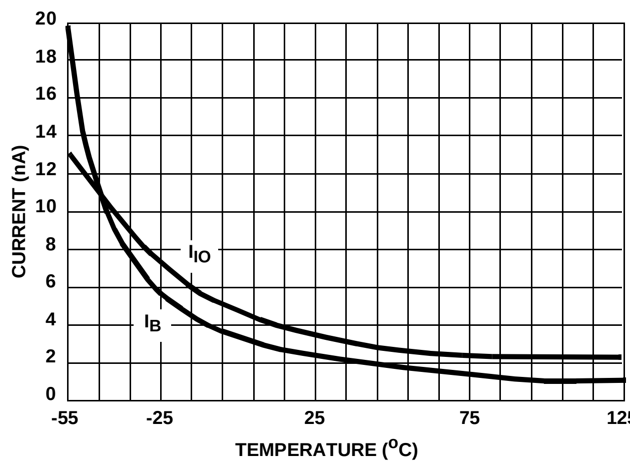


FIGURE 8. OFFSET CURRENT/BIAS CURRENT vs TEMPERATURE

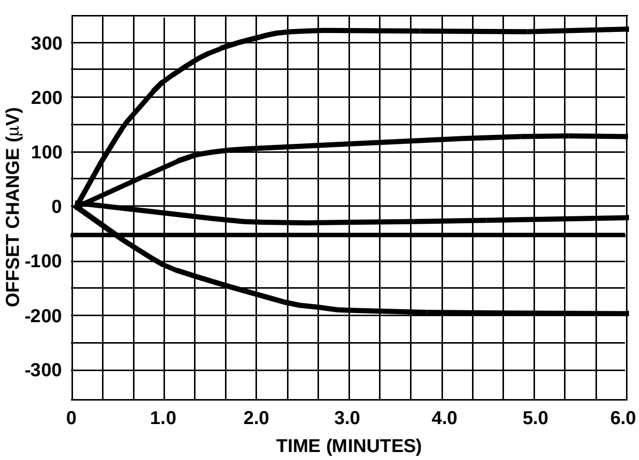


FIGURE 9. V_{IO} WARM-UP DRIFT (NORMALIZED FROM ZERO) (4 REPRESENTATIVE UNITS)

