Signetics

# NE/SE5539
# High Frequency Operational Amplifier

*Product Specification*

**Linear Products**

## DESCRIPTION

The NE/SE5539 is a very wide bandwidth, high slew rate, monolithic operational amplifier for use in video amplifiers, RF amplifiers, and extremely high slew rate amplifiers.

Emitter-follower inputs provide a true differential high input impedance device. Proper external compensation will allow design operation over a wide range of closed-loop gains, both inverting and non-inverting, to meet specific design requirements.

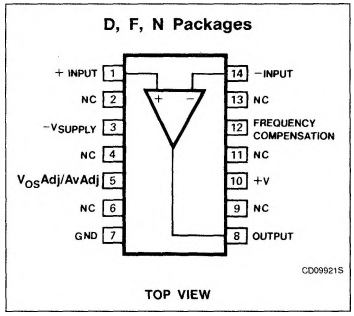
## FEATURES

- **Bandwidth**
  - **Unity gain – 350MHz**
  - **Full power – 48MHz**
  - **GBW – 1.2 GHz at 17dB**
- **Slew rate: 600/V$\mu$s**
- **$A_{VOL}$: 52dB typical**
- **Low noise – 4nV/$\sqrt{Hz}$ typical**
- **MIL-STD processing available**

## APPLICATIONS

- **High speed datacomm**
- **Video monitors & TV**
- **Satellite communications**
- **Image processing**
- **RF instrumentation & oscillators**
- **Magnetic storage**
- **Military communications**

## PIN CONFIGURATION




## ORDERING INFORMATION

| DESCRIPTION | TEMPERATURE RANGE | ORDER CODE |
|---|---|---|
| 14-Pin Plastic DIP | 0 to +70°C | NE5539N |
| 14-Pin Plastic SO | 0 to +70°C | NE5539D |
| 14-Pin Cerdip | 0 to +70°C | NE5539F |
| 14-Pin Plastic DIP | −55°C to +125°C | SE5539N |
| 14-Pin Cerdip | −55°C to +125°C | SE5539F |

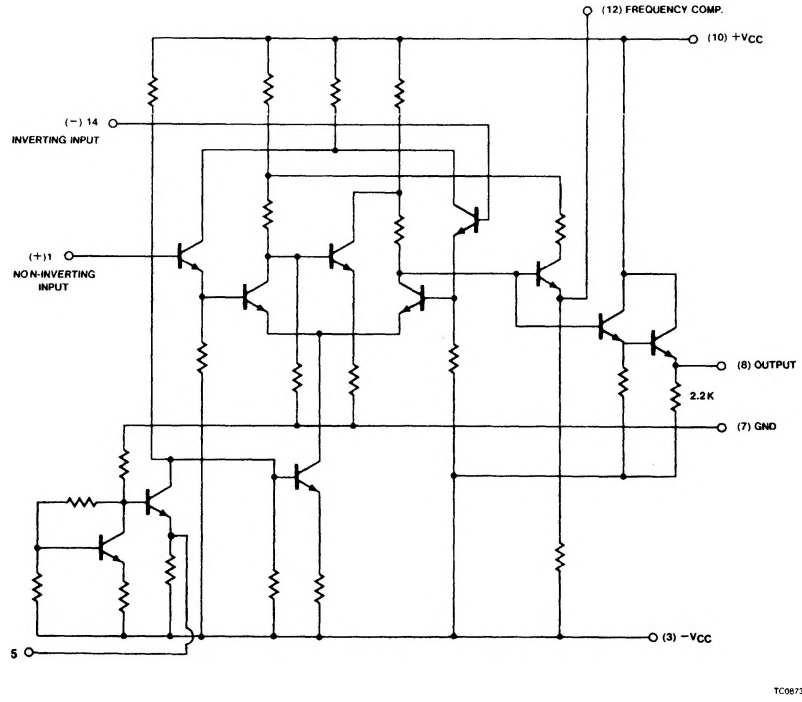
## ABSOLUTE MAXIMUM RATINGS[1]

