

# Low power dual operational amplifiers

## NE/SA/SE532/ LM158/258/358/A/2904

### DESCRIPTION

The 532/358/LM2904 consists of two independent, high gain, internally frequency-compensated operational amplifiers internally frequency-compensated operational amplifiers designed specifically to operate from a single power supply over a wide range of voltages. Operation from dual power supplies is also possible, and the low power supply current drain is independent of the magnitude of the power supply voltage.

### UNIQUE FEATURES

In the linear mode the input common-mode voltage range includes ground and the output voltage can also swing to includes ground and the output voltage can also swing to ground, even though operated from only a single power supply voltage. The unity gain cross frequency is temperature-compensated. The input bias current is also temperature-compensated.

### FEATURES

- Internally frequency-compensated for unity gain
- Large DC voltage gain—100dB
- Wide bandwidth (unity gain)—1MHz (temperature-compensated)

### PIN CONFIGURATIONS

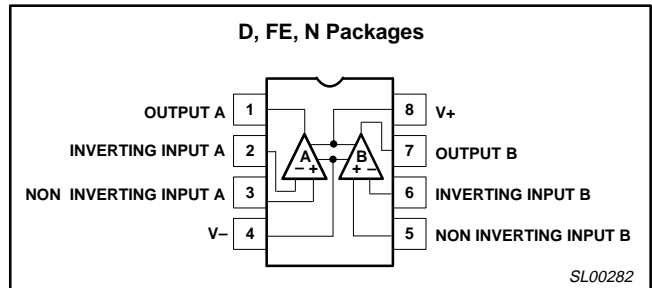


Figure 1. Pin Configuration

- Wide power supply range single supply— $3V_{DC}$  to  $30V_{DC}$  or dual supplies— $\pm 1.5V_{DC}$  to  $\pm 15V_{DC}$
- Very low supply current drain ( $400\mu A$ )—essentially independent of supply voltage ( $1mW/op\ amp\ at\ +5V_{DC}$ )
- Low input biasing current— $45nA_{DC}$  temperature-compensated
- Low input offset voltage— $2mV_{DC}$  and offset current— $5nA_{DC}$
- Differential input voltage range equal to the power supply voltage
- Large output voltage— $0V_{DC}$  to  $V+ 1.5V_{DC}$  swing

