

November 1996

## 100MHz, JFET Input, High Slew Rate, Uncompensated, Operational Amplifiers

### Features

- Wide Gain Bandwidth ( $A_V \geq 10$ ) ..... 100MHz
- High Slew Rate ..... 120V/ $\mu$ s
- Settling Time ..... 280ns
- Power Bandwidth ..... 1.9MHz
- Offset Voltage ..... 1.0mV
- Bias Current ..... 20pA

### Applications

- Video and RF Amplifiers
- Data Acquisition
- Pulse Amplifiers
- Precision Signal Generation

### Ordering Information

| PART NUMBER | TEMP. RANGE (°C) | PACKAGE         | PKG. NO. |
|-------------|------------------|-----------------|----------|
| HA2-5160-2  | -55 to 125       | 8 Pin Metal Can | T8.C     |
| HA2-5160-5  | 0 to 75          | 8 Pin Metal Can | T8.C     |
| HA2-5162-5  | 0 to 75          | 8 Pin Metal Can | T8.C     |

### Description

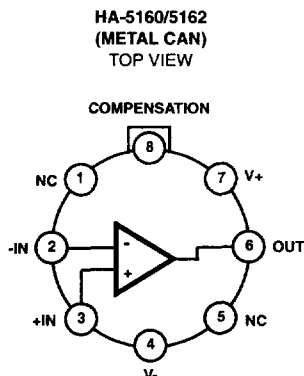
The HA-5160 is a wideband, uncompensated, operational amplifier with FET/Bipolar technologies and Dielectric Isolation. This monolithic amplifier features superior high frequency capabilities further enhanced by precision laser trimming of the input stage to provide excellent input characteristics. This device has excellent phase margin at a closed loop gain of 10 without external compensation.

The HA-5160/5162 offers a number of important advantages over similar FET input op amps from other manufacturers. In addition to superior bandwidth and settling characteristics, the Harris devices have nearly constant slew rate, bandwidth, and settling characteristics over the operating temperature range. This provides the user predictable performance in applications where settling time, full power bandwidth, closed loop bandwidth, or phase shift is critical. Note also that Harris specified all parameters at ambient (rather than junction) temperature to provide the designer meaningful data to predict actual operating performance.

Complementing the HA-5160/5162's predictable and excellent dynamic characteristics are very low input offset voltage, very low input bias current, and a very high input impedance. This ideal combination of features make these amplifiers most suitable for precision, high speed, data acquisition system designs and for a wide variety of signal conditioning applications. The HA-5160 provides excellent performance for applications which require both precision and high speed performance. The HA-5162 meets or exceeds the performance specifications of National's hybrid op amp, the LH0062.

Military version (/883) data sheets are available upon request.

### Pinout



NOTE: Case connected to V-.

# HA-5160, HA-5162

## Absolute Maximum Ratings

Voltage Between V+ and V- ..... 40V  
 Differential Input Voltage ..... 40V  
 Peak Output Current ..... Full Short Circuit Protection

## Operating conditions

Temperature Ranges  
 HA-5160-2 ..... -55°C to 125°C  
 HA-5160-5, HA-5162-5 ..... 0°C to 75°C  
 Supply Voltage Range (Typical) .....  $\pm 7V$  to  $\pm 18V$

## Thermal Information

Thermal Resistance (Typical, Note 1)  $\theta_{JA}$  (°C/W)  $\theta_{JC}$  (°C/W)  
 Metal Can Package ..... 155 67  
 Maximum Junction Temperature ..... 175°C  
 Maximum Storage Temperature Range ..... -65°C to 150°C  
 Maximum Lead Temperature (Soldering 10s) ..... 300°C

## Die Characteristics

Number of Transistors ..... 82  
 Substrate Potential (Powered Up) ..... Floating

**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.  $\theta_{JA}$  is measured with the component mounted on an evaluation PC board in free air.

