Signetics

# NE/SE538
## High Slew Rate Op Amp

***Product Specification***

**Linear Products**

### DESCRIPTION

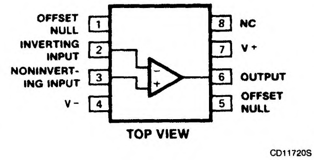
The NE/SE538 is a new generation operational amplifier featuring high slew rates combined with improved input characteristics. Internally-compensated for gains of 5 or larger, the SE538 offers guaranteed minimum slew rates of 40V/μs or larger. Industry standard pinout and internal compensation allow the user to upgrade system performance by directly replacing general purpose amplifiers, such as 748, 101A and 741.

### FEATURES

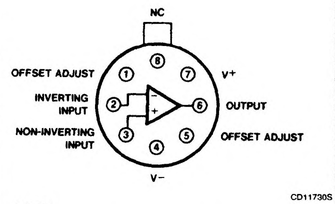
- **2mV typical input offset voltage**
- **80nA max input offset current**
- **Short-circuit protected**
- **Offset null capability**
- **Large common-mode and differential voltage ranges**
- **60V/μs typical slew rate (gain of +5, −4 min)**
- **6MHz typical gain bandwidth product (gain +5, −4 minimum)**
- **Internal frequency compensation (gain of +5, −4 minimum)**
- **Pinout: standard single op amp (748, 101A, 741, etc).**

### PIN CONFIGURATIONS

**D, FE, N Packages**

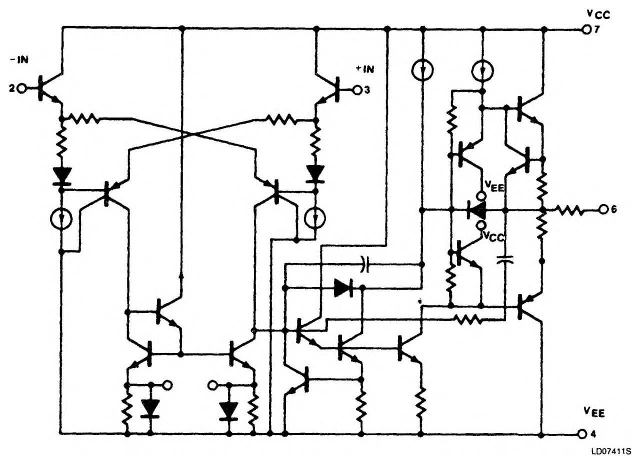



**H Package**[1]




NOTE:
1. Metal cans no longer available.

### EQUIVALENT SCHEMATIC (EACH AMPLIFIER)



# High Slew Rate Op Amp — NE/SE538

## ORDERING INFORMATION

| DESCRIPTION | TEMPERATURE RANGE | ORDER CODE |
|---|---|---|
| 8-Pin Plastic SO | 0 to +70°C | NE538D |
| 8-Pin Plastic DIP | 0 to +70°C | NE538N |
| 8-Pin Ceramic DIP | 0 to +70°C | NE538FE |
| 8-Pin Plastic DIP | -55°C to +125°C | SE538N |
| 8-Pin Ceramic DIP | -55°C to +125°C | SE538FE |

## ABSOLUTE MAXIMUM RATINGS

| SYMBOL | PARAMETER | RATING | UNIT |
|---|---|---|---|
| $V_{CC}$ | Supply voltage<br>SE military grade<br>NE commercial grade | <br>±22<br>±18 | <br>V<br>V |
| $P_D$ | Maximum power dissipation, $T_A$=25°C (still air)[1]<br>D package<br>F package<br>N package | <br>790<br>830<br>1200 | <br>mW<br>mW<br>mW |
| $V_{DIFF}$ | Differential input voltage | ±30 | V |
| $V_{IN}$ | Input voltage[2] | ±15 | V |
| $T_A$ | Operating ambient temperature range<br>SE military grade<br>NE commercial grade | <br>-55 to +125<br>0 to 70 | <br>°C<br>°C |
| | Output short-circuit[3] | indefinite | |
| $T_{STG}$ | Storage temperature range | -65 to +150 | °C |
| $T_{SOLD}$ | Lead soldering temperature (10sec max) | 300 | °C |

**NOTES:**

1. Derate above 25°C, at the following rates:
   D package at 6.3mW/°C
   F package at 6.7mW/°C
   N package at 9.6mW/°C
2. For supply voltages less than ±15V, the absolute maximum input voltage is equal to the supply voltage.
3. Short-circuit may be to ground or either supply. Rating applies to 125°C case temperature or 75°C ambient temperature.