### EQUIVALENT CIRCUIT

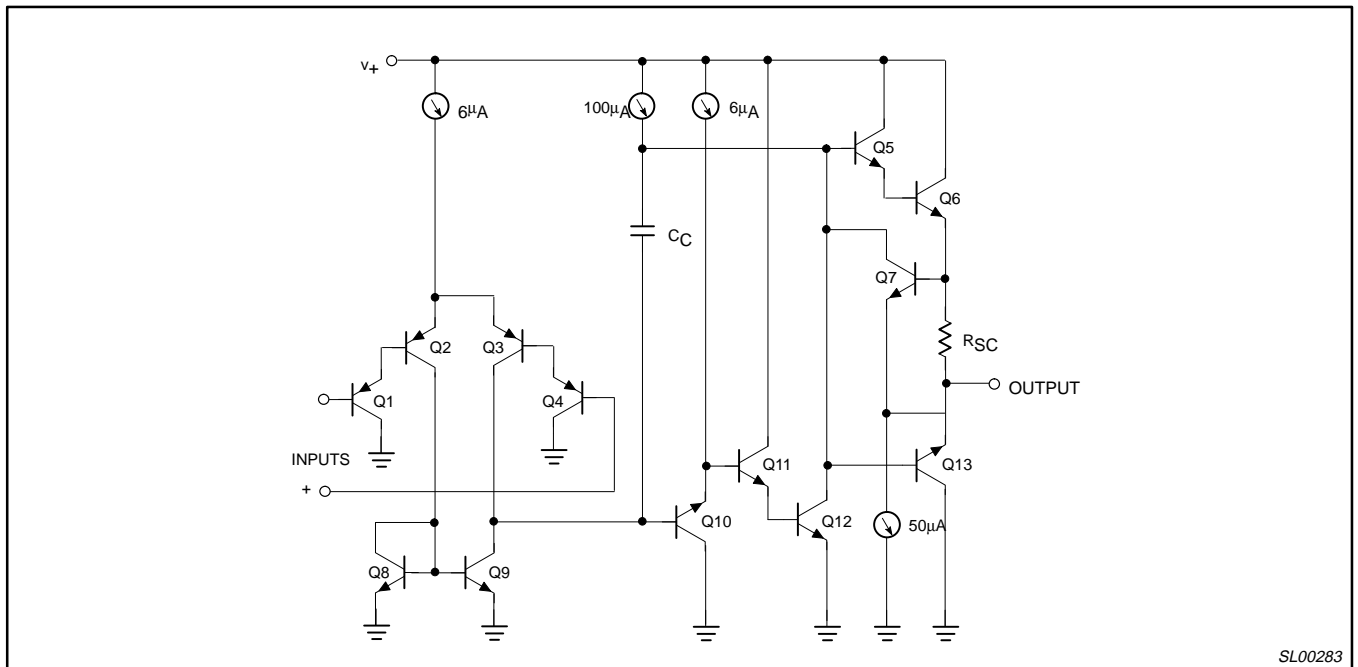


Figure 2. Equivalent Circuit

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## ORDERING INFORMATION

| DESCRIPTION                                 | TEMPERATURE RANGE | ORDER CODE | DWG #   |
|---|-------------------|------------|---------|
| 8-Pin Plastic Small Outline (SO) Package    | 0 to +70°C        | NE532D     | SOT96-1 |
| 8-Pin Plastic Dual In-Line Package (DIP)    | 0 to +70°C        | NE532N     | SOT97-1 |
| 8-Pin Plastic Small Outline (SO) Package    | -40°C to +85°C    | SA532D     | SOT96-1 |
| 8-Pin Plastic Dual In-Line Package (DIP)    | -40°C to +85°C    | SA532N     | SOT97-1 |
| 8-Pin Ceramic Dual In-Line Package (CERDIP) | -40°C to +85°C    | SA532FE    | 0580A   |
| 8-Pin Plastic Small Outline (SO) Package    | -40°C to +125°C   | LM2904D    | SOT96-1 |
| 8-Pin Plastic Dual In-Line Package (DIP)    | -40°C to +125°C   | LM2904N    | SOT97-1 |
| 8-Pin Ceramic Dual In-Line Package (CERDIP) | -55°C to +125°C   | LM158FE    | 0580A   |
| 8-Pin Plastic Dual In-Line Package (DIP)    | -25°C to +125°C   | LM258N     | SOT97-1 |
| 8-Pin Plastic Small Outline (SO) Package    | -25°C to +125°C   | LM258D     | SOT96-1 |
| 8-Pin Plastic Small Outline (SO) Package    | 0 to +70°C        | LM358D     | SOT96-1 |
| 8-Pin Plastic Dual In-Line Package (DIP)    | 0 to +70°C        | LM358N     | SOT97-1 |
| 8-Pin Plastic Dual In-Line Package (DIP)    | 0 to +70°C        | LM358AN    | SOT97-1 |
| 8-Pin Plastic Small Outline (SO) Package    | 0 to +70°C        | LM358AD    | SOT96-1 |
| 8-Pin Plastic Dual In-Line Package (DIP)    | -55°C to +125°C   | SE532N     | SOT97-1 |
| 8-Pin Ceramic Dual In-Line Package (CERDIP) | -55°C to +125°C   | SE532FE    | 0580A   |