## Electrical Specifications $V_{SUPPLY} = \pm 15V$ , Unless Otherwise Specified

| PARAMETER                     | TEST CONDITIONS                                  | TEMP.<br>(°C) | HA-5160-2<br>-55°C to 125°C |                  |     | HA-5160-5<br>0°C to 75°C |                  |     | HA-5162-5<br>0°C to 75°C |                  |     | UNITS |
|-------------------------------|--------------------------------------------------|---------------|-----------------------------|------------------|-----|--------------------------|------------------|-----|--------------------------|------------------|-----|-------|
|                               |                                                  |               | MIN                         | TYP              | MAX | MIN                      | TYP              | MAX | MIN                      | TYP              | MAX |       |
| INPUT CHARACTERISTICS         |                                                  |               |                             |                  |     |                          |                  |     |                          |                  |     |       |
| Offset Voltage                |                                                  | 25            | -                           | 1                | 3   | -                        | 1                | 3   | -                        | 3                | 15  | mV    |
|                               |                                                  | Full          | -                           | 3                | 5   | -                        | 3                | 5   | -                        | 5                | 20  | mV    |
| Offset Voltage Average Drift  |                                                  | Full          | -                           | 10               | -   | -                        | 20               | -   | -                        | 20               | 35  | μV/°C |
| Bias Current                  |                                                  | 25            | -                           | 20               | 50  | -                        | 20               | 50  | -                        | 20               | 65  | pA    |
|                               |                                                  | Full          | -                           | 5                | 10  | -                        | 5                | 10  | -                        | 5                | 10  | nA    |
| Offset Current                |                                                  | 25            | -                           | 2                | 10  | -                        | 2                | 10  | -                        | 2                | 10  | pA    |
|                               |                                                  | Full          | -                           | 2                | 5   | -                        | 2                | 5   | -                        | 2                | 5   | nA    |
| Input Capacitance             |                                                  | 25            | -                           | 5                | -   | -                        | 5                | -   | -                        | 5                | -   | pF    |
| Input Resistance              |                                                  | 25            | -                           | 10 <sup>12</sup> | -   | -                        | 10 <sup>12</sup> | -   | -                        | 10 <sup>12</sup> | -   | Ω     |
| Common Mode Range             |                                                  | Full          | ±10                         | ±11              | -   | ±10                      | ±11              | -   | ±10                      | ±11              | -   | V     |
| TRANSFER CHARACTERISTICS      |                                                  |               |                             |                  |     |                          |                  |     |                          |                  |     |       |
| Large Signal Voltage Gain     | V <sub>OUT</sub> = ±10V,<br>R <sub>L</sub> = 2kΩ | 25            | 75                          | 150              | -   | 75                       | 150              | -   | 25                       | 100              | -   | kV/V  |
|                               |                                                  | Full          | 60                          | 100              | -   | 60                       | 100              | -   | 25                       | 75               | -   | kV/V  |
| Common Mode Rejection Ratio   | V <sub>CM</sub> = ±10V                           | Full          | 74                          | 80               | -   | 74                       | 80               | -   | 70                       | 80               | -   | dB    |
| Minimum Stable Gain           |                                                  | 25            | 10                          | -                | -   | 10                       | -                | -   | 10                       | -                | -   | V/V   |
| Gain Bandwidth Product        | A <sub>V</sub> ≥ 10                              | Full          | -                           | 100              | -   | -                        | 100              | -   | -                        | 100              | -   | MHz   |
| OUTPUT CHARACTERISTICS        |                                                  |               |                             |                  |     |                          |                  |     |                          |                  |     |       |
| Output Voltage Swing          | R <sub>L</sub> = 2kΩ                             | 25            | ±10                         | ±11              | -   | ±10                      | ±11              | -   | ±10                      | ±11              | -   | V     |
|                               |                                                  | Full          | ±10                         | ±11              | -   | ±10                      | ±11              | -   | ±10                      | ±11              | -   | V     |
| Output Current                | V <sub>OUT</sub> = ±10V                          | 25            | ±10                         | ±20              | -   | ±10                      | ±20              | -   | ±10                      | ±20              | -   | mA    |
| Output Short Circuit Current  |                                                  | 25            | -                           | ±35              | -   | -                        | ±35              | -   | -                        | ±35              | -   | mA    |
| Full Power Bandwidth (Note 2) | V <sub>OUT</sub> = ±10V,<br>R <sub>L</sub> = 2kΩ | 25            | 1.6                         | 1.9              | -   | 1.6                      | 1.9              | -   | 0.8                      | 1.1              | -   | MHz   |
| Output Resistance             | Open Loop                                        | 25            | -                           | 50               | -   | -                        | 50               | -   | -                        | 50               | -   | Ω     |
| TRANSIENT RESPONSE (Note 3)   |                                                  |               |                             |                  |     |                          |                  |     |                          |                  |     |       |
| Rise Time                     | A <sub>V</sub> = +10                             | 25            | -                           | 20               | -   | -                        | 20               | -   | -                        | 20               | -   | ns    |
| Slew Rate                     | A <sub>V</sub> = +10                             | 25            | 100                         | 120              | -   | 100                      | 120              | -   | 50                       | 70               | -   | V/μs  |
| Settling Time (Note 4)        | A <sub>V</sub> = -10                             | 25            | -                           | 280              | -   | -                        | 280              | -   | -                        | 400              | -   | ns    |