# High Slew Rate Op Amp — NE/SE538

## DC ELECTRICAL CHARACTERISTICS $T_A = 25°C$, $V_S = \pm 15V$, unless otherwise specified.

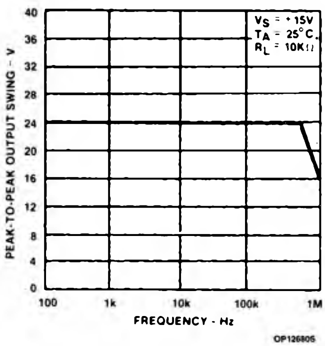
| SYMBOL | PARAMETER | TEST CONDITIONS | SE538 | | | NE538 | | | UNIT |
|---|---|---|---|---|---|---|---|---|---|
| | | | Min | Typ | Max | Min | Typ | Max | |
| $V_{OS}$ | Input offset voltage | $R_S \leq 10k\Omega$<br>$R_S \leq 10k\Omega$, over temp. | | 0.7 | 4.0<br>5.0 | | 2.0 | 6.0<br>7.0 | mV<br>mV |
| $\Delta V_{OS}$ | Input offset voltage drift | $R_S = 0\Omega$, over temp. | | 4.0 | | | 6.0 | | μV/°C |
| $I_{OS}$<br><br>$\Delta I_{OS}$ | Input offset current<br><br>Input offset current | <br>Over temp.<br>Over temp. | | 5<br><br>25 | 20<br>40 | | 15<br><br>40 | 40<br>80 | nA<br>nA<br>pA/°C |
| $I_B$<br><br>$\Delta I_B$ | Input current<br><br>Input current | <br>Over temp.<br>Over temp. | | 45<br><br>50 | 80<br>200 | | 65<br><br>80 | 150<br>200 | nA<br>nA<br>pA/°C |
| $V_{CM}$ | Input common-mode voltage range | | ±12 | ±13 | | ±12 | ±13 | | V |
| CMRR | Common-mode rejection ratio | $R_S \leq 10k\Omega$, over temp. | 70 | 90 | | 70 | 90 | | dB |
| PSRR | Power supply rejection ratio | $R_S \leq 10k\Omega$, over temp. | | 30 | 150 | | 30 | 150 | μV/V |
| $R_{IN}$ | Input resistance | | 3 | 10 | | 1 | 6 | | MΩ |
| $A_{VOL}$ | Large-signal voltage gain | $R_L \geq 2k\Omega$, , $V_{OUT} = \pm 10V$<br>Over temp.,<br>$R_L \geq 2k\Omega$, $V_{OUT} = \pm 10V$ | 50<br>25 | 200 | | 50<br>25 | 200 | | V/mV<br>V/mV |
| $V_{OUT}$ | Output voltage swing | Over temp., $R_L \geq 2k\Omega$<br>Over temp., $R_L \geq 10k\Omega$ | ±10<br>±12 | ±13<br>±14 | | ±10<br>±12 | ±13<br>±14 | | V<br>V |
| $I_{CC}$ | Supply current | <br>Over temp. | | 2<br>2.2 | 3<br>3.6 | | 2<br>2.2 | 3<br>3.6 | mA<br>mA |
| $P_D$ | Power dissipation | <br>Over temp. | | 60<br>66 | 90<br>108 | | 60<br>66 | 90<br>108 | mW<br>mW |
| $I_{SC}$ | Output short-circuit current | | 10 | 25 | 50 | 10 | 25 | 50 | mA |
| $R_{OUT}$ | Output resistance | | | 100 | | | 100 | | Ω |