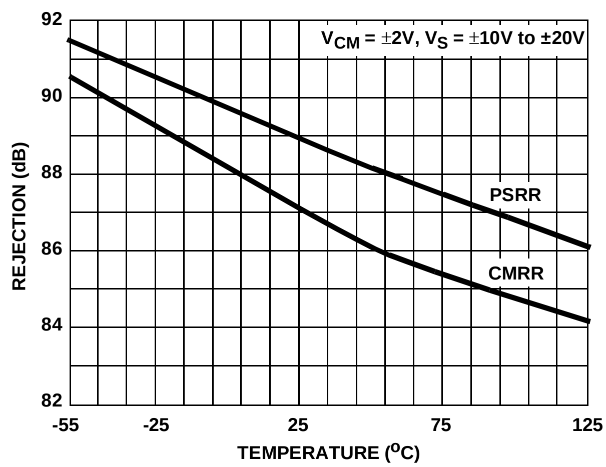


FIGURE 10. PSRR/CMRR vs TEMPERATURE

Typical Performance Curves $V_S = \pm15V$, $T_A = 25^oC$ **(Continued)**

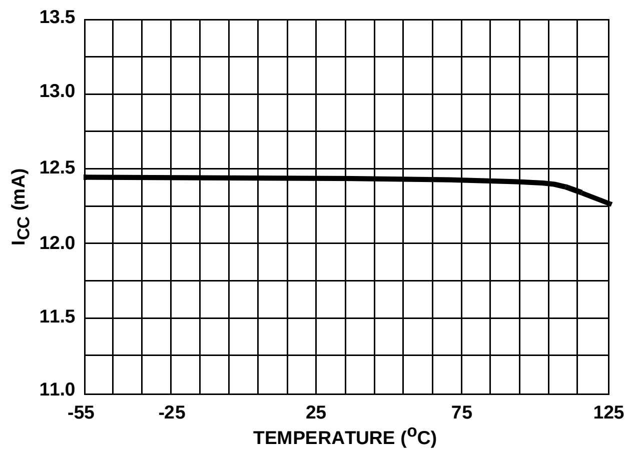


FIGURE 11. I_{CC} vs TEMPERATURE

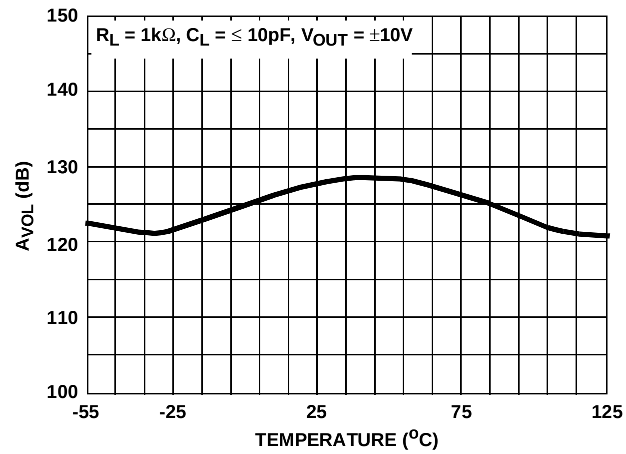


FIGURE 12. A_{VOL} vs TEMPERATURE

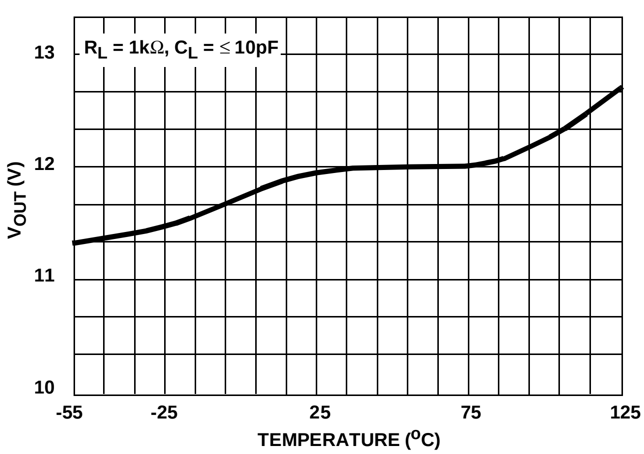


FIGURE 13. V_{OUT} vs TEMPERATURE

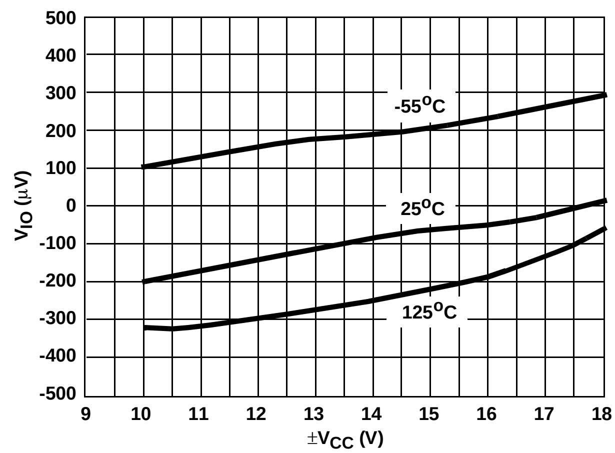