3

OPERATIONAL  
AMPLIFIERS

# HA-5160, HA-5162

## Electrical Specifications $V_{SUPPLY} = \pm 15V$ , Unless Otherwise Specified (Continued)

| PARAMETER                    | TEST CONDITIONS               | TEMP.<br>(°C) | HA-5160-2<br>-55°C to 125°C |     |     | HA-5160-5<br>0°C to 75°C |     |     | HA-5162-5<br>0°C to 75°C |     |     | UNITS |
|------------------------------|-------------------------------|---------------|-----------------------------|-----|-----|--------------------------|-----|-----|--------------------------|-----|-----|-------|
|                              |                               |               | MIN                         | TYP | MAX | MIN                      | TYP | MAX | MIN                      | TYP | MAX |       |
| POWER SUPPLY CHARACTERISTICS |                               |               |                             |     |     |                          |     |     |                          |     |     |       |
| Supply Current               |                               | Full          | -                           | 8   | 10  | -                        | 8   | 10  | -                        | 8   | 12  | mA    |
| Power Supply Rejection Ratio | V <sub>S</sub> = ±10V to ±20V | 25            | 74                          | 86  | -   | 74                       | 86  | -   | 70                       | 86  | -   | dB    |

### NOTES:

2. Full Power Bandwidth guaranteed, based on slew rate measurement using:  $FPBW = \frac{\text{Slew Rate}}{2\pi V_{PEAK}}$ .
3. Refer to Test circuits section of the data sheet.
4. Settling Time is measured to 0.2% of final value for a 10V output step.

## Test Circuits and Waveforms

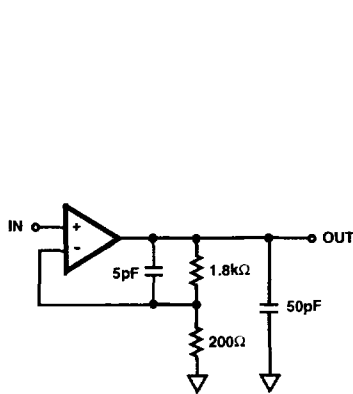
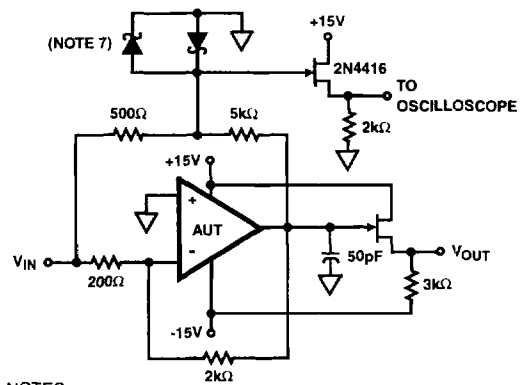


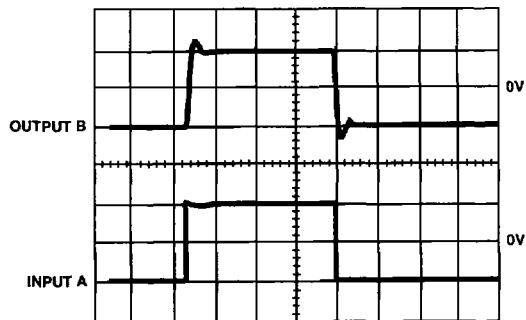
FIGURE 1. LARGE AND SMALL SIGNAL RESPONSE TEST CIRCUIT