## AC ELECTRICAL CHARACTERISTICS $T_A = 25°C$, unless otherwise specified.

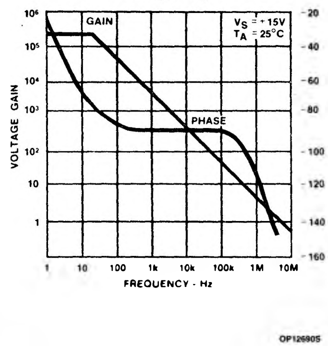
| SYMBOL | PARAMETER | TEST CONDITIONS | SE538 | | | NE538 | | | UNIT |
|---|---|---|---|---|---|---|---|---|---|
| | | | Min | Typ | Max | Min | Typ | Max | |
| GBW | Gain bandwidth product<br>(Gain +5, −4 minimum) | | | 6 | | | 6 | | MHz |
| $t_R$ | Transient response<br>Small-signal rise time<br>Small-signal overshoot | | | <br>0.25<br>6 | | | <br>0.25<br>6 | | <br>μs<br>% |
| $t_S$ | Settling time | To 0.1% | | 1.2 | | | 1.2 | | μs |
| SR | Slew rate | Minimum gain = 5<br>Noninverting $R_L \geq 2k\Omega$ | 40 | 60 | | | 60 | | V/μs |
| $V_{NOISE}$ | Input noise voltage | f = 1kHz, $T_A = 25°C$ | | 30 | | | 30 | | $nV/\sqrt{Hz}$ |

## TYPICAL PERFORMANCE CHARACTERISTICS

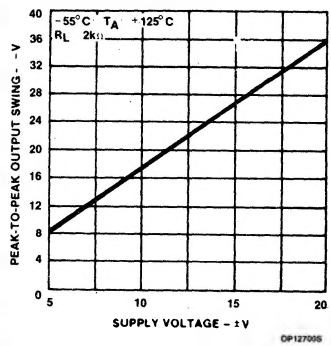
**Output Voltage Swing as a Function of Frequency**