| SYMBOL | PARAMETER | RATING | UNIT |
|---|---|---|---|
| $V_{CC}$ | Supply voltage | ±12 | V |
| $P_{DMAX}$ | Maximum power dissipation, $T_A$ = 25°C (still-air)[2] | | |
| | F package | 1.17 | W |
| | N package | 1.45 | W |
| | D package | 0.99 | W |
| $T_{STG}$ | Storage temperature range | −65 to +150 | °C |
| $T_J$ | Max junction temperature | 150 | °C |
| $T_A$ | Operating temperature range | | |
| | NE | 0 to 70 | °C |
| | SE | −55 to +125 | °C |
| $T_{SOLD}$ | Lead temperature (10sec max) | 300 | °C |

**NOTES:**

1. Differential input voltage should not exceed 0.25V to prevent excessive input bias current and common-mode voltage 2.5V. These voltage limits may be exceeded if current is limited to less than 10mA.
2. Derate above 25°C, at the following rates:
   F package at 9.3 mW/°C
   N package at 11.6 mW/°C
   D package at 7.9 mW/°C

## EQUIVALENT CIRCUIT




## DC ELECTRICAL CHARACTERISTICS $V_{CC} = \pm 8V$, $T_A = 25°C$, unless otherwise specified.

| SYMBOL | PARAMETER | TEST CONDITIONS | | SE5539 | | | NE5539 | | | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Min | Typ | Max | Min | Typ | Max | |
| $V_{OS}$ | Input offset voltage | $V_O = 0V$, $R_S = 100\Omega$ | Over temp | | 2 | 5 | | | | mV |
| | | | $T_A = 25°C$ | | 2 | 3 | | 2.5 | 5 | |
| | $\Delta V_{OS}/\Delta T$ | | | | 5 | | | 5 | | μV/°C |
| $I_{OS}$ | Input offset current | | Over temp | | 0.1 | 3 | | | | μA |
| | | | $T_A = 25°C$ | | 0.1 | 1 | | | 2 | |
| | $\Delta I_{OS}/\Delta T$ | | | | 0.5 | | | 0.5 | | nA/°C |
| $I_B$ | Input bias current | | Over temp | | 6 | 25 | | | | μA |
| | | | $T_A = 25°C$ | | 5 | 13 | | 5 | 20 | |
| | $\Delta I_B/\Delta T$ | | | | 10 | | | 10 | | nA/°C |
| CMRR | Common-mode rejection ratio | $F = 1kHz$, $R_S = 100\Omega$, $V_{CM} \pm 1.7V$ | | 70 | 80 | | 70 | 80 | | dB |
| | | | Over temp | 70 | 80 | | | | | dB |
| $R_{IN}$ | Input impedance | | | | 100 | | | 100 | | kΩ |
| $R_{OUT}$ | Output impedance | | | | 10 | | | 10 | | Ω |