### NOTES:

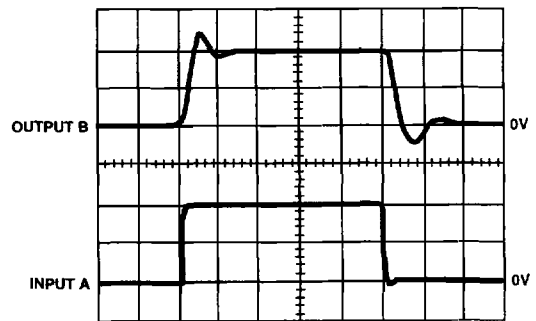
5.  $A_V = -10$ .
6. Feedback and summing resistors should be 0.1% matched.
7. Clipping diodes are optional. HP5082-2810 recommended.

FIGURE 2. SETTLING TIME TEST CIRCUIT



Vertical Scale: A = 0.5V/Div., B = 5V/Div.  
Horizontal Scale: 500ns/Div.

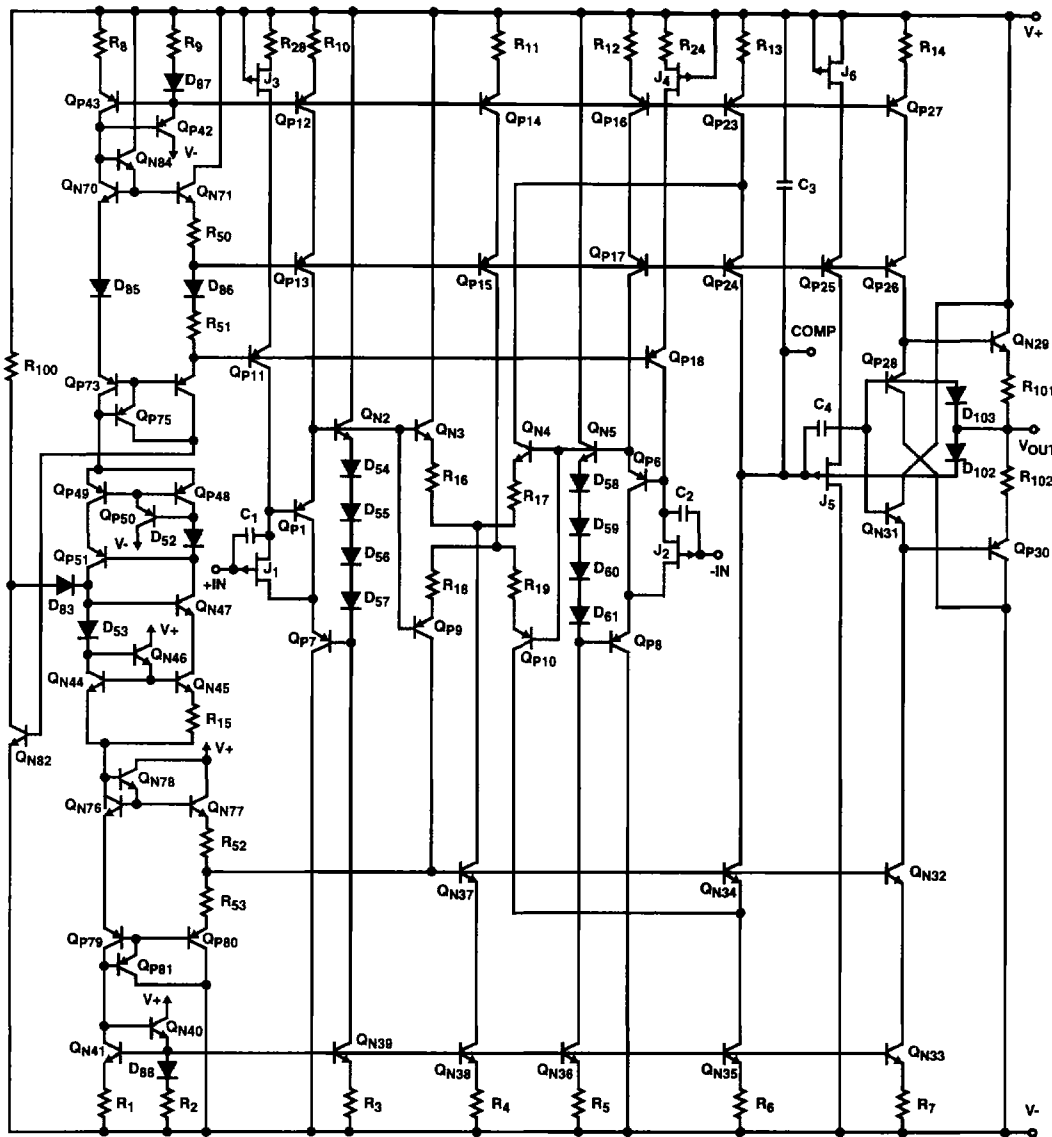
LARGE SIGNAL RESPONSE



Vertical Scale: A = 10mV/Div., B = 100mV/Div.  
Horizontal Scale: 100ns/Div.

SMALL SIGNAL RESPONSE

Schematic Diagram



3

OPERATIONAL  
AMPLIFIERS

## Application Information

### Power Supply Decoupling

Although not absolutely necessary, it is recommended that all power supply lines be decoupled with 0.01 $\mu$ F ceramic capacitors to ground. Decoupling capacitors should be located as near to the amplifier terminals as possible.

### Stability

The phase margin of the HA-5160/5162 will be improved by connecting a small capacitor (>10pF) between the output