FIGURE 14. V_{IO} vs $\pm V_{CC}$ vs TEMPERATURE

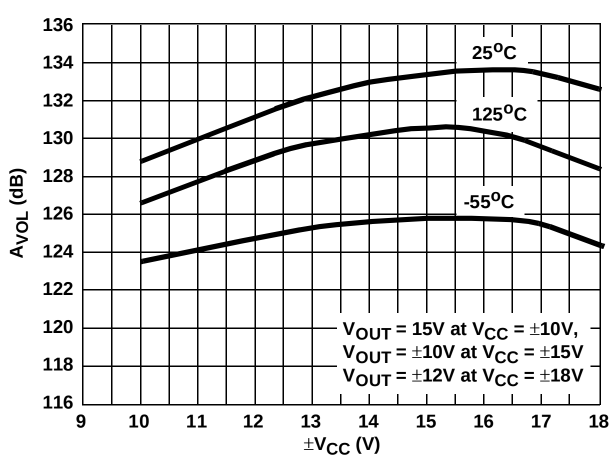


FIGURE 15. A_{VOL} vs $\pm V_{CC}$ vs TEMPERATURE

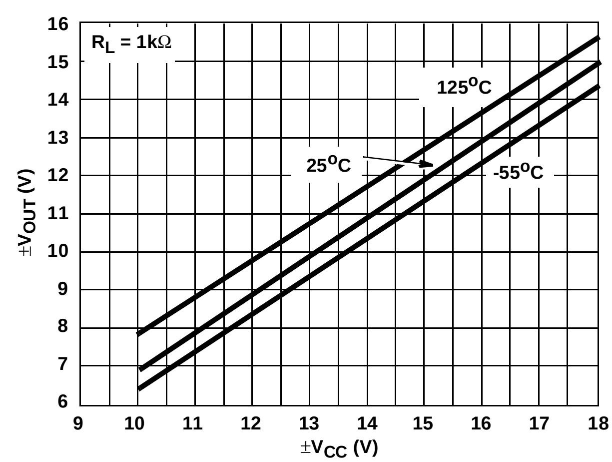


FIGURE 16. $\pm V_{OUT}$ vs $\pm V_{CC}$ vs TEMPERATURE

Typical Performance Curves $V_S = \pm15V$, $T_A = 25^oC$ **(Continued)**

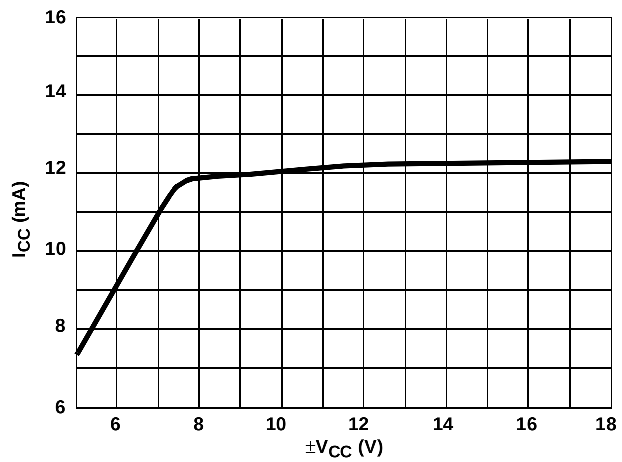


FIGURE 17. SUPPLY CURRENT vs SUPPLY VOLTAGE

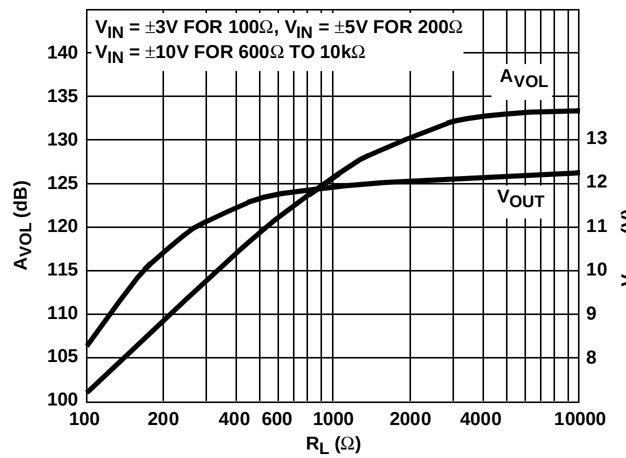