## ABSOLUTE MAXIMUM RATINGS

| SYMBOL            | PARAMETER   | RATING      | UNIT            |
|-------------------|---|-------------|-----------------|
| V <sub>S</sub>    | Supply voltage, V <sub>+</sub>  | 32 or ±16   | V <sub>DC</sub> |
|                   | Differential input voltage  | 32          | V <sub>DC</sub> |
| V <sub>IN</sub>   | Input voltage   | -0.3 to +32 | V <sub>DC</sub> |
| P <sub>D</sub>    | Maximum power dissipation<br>T <sub>A</sub> =25°C (Still air) <sup>1</sup>                              |             |                 |
|                   | FE package  | 780         | mW              |
|                   | N package   | 1160        | mW              |
|                   | D package   | 780         | mW              |
|                   | Output short-circuit to GND <sup>5</sup><br>V <sub>+</sub> <15 V <sub>DC</sub> and T <sub>A</sub> =25°C | Continuous  |                 |
| T <sub>A</sub>    | Operating ambient temperature range   |             |                 |
|                   | NE532/LM358/LM358A  | 0 to +70    | °C              |
|                   | LM258   | -25 to +85  | °C              |
|                   | LM2904  | -40 to +125 | °C              |
|                   | SA532   | -40 to +85  | °C              |
|                   | SE532/LM158   | -55 to +125 | °C              |
| T <sub>STG</sub>  | Storage temperature range   | -65 to +150 | °C              |
| T <sub>SOLD</sub> | Lead soldering temperature (10sec max)  | 300         | °C              |

## NOTES:

- Derate above 25°C, at the following rates:  
FE package at 6.2mW/°C  
N package at 9.3mW/°C  
D package at 6.2mW/°C

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## DC ELECTRICAL CHARACTERISTICS

T<sub>A</sub> = 25°C, V<sub>+</sub> = +5V, unless otherwise specified.