**DC ELECTRICAL CHARACTERISTICS** (Continued) $V_{CC} = \pm 8V$, $T_A = 25°C$, unless otherwise specified.

| SYMBOL | PARAMETER | TEST CONDITIONS | | | SE5539 | | | NE5539 | | | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Min | Typ | Max | Min | Typ | Max | |
| $V_{OUT}$ | Output voltage swing | $R_L = 150\Omega$ to GND and $470\Omega$ to $-V_{CC}$ | | +Swing | | | | +2.3 | +2.7 | | V |
| | | | | -Swing | | | | -1.7 | -2.2 | | |
| $V_{OUT}$ | Output voltage swing | $R_L = 2k\Omega$ to GND | Over temp | +Swing | +2.3 | +3.0 | | | | | V |
| | | | | -Swing | -1.5 | -2.1 | | | | | |
| | | | $T_A = 25°C$ | +Swing | +2.5 | +3.1 | | | | | V |
| | | | | -Swing | -2.0 | -2.7 | | | | | |
| $I_{CC}+$ | Positive supply current | $V_O = 0$, $R_1 = \infty$ | | Over temp | | 14 | 18 | | | | mA |
| | | | | $T_A = 25°C$ | | 14 | 17 | | 14 | 18 | |
| $I_{CC}-$ | Negative supply current | $V_O = 0$, $R_1 = \infty$ | | Over temp | | 11 | 15 | | | | mA |
| | | | | $T_A = 25°C$ | | 11 | 14 | | 11 | 15 | |
| PSRR | Power supply rejection ratio | $\Delta V_{CC} = \pm 1V$ | | Over temp | | 300 | 1000 | | | | µV/V |
| | | | | $T_A = 25°C$ | | | | | 200 | 1000 | |
| $A_{VOL}$ | Large signal voltage gain | $V_O = +2.3V, -1.7V$ $R_L = 150\Omega$ to GND, $470\Omega$ to $-V_{CC}$ | | | | | | 47 | 52 | 57 | dB |
| $A_{VOL}$ | Large signal voltage gain | $V_O = +2.3V, -1.7V$ $R_L = 2\Omega$ to GND | | | | | | | | | dB |
| | | | | $T_A = 25°C$ | | | | 47 | 52 | 57 | |
| $A_{VOL}$ | Large signal voltage gain | $V_O = +2.5V, -2.0V$ $R_L = 2k\Omega$ to GND | | Over temp | 46 | | 60 | | | | dB |
| | | | | $T_A = 25°C$ | 48 | 53 | 58 | | | | |

**DC ELECTRICAL CHARACTERISTICS** $V_{CC} = \pm 6V$, $T_A = 25°C$, unless otherwise specified.

| SYMBOL | PARAMETER | TEST CONDITIONS | | | SE5539 | | | UNIT |
|---|---|---|---|---|---|---|---|---|
| | | | | | Min | Typ | Max | |
| $V_{OS}$ | Input offset voltage | | | Over temp | | 2 | 5 | mV |
| | | | | $T_A = 25°C$ | | 2 | 3 | |
| $I_{OS}$ | Input offset current | | | Over temp | | 0.1 | 3 | µA |
| | | | | $T_A = 25°C$ | | 0.1 | 1 | |
| $I_B$ | Input bias current | | | Over temp | | 5 | 20 | µA |
| | | | | $T_A = 25°C$ | | 4 | 10 | |
| CMRR | Common-mode rejection ratio | $V_{CM} = \pm 1.3V$, $R_S = 100\Omega$ | | | 70 | 85 | | dB |
| $I_{CC}+$ | Positive supply current | | | Over temp | | 11 | 14 | mA |
| | | | | $T_A = 25°C$ | | 11 | 13 | |
| $I_{CC}-$ | Negative supply current | | | Over temp | | 8 | 11 | mA |
| | | | | $T_A = 25°C$ | | 8 | 10 | |
| PSRR | Power supply rejection ratio | $\Delta V_{CC} = \pm 1V$ | | Over temp | | 300 | 1000 | µV/V |
| | | | | $T_A = 25°C$ | | | | |
| $V_{OUT}$ | Output voltage swing | $R_L = 150\Omega$ to GND and $390\Omega$ to $-V_{CC}$ | Over temp | +Swing | +1.4 | +2.0 | | V |
| | | | | -Swing | -1.1 | -1.7 | | |
| | | | $T_A = 25°C$ | +Swing | +1.5 | +2.0 | | |
| | | | | -Swing | -1.4 | -1.8 | | |

## AC ELECTRICAL CHARACTERISTICS $V_{CC} = \pm 8V$, $R_L = 150\Omega$ to GND & $470\Omega$ to $-V_{CC}$, unless otherwise specified.