and the inverting input of the device. This small capacitor compensates for the input capacitance of the FET.

### Capacitive Loads

When driving large capacitive loads (>100pF), it is suggested that a small resistor ( $\approx$ 100 $\Omega$ ) be connected in series with the output of the device and inside the feedback loop.

### Power Supply Minimum

The absolute supply minimum is  $\pm$ 6V and the safe level is  $\pm$ 7V.

## Typical Applications

### SUGGESTED COMPENSATION FOR UNITY GAIN STABILITY (NOTE)

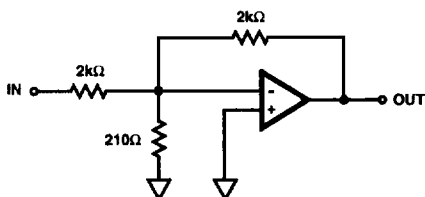


FIGURE 3A. INVERTING UNITY GAIN CIRCUIT

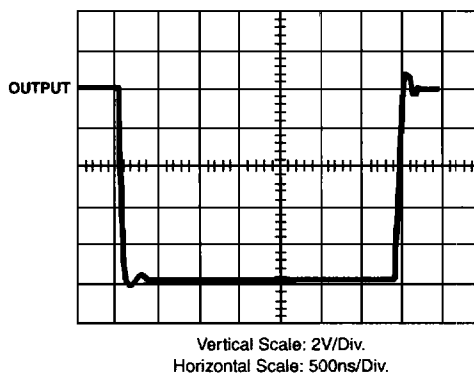


FIGURE 3B. INVERTING UNITY GAIN PULSE RESPONSE

FIGURE 3. GAIN OF -1

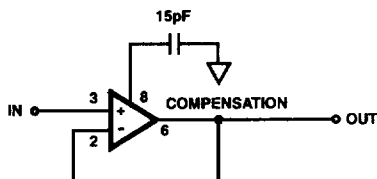


FIGURE 4A. NONINVERTING UNITY GAIN CIRCUIT

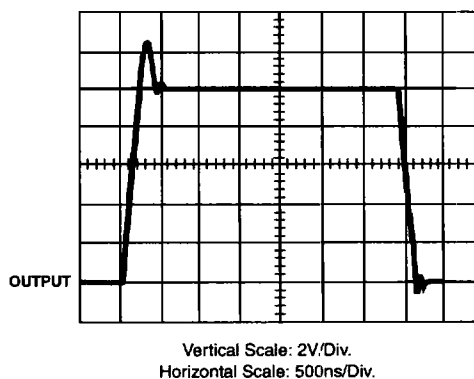


FIGURE 4B. NONINVERTING UNITY GAIN PULSE RESPONSE

FIGURE 4. GAIN OF +1

NOTE: Values were determined experimentally for optimum speed and settling time.

