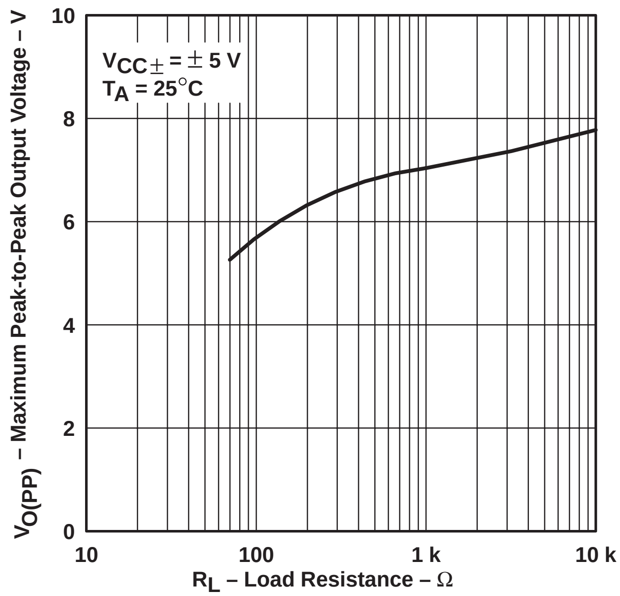
- **Excellent Output Drive Capability**
  **$V_O$ = ± 2.5 V Min at $R_L$ = 100 Ω,**
  **$V_{CC\pm}$ = ± 5 V**
  **$V_O$ = ± 12.5 V Min at $R_L$ = 600 Ω,**
  **$V_{CC\pm}$ = ± 15 V**
- **Low Supply Current . . . 280 μA Typ**
- **Decompensated for High Slew Rate and Gain-Bandwidth Product**
  **$A_{VD}$ = 0.5 Min**
  **Slew Rate = 10 V/μs Typ**
  **Gain-Bandwidth Product = 6.5 MHz Typ**
- **Wide Operating Supply Voltage Range**
  **$V_{CC\pm}$ = ± 3.5 V to ± 18 V**
- **High Open-Loop Gain . . . 280 V/mV Typ**
- **Low Offset Voltage . . . 500 μV Max**
- **Low Offset Voltage Drift With Time**
  **0.04 μV/Month Typ**
- **Low Input Bias Current . . . 5 pA Typ**

## description

The TLE2161, TLE2161A, and TLE2161B are JFET-input, low-power, precision operational amplifiers manufactured using the Texas Instruments Excalibur process. Decompensated for stability with a minimum closed-loop gain of 5, these devices combine outstanding output drive capability with low power consumption, excellent dc precision, and high gain-bandwidth product.

In addition to maintaining the traditional JFET advantages of fast slew rates and low input bias and offset currents, the Excalibur process offers outstanding parametric stability over time and temperature. This results in a device that remains precise even with changes in temperature and over years of use.

**MAXIMUM PEAK-TO-PEAK OUTPUT VOLTAGE**
**vs**
**LOAD RESISTANCE**




**AVAILABLE OPTIONS**

| $T_A$ | $V_{IO}$max AT 25°C | PACKAGE | | | |
|---|---|---|---|---|---|
| | | SMALL OUTLINE (D) | CHIP CARRIER (FK) | CERAMIC DIP (JG) | PLASTIC DIP (P) |
| 0°C to 70°C | 500 μV | — | — | — | TLE2161BCP |
| | 1.5 mV | TLE2161ACD | | | TLE2161ACP |
| | 3 mV | TLE2161CD | — | — | TLE2161CP |
| –40°C to 85°C | 500 μV | — | — | — | TLE2161BIP |
| | 1.5 mV | TLE2161AID | | | TLE2161AIP |
| | 3 mV | TLE2161ID | — | — | TLE2161IP |
| –55°C to 125°C | 500 μV | — | — | TLE2161BMJG | TLE2161BMP |
| | 1.5 mV | TLE2161AMD | TLE2161AMFK | TLE2161AMJG | TLE2161AMP |
| | 3 mV | TLE2161MD | TLE2161MFK | TLE2161MJG | TLE2161MP |

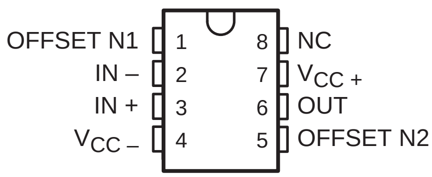
The D packages are available taped and reeled. Add R suffix to device type (e.g., TLE2161ACDR).