| SYMBOL | PARAMETER | TEST CONDITIONS | SE5539 | | | NE5539 | | | UNIT |
|---|---|---|---|---|---|---|---|---|---|
| | | | Min | Typ | Max | Min | Typ | Max | |
| BW | Gain bandwidth product | $A_{CL} = 7$, $V_O = 0.1\ V_{P-P}$ | | 1200 | | | 1200 | | MHz |
| | Small-signal bandwidth | $A_{CL} = 2$, $R_L = 150\Omega$[1] | | 110 | | | 110 | | MHz |
| $t_S$ | Settling time | $A_{CL} = 2$, $R_L = 150\Omega$[1] | | 15 | | | 15 | | ns |
| SR | Slew rate | $A_{CL} = 2$, $R_L = 150\Omega$[1] | | 600 | | | 600 | | V/μs |
| $t_{PD}$ | Propagation delay | $A_{CL} = 2$, $R_L = 150\Omega$[1] | | 7 | | | 7 | | ns |
| | Full power response | $A_{CL} = 2$, $R_L = 150\Omega$[1] | | 48 | | | 48 | | MHz |
| | Full power response | $A_V = 7$, $R_L = 150\Omega$[1] | | 20 | | | 20 | | MHz |
| | Input noise voltage | $R_S = 50\Omega$, 1MHz | | 4 | | | 4 | | $nV/\sqrt{Hz}$ |
| | Input noise current | 1MHz | | 6 | | | 6 | | $pA/\sqrt{Hz}$ |

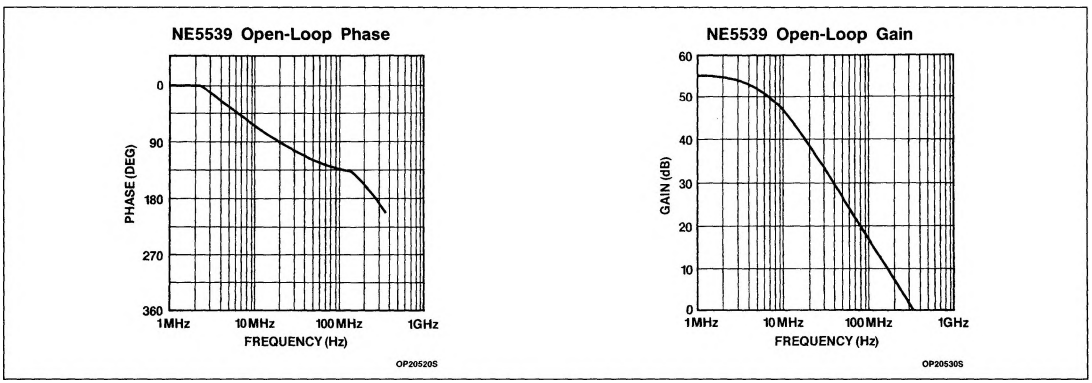
**NOTE:**
1. External compensation.

## AC ELECTRICAL CHARACTERISTICS $V_{CC} = \pm 6V$, $R_L = 150\Omega$ to GND and $390\Omega$ to $-V_{CC}$, unless otherwise specified.

| SYMBOL | PARAMETER | TEST CONDITIONS | SE5539 | | | UNIT |
|---|---|---|---|---|---|---|
| | | | Min | Typ | Max | |
| BW | Gain bandwidth product | $A_{CL} = 7$ | | 700 | | MHz |
| | Small-signal bandwidth | $A_{CL} = 2$[1] | | 120 | | MHz |
| $t_S$ | Settling time | $A_{CL} = 2$[1] | | 23 | | ns |
| SR | Slew rate | $A_{CL} = 2$[1] | | 330 | | V/μs |
| $t_{PD}$ | Propagation delay | $A_{CL} = 2$[1] | | 4.5 | | ns |
| | Full power response | $A_{CL} = 2$[1] | | 20 | | MHz |

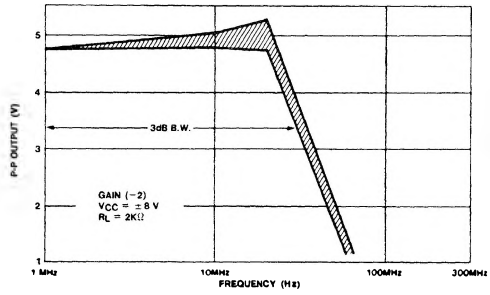
**NOTE:**
1. External compensation.