FIGURE 18. A_{VOL}/V_{OUT} vs R_L

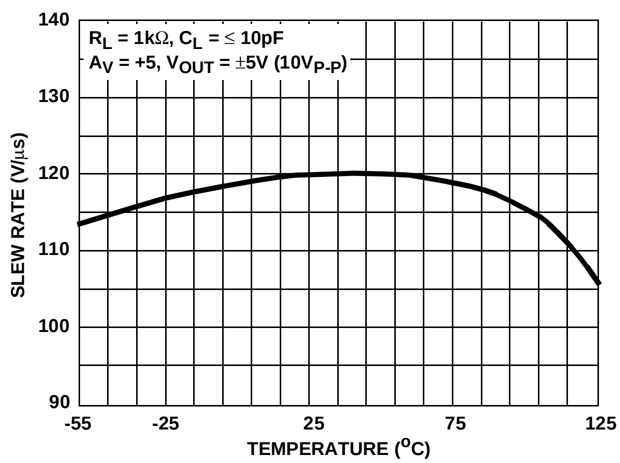


FIGURE 19. SLEW RATE vs TEMPERATURE

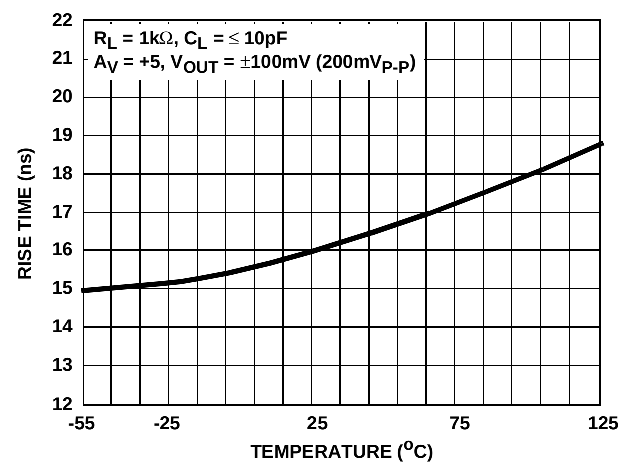


FIGURE 20. RISE TIME vs TEMPERATURE

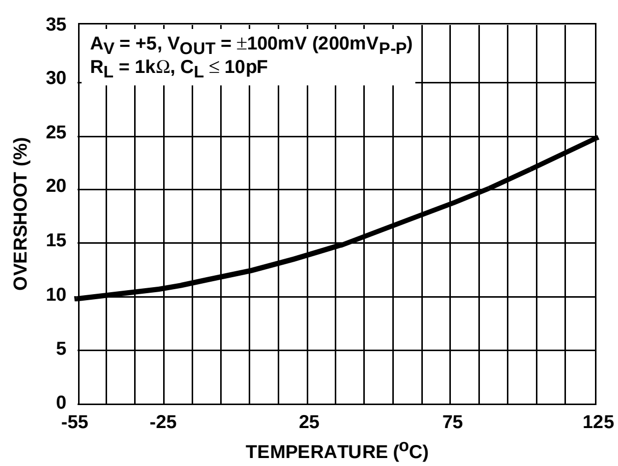


FIGURE 21. OVERSHOOT vs TEMPERATURE

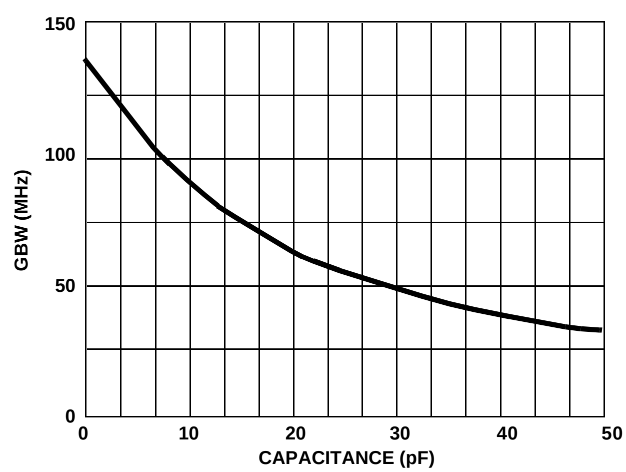


FIGURE 22. GAIN BANDWIDTH PRODUCT vs COMPENSATION CAPACITANCE TO GND