## description (continued)

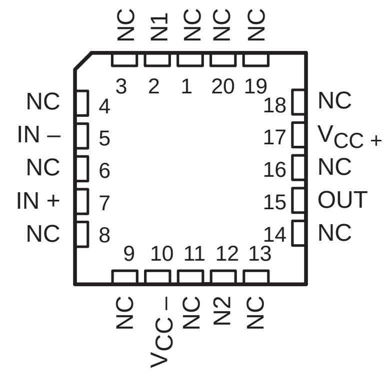
A variety of available options includes small-outline packages and chip-carrier versions for high-density system applications.

The C-suffix devices are characterized for operation from 0°C to 70°C. The I-suffix devices are characterized for operation from – 40°C to 85°C. The M-suffix devices are characterized for operation over the full military temperature range of – 55°C to 125°C.

**D, JG, OR P PACKAGE**
**(TOP VIEW)**

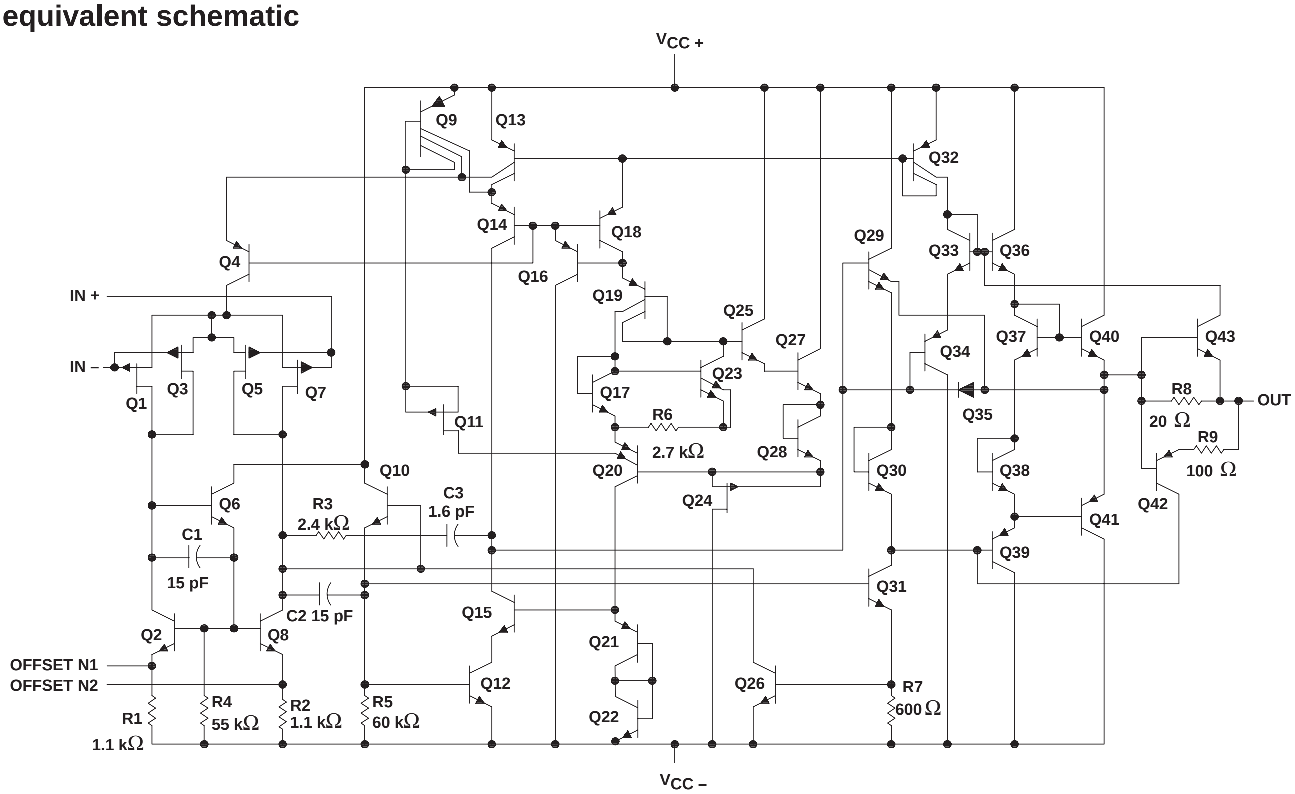



**FK PACKAGE**
**(TOP VIEW)**




NC – No internal connection

## equivalent schematic




All component values are nominal.

## absolute maximum ratings over operating free-air temperature range (unless otherwise noted)†

Supply voltage, $V_{CC+}$ (see Note 1) .......... 19 V
Supply voltage, $V_{CC-}$ .......... – 19 V
Differential input voltage, $V_{ID}$ (see Note 2) .......... ± 38 V
Input voltage range, $V_I$ (any input) .......... $V_{CC\pm}$
Input current, $I_I$ (each input) .......... ± 1 mA
Output current, $I_O$ .......... ± 80 mA
Total current into $V_{CC+}$ .......... 80 mA
Total current out of $V_{CC-}$ .......... 80 mA
Duration of short-circuit current at (or below) 25°C (see Note 3) .......... unlimited
Continuous total power dissipation .......... See Dissipation Rating Table
Operating free-air temperature range, $T_A$: C suffix .......... 0°C to 70°C
I suffix .......... – 40°C to 85°C
M suffix .......... – 55°C to 125°C
Storage temperature range, $T_{stg}$ .......... – 65°C to 150°C
Case temperature for 60 seconds: FK package .......... 260°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds: D or P package .......... 260°C