## TYPICAL PERFORMANCE CURVES



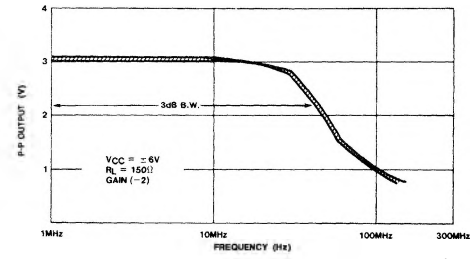
## TYPICAL PERFORMANCE CURVES (Continued)

**Power Bandwidth (SE)**



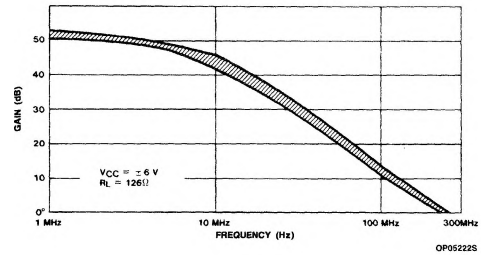

OP05202S

**Power Bandwidth (NE)**



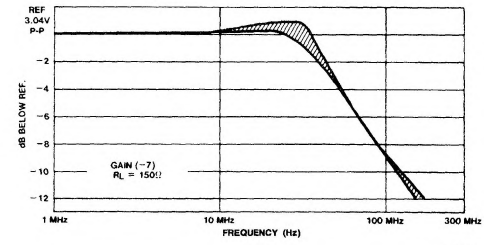

OP05212S

**SE5539 Open-Loop Gain vs Frequency**



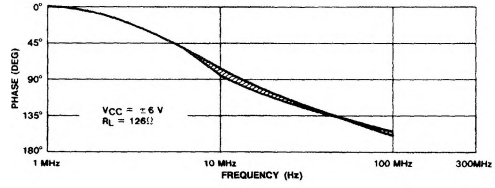

OP05222S

**Power Bandwidth**

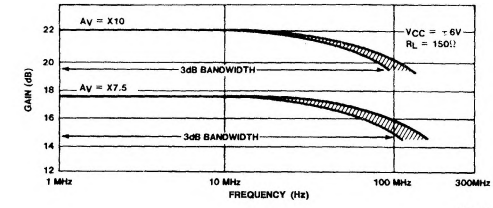



OP05231S

**SE5539 Open-Loop Phase vs Frequency**




**Gain Bandwidth Product vs Frequency**




OP05251S

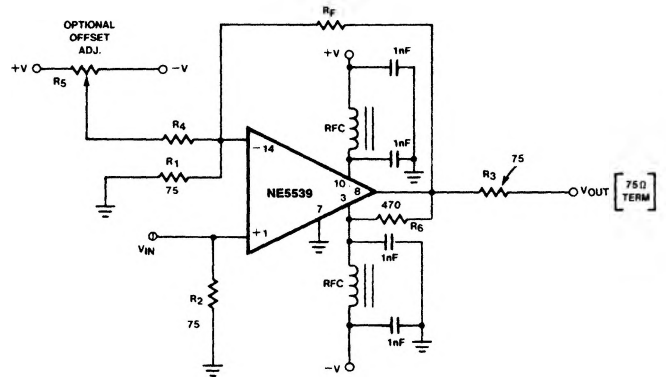
**NOTE**

Indicates typical distribution $-55°C \leq T_A \leq 125°C$

OP05241S

## CIRCUIT LAYOUT CONSIDERATIONS

As may be expected for an ultra-high frequency, wide-gain bandwidth amplifier, the physical circuit layout is extremely critical. Breadboarding is not recommended. A double-sided copper-clad printed cirucit board will result in more favorable system operation. An example utilizing a 28dB non-inverting amp is shown in Figure 1.