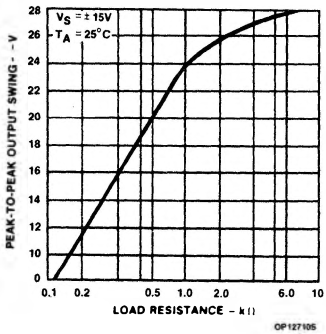

**Open Loop Voltage Gain as a Function of Frequency**



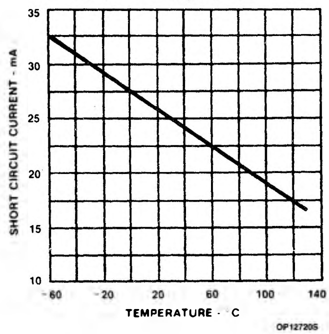

**Output Voltage Swing as a Function of Supply Voltage**



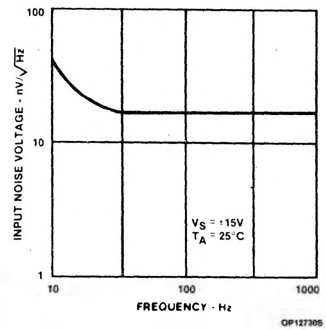

**Output Voltage Swing as a Function of Load Resistance**



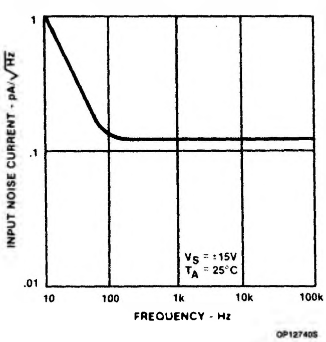

**Output Short-Circuit Current as a Function of Ambient Temperature**



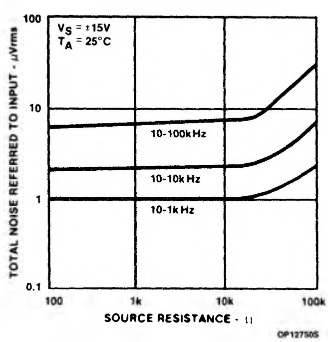

**Input Noise Voltage as a Function of Frequency**



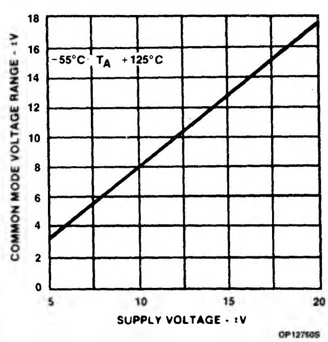

**Input Noise Current as a Function of Frequency**




**Broadband Noise for Various Bandwidths**

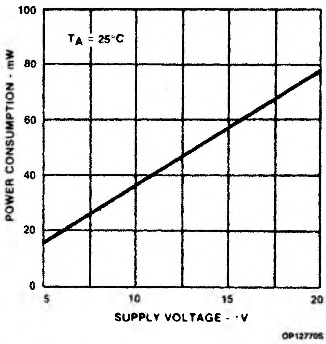



**Input Common-Mode Voltage Range as a Function of Supply Voltage**

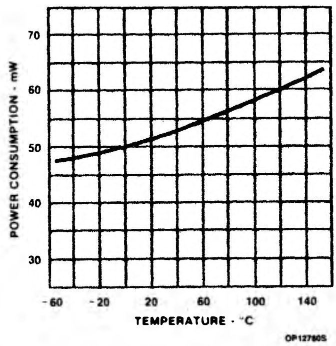


## TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

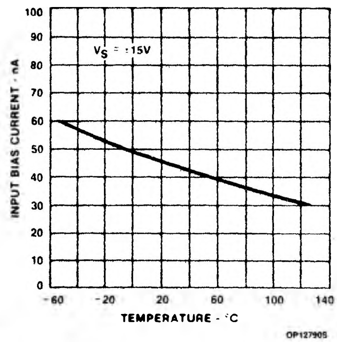
**Power Consumption as a Function of Supply Voltage**