# Typical Performance Curves

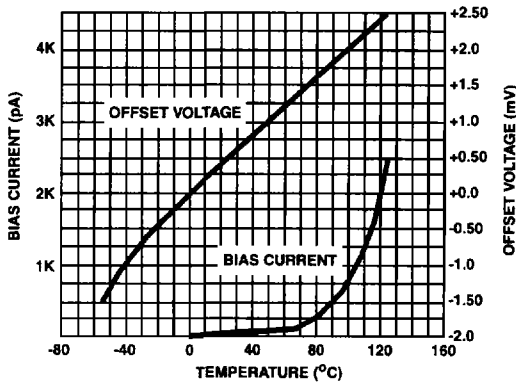


FIGURE 5. INPUT OFFSET VOLTAGE AND BIAS CURRENT vs TEMPERATURE

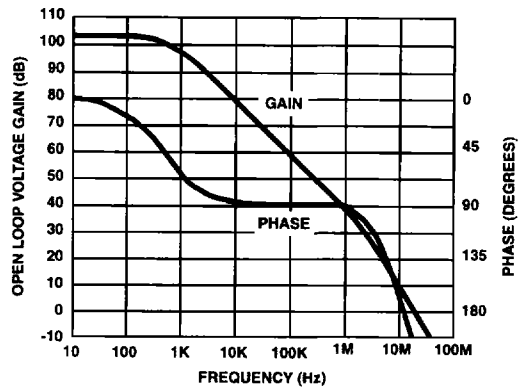


FIGURE 6. OPEN LOOP FREQUENCY RESPONSE

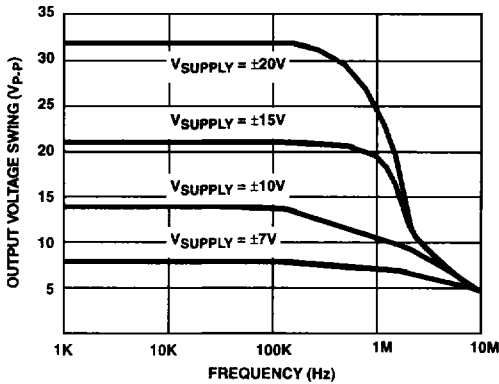


FIGURE 7. OUTPUT VOLTAGE SWING vs FREQUENCY

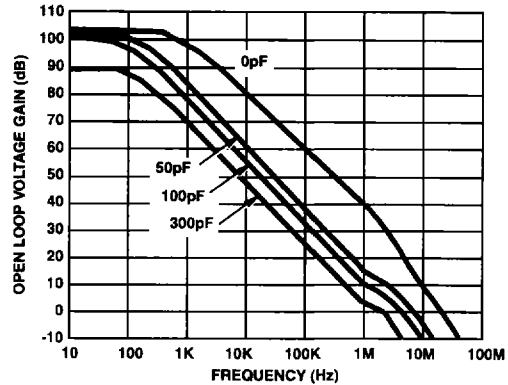


FIGURE 8. OPEN LOOP FREQUENCY RESPONSE FOR VARIOUS COMPENSATION CAPACITANCES

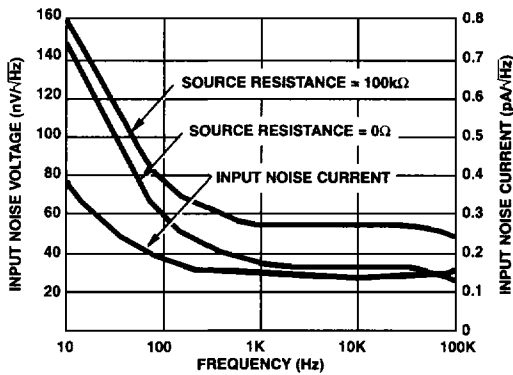


FIGURE 9. INPUT NOISE VOLTAGE AND NOISE CURRENT vs FREQUENCY

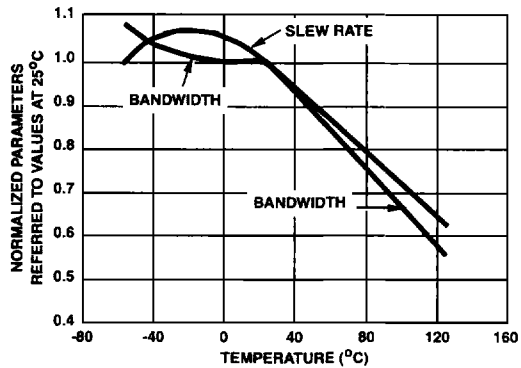