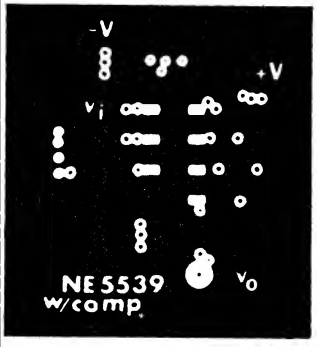



**NOTES:**
$R_1$ = 75Ω 5% CARBON
$R_2$ = 75Ω 5% CARBON
$R_3$ = 75Ω 5% CARBON
$R_4$ = 36k 5% CARBON

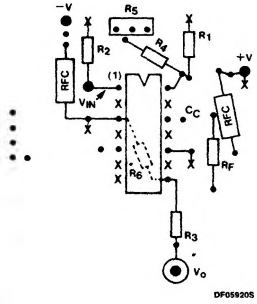
$R_5$ = 20k TRIMPOT (CERMET)
$R_F$ = 1.5k (28dB GAIN)
$R_6$ = 470Ω 5% CARBON

RFC 3T # 26 BUSS WIRE ON FERROXCUBE VK 200 09/3B CORE
BYPASS CAPACITORS
1nF CERAMIC
(MEPCO OR EQUIV.)

**Top Plane Copper[1] (Component Side)**

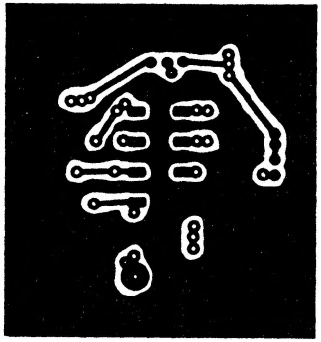



**Component Side (Component Layout)**




**NOTES:**
(X) indicates ground connection to top plane.
*$R_6$ is on bottom side.

**Bottom Plane Copper[1]**




**NOTE:**
1. Bond edges of top and bottom ground plane copper.

**Figure 1. 28dB Non-Inverting Amp Sample PC Layout**

## NE5539 COLOR VIDEO AMPLIFIER

The NE5539 wideband operational amplifier is easily adapted for use as a color video amplifier. A typical circuit is shown in Figure 2 along with vector-scope[1] photographs showing the amplifier differential gain and phase response to a standard five-step modulated staircase linearity signal (Figures 3, 4 and 5). As can be seen in Figure 4, the gain varies less than 0.5% from the bottom to the top of the staircase. The maximum differential phase shown in Figure 5 is approximately +0.1°.

The amplifier circuit was optimized for a 75Ω input and output termination impedance with a gain of approximately 10 (20dB).