| SYMBOL             | PARAMETER                                    | TEST CONDITIONS  | SE532, LM158/258          |                           |  | NE/SA532/<br>LM358/LM2904 |                           |  | UNIT                       |
|--------------------|--|--|---------------------------|---------------------------|--|---------------------------|---------------------------|--|----------------------------|
|                    |  |  | Min                       | Typ                       | Max  | Min                       | Typ                       | Max  |                            |
| V <sub>OS</sub>    | Offset voltage <sup>1</sup>                  | R <sub>S</sub> =0Ω<br>R <sub>S</sub> =0Ω, over temp.   |                           | ±2                        | ±5<br>±7                                   |                           | ±2                        | ±7<br>±9                                   | mV<br>mV                   |
| V <sub>OS</sub>    | Drift  | R <sub>S</sub> =0Ω, over temp.   |                           | 7                         |  |                           | 7                         |  | μV/°C                      |
| I <sub>OS</sub>    | Offset current                               | I <sub>IN</sub> (+)-I <sub>IN</sub> (-)<br>Over temp.  |                           | ±3                        | ±30<br>±100                                |                           | ±5                        | ±50<br>±150                                | nA<br>nA                   |
| I <sub>OS</sub>    | Drift  | Over temp.   |                           | 10                        |  |                           | 10                        |  | pA/°C                      |
| I <sub>BIAS</sub>  | Input current <sup>2</sup>                   | I <sub>IN</sub> (+) or I <sub>IN</sub> (-)<br>Over temp., I <sub>IN</sub> (+) or I <sub>IN</sub> (-)   |                           | 45<br>40                  | 150<br>300                                 |                           | 45<br>40                  | 250<br>500                                 | nA<br>nA                   |
| I <sub>B</sub>     | Drift  | Over temp.   |                           | 50                        |  |                           | 50                        |  | pA/°C                      |
| V <sub>CM</sub>    | Common-mode voltage range <sup>3</sup>       | V <sub>+</sub> =30V<br>Over temp., V <sub>+</sub> =30V   | 0<br>0                    |                           | V <sub>+</sub> -1.5<br>V <sub>+</sub> -2.0 | 0<br>0                    |                           | V <sub>+</sub> -1.5<br>V <sub>+</sub> -2.0 | V<br>V                     |
| CMRR               | Common-mode rejection ratio                  | V <sub>+</sub> =30V  | 70                        | 85                        |  | 65                        | 70                        |  | dB                         |
| V <sub>OH</sub>    | Output voltage swing                         | R <sub>L</sub> ≥2kΩ, V <sub>+</sub> =30V,<br>over temp.<br>R <sub>L</sub> ≥10kΩ, V <sub>+</sub> =30V,<br>over temp.  | 26<br>27                  | 28                        |  | 26<br>27                  | 28                        |  | V<br>V                     |
| V <sub>OL</sub>    | Output voltage swing                         | R <sub>L</sub> ≥10kΩ, over temp.   |                           | 5                         | 20   |                           | 5                         | 20   | mV                         |
| I <sub>CC</sub>    | Supply current                               | R <sub>L</sub> =∞, V <sub>+</sub> =30V<br>R <sub>L</sub> =∞ on all amplifiers,<br>over temp., V <sub>+</sub> =30V  |                           | 0.5<br>0.6                | 1.0<br>1.2                                 |                           | 0.5<br>0.6                | 1.0<br>1.2                                 | mA<br>mA                   |
| A <sub>VOL</sub>   | Large-signal voltage gain                    | R <sub>L</sub> ≥2kΩ, V <sub>OUT</sub> ±10V,<br>V <sub>+</sub> =15V<br>(for large V <sub>O</sub> swing)<br>over temp.   | 50<br>25                  | 100                       |  | 25<br>15                  | 100                       |  | V/mV<br>V/mV               |
| PSRR               | Supply voltage rejection ratio               | R <sub>S</sub> =0Ω   | 65                        | 100                       |  | 65                        | 100                       |  | dB                         |
|                    | Amplifier-to-amplifier coupling <sup>4</sup> | f=1kHz to 20kHz<br>(input referred)  |                           | -120                      |  |                           | -120                      |  | dB                         |
| I <sub>OUT</sub>   | Output current                               | V <sub>IN+</sub> =+1V <sub>DC</sub> , V <sub>IN-</sub> =0V <sub>DC</sub> ,<br>V <sub>+</sub> =15V <sub>DC</sub><br>V <sub>IN+</sub> =+1V <sub>DC</sub> , V <sub>IN-</sub> =0V <sub>DC</sub> ,<br>V <sub>+</sub> =15V <sub>DC</sub> , over temp.<br>V <sub>IN-</sub> =+1V <sub>DC</sub> , V <sub>IN+</sub> =0V <sub>DC</sub> ,<br>V <sub>+</sub> =15V <sub>DC</sub><br>V <sub>IN-</sub> =+1V <sub>DC</sub> , V <sub>IN+</sub> =0V <sub>DC</sub> ,<br>V <sub>+</sub> =15V <sub>DC</sub> , over temp.<br>V <sub>IN+</sub> =0V, V <sub>IN-</sub> =+1V <sub>DC</sub> ,<br>V <sub>O</sub> =200mV | 20<br>10<br>10<br>5<br>12 | 40<br>20<br>20<br>8<br>50 |  | 20<br>10<br>10<br>5<br>12 | 40<br>20<br>20<br>8<br>50 |  | mA<br>mA<br>mA<br>mA<br>μA |
| I <sub>SC</sub>    | Short circuit current <sup>5</sup>           |  |                           | 40                        | 60   |                           | 40                        | 60   | mA                         |
|                    | Differential input voltage <sup>6</sup>      |  |                           |                           | V <sub>+</sub>                             |                           |                           | V <sub>+</sub>                             | V                          |
| GBW                | Unity gain bandwidth                         | T <sub>A</sub> =25°C   |                           | 1                         |  |                           | 1                         |  | MHz                        |
| SR                 | Slew rate                                    | T <sub>A</sub> =25°C   |                           | 0.3                       |  |                           | 0.3                       |  | V/μs                       |
| V <sub>NOISE</sub> | Input noise voltage                          | T <sub>A</sub> =25°C, f=1kHz   |                           | 40                        |  |                           | 40                        |  | nV/√Hz                     |