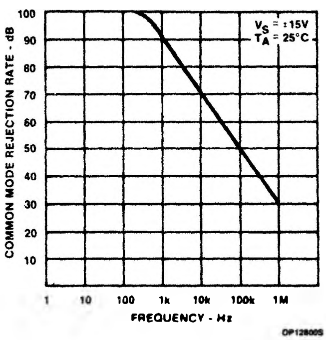

**Power Consumption as a Function of Ambient Temperature**



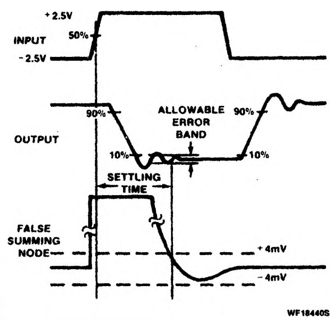

**Input Bias Current as a Function of Ambient Temperature**



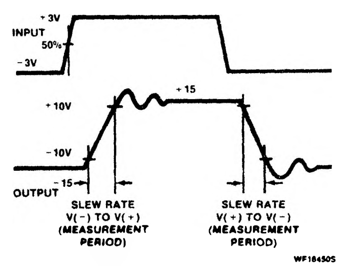

**Common-Mode Rejection Ratio as a Function of Frequency**



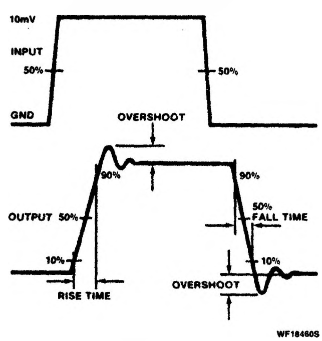

**Settling Time Measurement Waveforms**



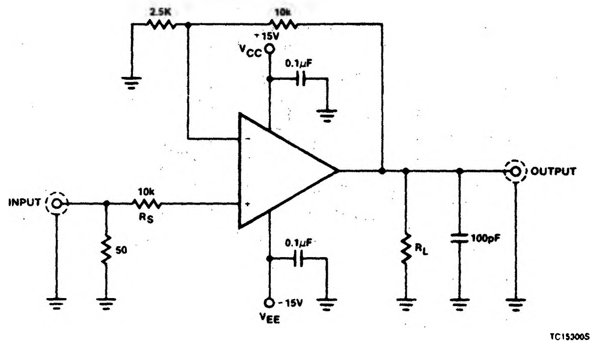

**Slew Rate Measurement $V_{CC}$ = ± 20V**




**Small-Signal Transient Response Definitions**

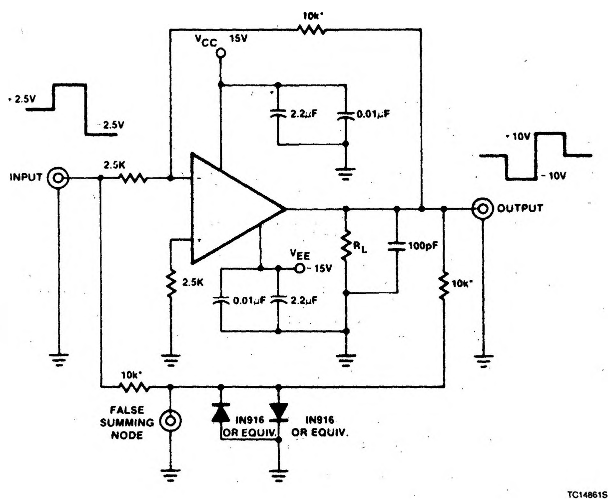


## TEST LOAD CIRCUITS




**NOTES:**
Pins not shown are not connected.
All resistor values are typical and in ohms.

**Slew Rate and Small-Signal Transient Response Test Circuit**




**NOTES:**
*Match to within 0.01%.
Pins not shown are not connected.
All resistor values are typical and in ohms.

**Settling Time Test Circuit**

# High Slew Rate Op Amp NE/SE538

## APPLICATIONS

The internal frequency compensation is designed for a minimum inverting gain of 4 and a minimum non-inverting gain of 5. Below these gains the NE538 will be unstable and will need external compensation (see Figures 1 and 2).

The higher slew rate of the NE538 has made this device quite appealing for high-speed designs, and the fact that it has a standard pinout will allow it to be used to upgrade existing systems that now use the μA741 or μ748.

Equations:

$$f_{LAG} = \frac{1\ (6MHz)}{10} = \frac{1}{2\pi R_L C_L}$$

$$f_{LEAD} = 6MHz = \frac{1}{2\pi R_F C_F}$$

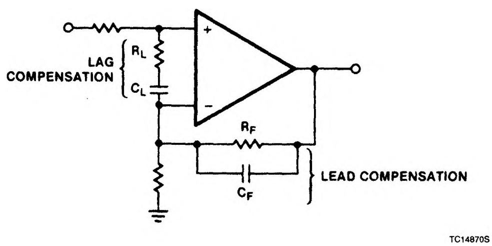



Figure 1. Non-Inverting Configuration

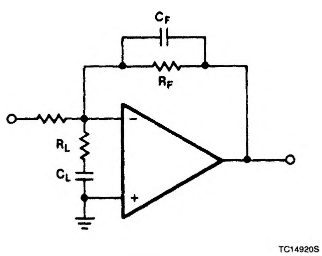



Figure 2. Inverting Configuration

## VOLTAGE COMPARATOR

Inexpensive voltage comparators with only modest parameters are often needed. The op amp is often used in the configuration because the high gain provides good selectivity. Figure 6 shows a circuit usable with most any op amp. The zener is selected for the output voltage required (5.1 volt for TTL), and the resistor provides some current protection to the op amp output structure. $V_{REF}$ can be any voltage within the wide common-mode range of the amplifier — another advantage of using op amps for comparators.

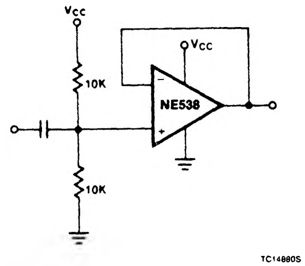



Figure 3. Voltage-Follower With Single Power Source

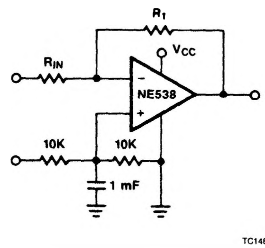



Figure 4. Inverting Amp With Single Power Supply

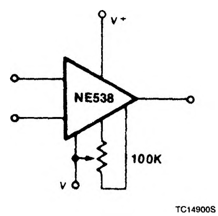
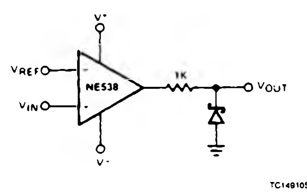



Figure 5. Offset Adjust Circuit




NOTE:
All resistor values are in ohms.

Figure 6. Voltage Comparator