**NOTE:**

1. The input signal was 200mV and the output 2V. $V_{CC}$ was ±8V.

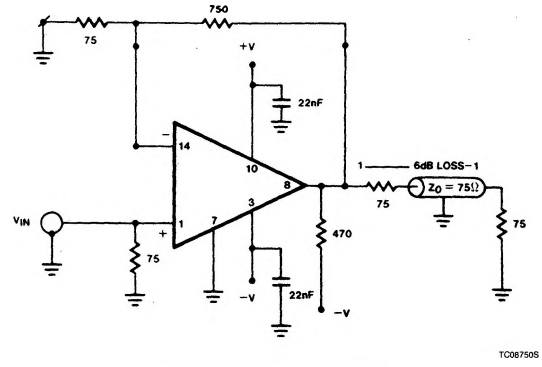



**Figure 2. NE5539 Video Amplifier**

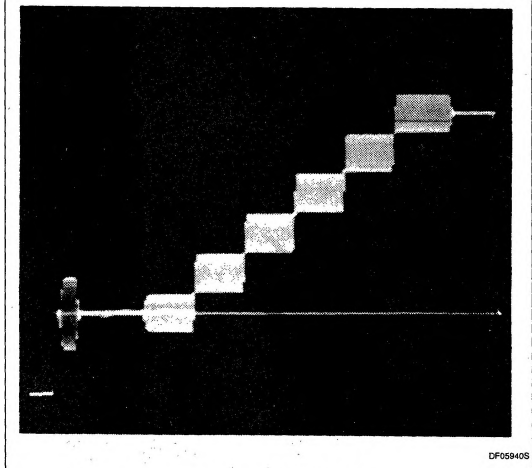



**Figure 3. Input Signal**

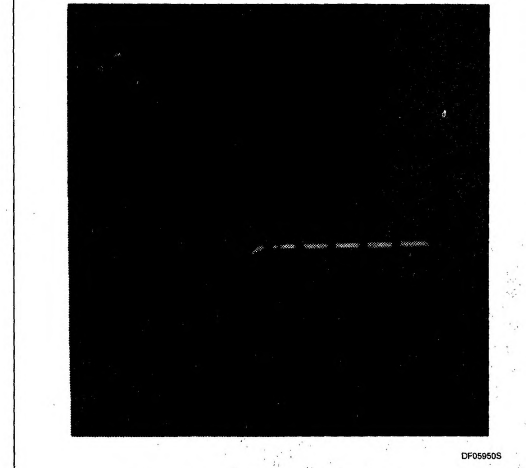



**Figure 4. Differential Gain < 0.5%**

**NOTE:**
Instruments used for these measurements were Tektronix 146 NTSC test signal generator, 520A NTSC vectorseope, and 1480 waveform monitor.

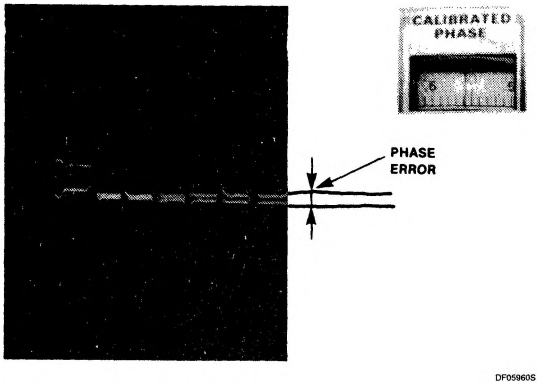



Figure 5. Differential Phase +0.1°

## APPLICATIONS

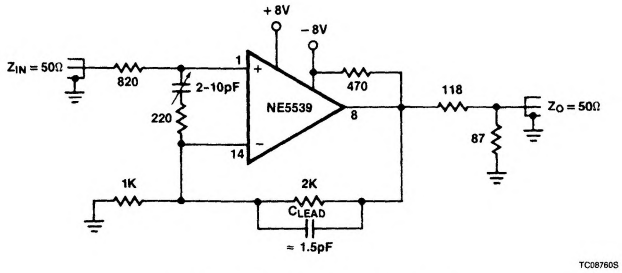



Figure 6. Non-Inverting Follower

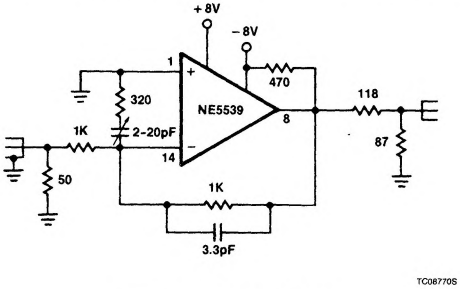



Figure 7. Inverting Follower