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| SYMBOL      | PARAMETER                                    | TEST CONDITIONS  | LM358A        |               |                        | UNIT                         |
|-------------|--|--|---------------|---------------|------------------------|------------------------------|
|             |  |  | Min           | Typ           | Max                    |                              |
| $V_{OS}$    | Offset voltage <sup>1</sup>                  | $R_S=0\Omega$<br>$R_S=0\Omega$ , over temp.  |               | $\pm 2$       | $\pm 3$<br>$\pm 5$     | mV<br>mV                     |
| $V_{OS}$    | Drift  | $R_S=0\Omega$ , over temp.   |               | 7             | 20                     | $\mu\text{V}/^\circ\text{C}$ |
| $I_{OS}$    | Offset current                               | $I_{IN (+)}-I_{IN (-)}$<br>Over temp.  |               | 5             | $\pm 30$<br>$\pm 75$   | nA<br>nA                     |
| $I_{OS}$    | Drift  | Over temp.   |               | 10            | 300                    | $\text{pA}/^\circ\text{C}$   |
| $I_{BIAS}$  | Input current <sup>2</sup>                   | $I_{IN (+)}$ or $I_{IN (-)}$<br>Over temp., $I_{IN (+)}$ or $I_{IN (-)}$   |               | 45<br>40      | 100<br>200             | nA<br>nA                     |
| $I_B$       | Drift  | Over temp.   |               | 50            |                        | $\text{pA}/^\circ\text{C}$   |
| $V_{CM}$    | Common-mode voltage range <sup>3</sup>       | $V_+=30\text{V}$<br>Over temp., $V_+=30\text{V}$   | 0<br>0        |               | $V_+-1.5$<br>$V_+-2.0$ | V<br>V                       |
| CMRR        | Common-mode rejection ratio                  | $V_+=30\text{V}$   | 65            | 85            |                        | dB                           |
| $V_{OH}$    | Output voltage swing                         | $R_L \geq 2\text{k}\Omega$ , $V_+=30\text{V}$ ,<br>over temp.<br>$R_L \geq 10\text{k}\Omega$ , $V_+=30\text{V}$ ,<br>over temp.  | 26<br>27      | 28            |                        | V<br>V                       |
| $V_{OL}$    | Output voltage swing                         | $R_L \geq 10\text{k}\Omega$ , over temp.   |               | 5             | 20                     | mV                           |
| $I_{CC}$    | Supply current                               | $R_L = \infty$ , $V_+=30\text{V}$<br>$R_L = \infty$ on all amplifiers,<br>over temp., $V_+=30\text{V}$   |               | 0.5<br>0.6    | 1.0<br>1.2             | mA<br>mA                     |
| $A_{VOL}$   | Large-signal voltage gain                    | $R_L \geq 2\text{k}\Omega$ , $V_{OUT} \pm 10\text{V}$ ,<br>$V_+=15\text{V}$<br>(for large $V_O$ swing)<br>over temp.   | 25<br>15      | 100           |                        | V/mV<br>V/mV                 |
| PSRR        | Supply voltage rejection ratio               | $R_S=0\Omega$  | 65            | 100           |                        | dB                           |
|             | Amplifier-to-amplifier coupling <sup>4</sup> | $f=1\text{kHz}$ to $20\text{kHz}$ (input referred)   |               | -120          |                        | dB                           |
| $I_{OUT}$   | Output current<br>Source                     | $V_{IN+}=+1V_{DC}$ , $V_{IN-}=0V_{DC}$ ,<br>$V_+=15V_{DC}$<br>$V_{IN+}=+1V_{DC}$ , $V_{IN-}=0V_{DC}$ ,<br>$V_+=15V_{DC}$ , over temp.  | 20<br>10      | 40<br>20      |                        | mA<br>mA                     |
|             | Sink   | $V_{IN-}=+1V_{DC}$ , $V_{IN+}=0V_{DC}$ ,<br>$V_+=15V_{DC}$<br>$V_{IN-}=+1V_{DC}$ , $V_{IN+}=0V_{DC}$ ,<br>$V_+=15V_{DC}$ , over temp.<br>$V_{IN+}=0V$ , $V_{IN-}=+1V_{DC}$ ,<br>$V_O=200\text{mV}$ | 10<br>5<br>12 | 20<br>8<br>50 |                        | mA<br>mA<br>$\mu\text{A}$    |
| $I_{SC}$    | Short circuit current <sup>5</sup>           |  |               | 40            | 60                     | mA                           |
|             | Differential input voltage <sup>6</sup>      |  |               |               | $V_+$                  | V                            |
| GBW         | Unity gain bandwidth                         | $T_A=25^\circ\text{C}$   |               | 1             |                        | MHz                          |
| SR          | Slew rate                                    | $T_A=25^\circ\text{C}$   |               | 0.3           |                        | $\text{V}/\mu\text{s}$       |
| $V_{NOISE}$ | Input noise voltage                          | $T_A=25^\circ\text{C}$ , $f=1\text{kHz}$   |               | 40            |                        | $\text{nV}/\text{Hz}$        |