Typical Performance Curves $V_S = \pm15V$, $T_A = 25^oC$ **(Continued)**

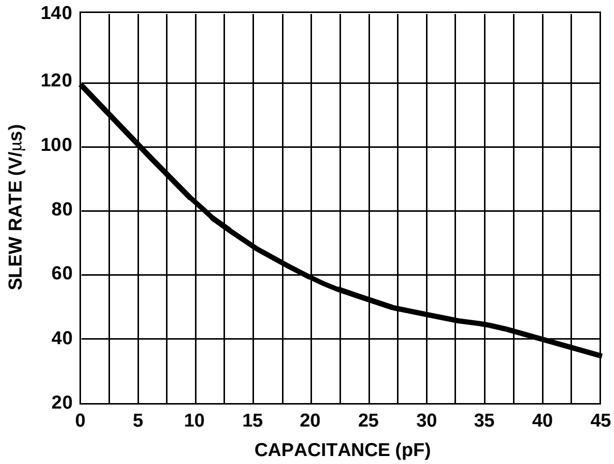


FIGURE 23. SLEW RATE vs COMPENSATION CAPACITANCE TO GND

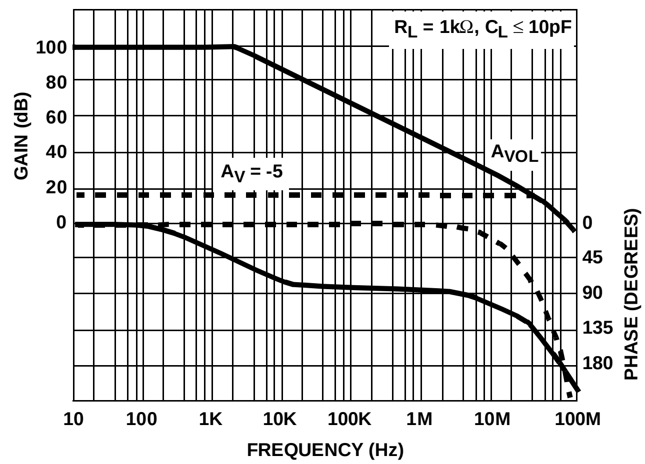


FIGURE 24. GAIN AND PHASE vs FREQUENCY

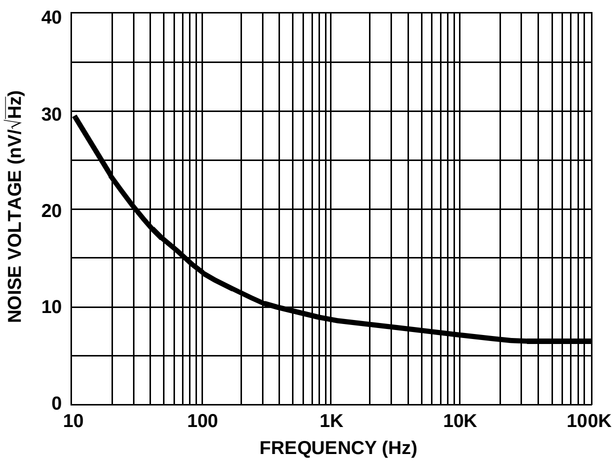


FIGURE 25. INPUT NOISE VOLTAGE DENSITY

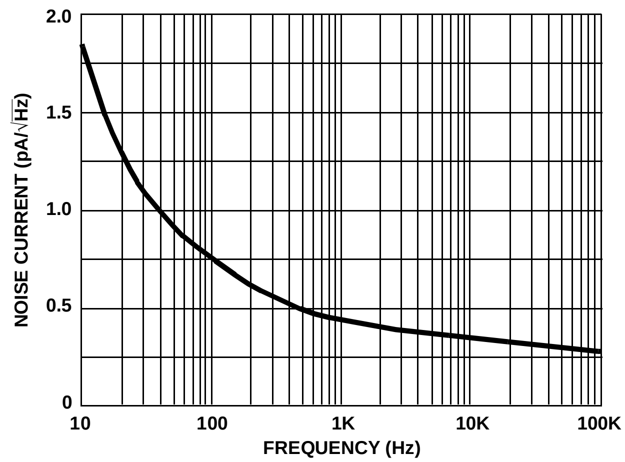
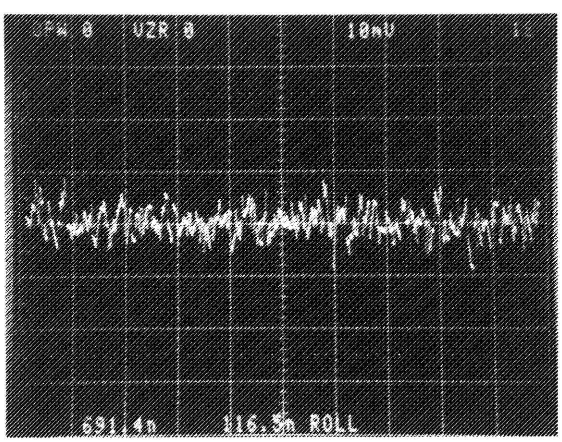
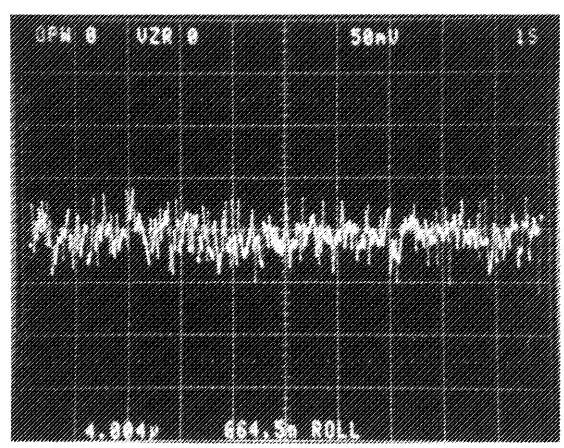