FIGURE 10. NORMALIZED AC PARAMETERS vs TEMPERATURE

**Typical Performance Curves** (Continued)

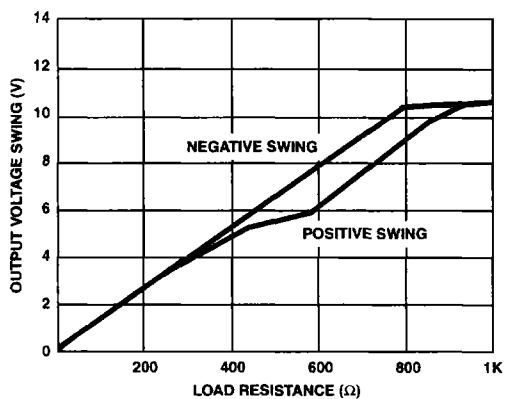


FIGURE 11. OUTPUT VOLTAGE SWING vs LOAD RESISTANCE

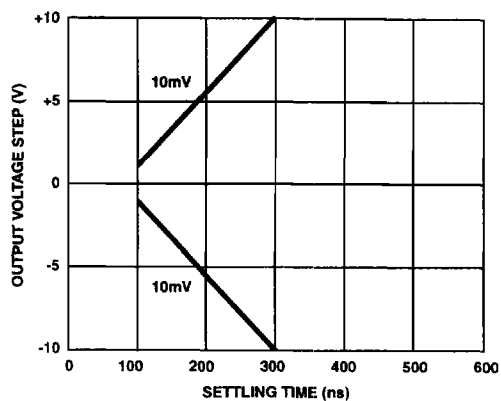


FIGURE 12. SETTLING TIME FOR VARIOUS OUTPUT STEP VOLTAGES

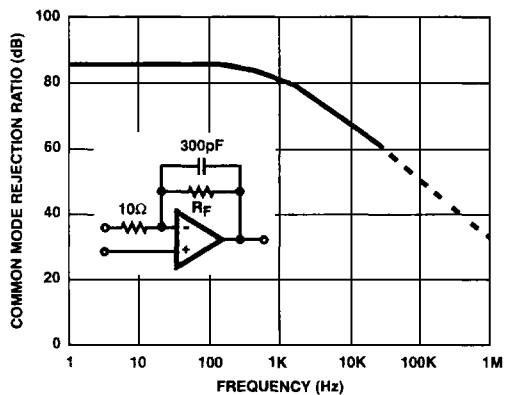


FIGURE 13. COMMON MODE REJECTION RATIO vs FREQUENCY

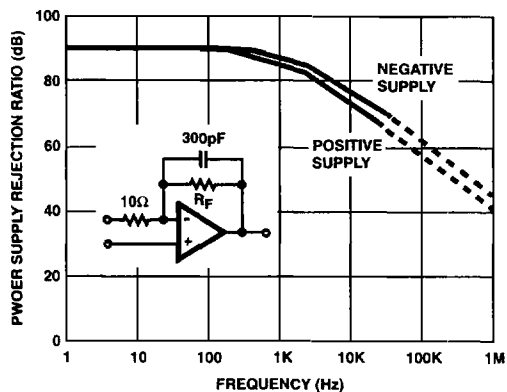


FIGURE 14. POWER SUPPLY REJECTION RATIO vs FREQUENCY

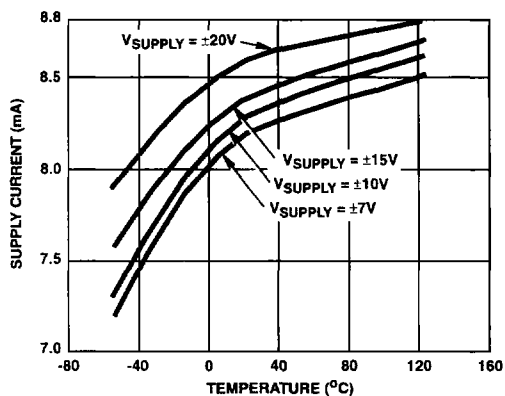


FIGURE 15. POWER SUPPLY CURRENT vs TEMPERATURE