**NOTES:**

- $V_O \approx 1.4\text{V}$ ,  $R_S=0\Omega$  with  $V_+$  from  $5\text{V}$  to  $30\text{V}$ ; and over the full input common-mode range ( $0\text{V}$  to  $V_+ - 1.5\text{V}$ ).
- The direction of the input current is out of the IC due to the PNP input stage. This current is essentially constant, independent of the state of the output so no loading change exists on the input lines.
- The input common-mode voltage or either input signal voltage should not be allowed to go negative by more than  $0.3\text{V}$ . The upper end of the common-mode voltage range is  $V_+ - 1.5\text{V}$ , but either or both inputs can go to  $+32\text{V}$  without damage.
- Due to proximity of external components, insure that coupling is not originating via stray capacitance between these external parts. This typically can be detected as this type of capacitance coupling increases at higher frequencies.
- Short-circuits from the output to  $V_+$  can cause excessive heating and eventual destruction. The maximum output current is approximately  $40\text{mA}$  independent of the magnitude of  $V_+$ . At values of supply voltage in excess of  $+15V_{DC}$ , continuous short-circuits can exceed the power dissipation ratings and cause eventual destruction.
- The input common-mode voltage or either input signal voltage should not be allowed to go negative by more than  $0.3\text{V}$ . The upper end of the common-mode voltage range is  $V_+ - 1.5\text{V}$ , but either or both inputs can go to  $+32V_{DC}$  without damage.

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TYPICAL PERFORMANCE CHARACTERISTICS