FIGURE 26. INPUT NOISE CURRENT DENSITY



P-P(RTI) = 691.4nV, RMS(RTI) = 116.5nV, $A_V = 25000$

FIGURE 27. PEAK TO PEAK NOISE 0.1Hz TO 10Hz



P-P(RTI) = 4.004μV, RMS(RTI) = 664.5nV, $A_V = 25000$

FIGURE 28. PEAK TO PEAK NOISE 0.1Hz TO 1MHz

Typical Performance Curves $V_S = \pm15V$, $T_A = 25^oC$ **(Continued)**

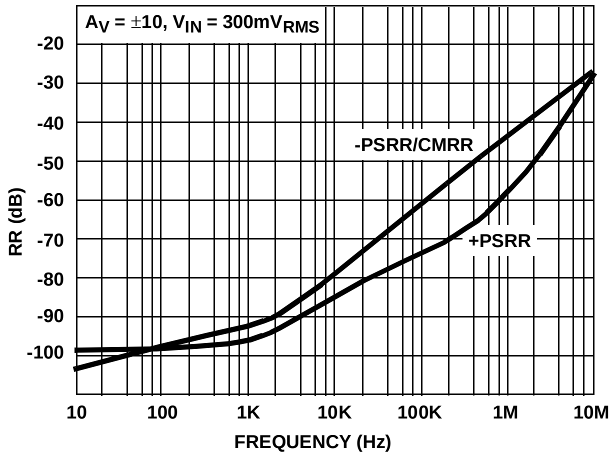


FIGURE 29. REJECTION RATIOS vs FREQUENCY

Die Characteristics

DIE DIMENSIONS:
85 mils x 91 mils x 19 mils
2160μm x 2320μm x 483μm

METALLIZATION:
Type: Aluminum, 1% Copper
Thickness: 16kÅ ±2kÅ

SUBSTRATE POTENTIAL
V-

NOTE: The substrate may be left floating (Insulating Die Mount) or it may be mounted on conductor at V- potential.

PASSIVATION:
Type: Nitride over Silox
Silox Thickness: 12kÅ ±2kÅ
Nitride Thickness: 3.5kÅ ±1kÅ

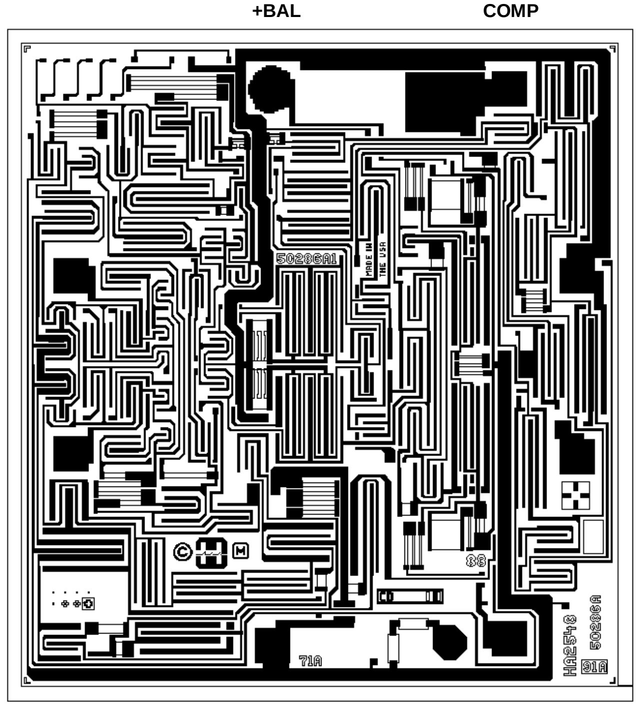
TRANSISTOR COUNT:
60

Metallization Mask Layout

HA-2548

+BAL COMP

-IN V+



+IN OUT

V- -BAL