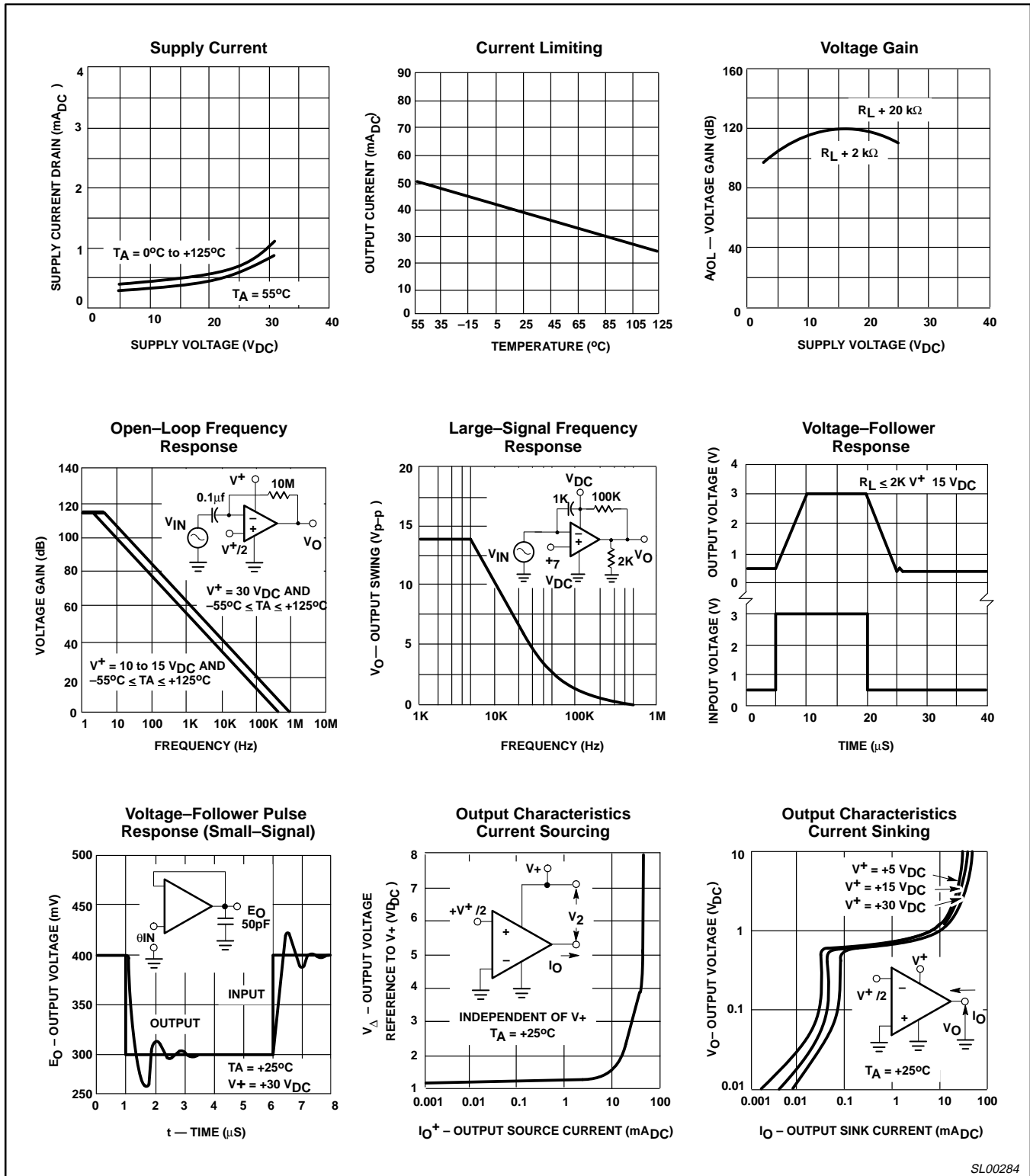


Figure 3. Typical Performance Characteristics

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## TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

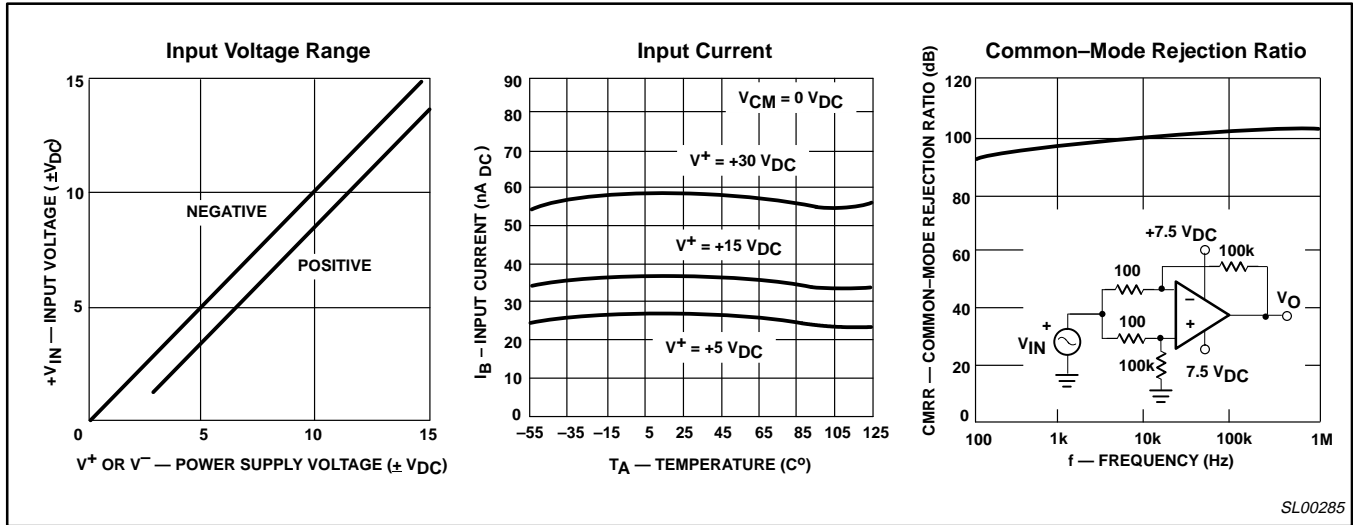


Figure 4. Typical Performance Characteristics (cont.)

## TYPICAL APPLICATIONS

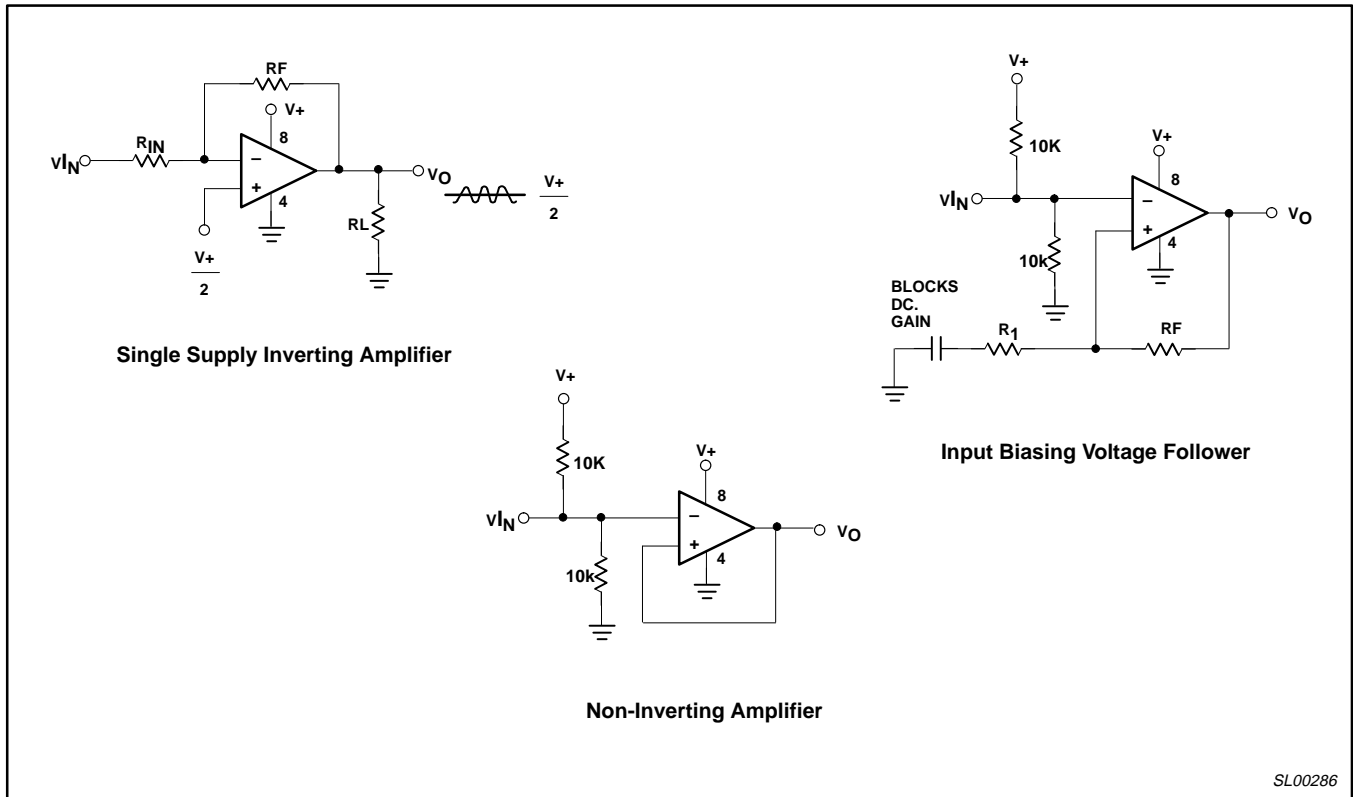


Figure 5. Typical Applications