Lead temperature 1,6 mm (1/16 inch) from case for 60seconds: JG package .......... 300°C

† Stresses beyond those listed under “absolute maximum ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under “recommended operating conditions” is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

NOTES: 1. All voltage values, except differential voltages, are with respect to the midpoint between $V_{CC+}$, and $V_{CC-}$.
2. Differential voltages are at IN+ with respect to IN–.
3. The output may be shorted to either supply. Temperature and /or supply voltages must be limited to ensure that the maximum dissipation rating is not exceeded.

**DISSIPATION RATING TABLE**

| PACKAGE | $T_A \le 25°C$ POWER RATING | DERATING FACTOR ABOVE $T_A = 25°C$ | $T_A = 70°C$ POWER RATING | $T_A = 85°C$ POWER RATING | $T_A = 125°C$ POWER RATING |
|---|---|---|---|---|---|
| D | 725 mW | 5.8 mW/°C | 464 mW | 377 mW | 145 mW |
| FK | 1375 mW | 11.0 mW/°C | 880 mW | 715 mW | 275 mW |
| JG | 1050 mW | 8.4 mW/°C | 672 mW | 546 mW | 210 mW |
| P | 1000 mW | 8.0 mW/°C | 640 mW | 520 mW | 200 mW |

## recommended operating conditions

| | | C SUFFIX | | I SUFFIX | | M SUFFIX | | UNIT |
|---|---|---|---|---|---|---|---|---|
| | | MIN | MAX | MIN | MAX | MIN | MAX | |
| Supply voltage, $V_{CC\pm}$ | | ±3.5 | ±18 | ±3.5 | ±18 | +3.5 | ±18 | V |
| Common-mode input voltage, $V_{IC}$ | $V_{CC\pm} = \pm 5$ V | –1.6 | 4 | –1.6 | 4 | –1.6 | 4 | V |
| | $V_{CC\pm} = \pm 15$ V | –11 | 13 | –11 | 13 | –11 | 13 | |
| Operating free-air temperature, $T_A$ | | 0 | 70 | –40 | 85 | –55 | 125 | °C |

## electrical characteristics at specified free-air temperature, $V_{CC\pm} = \pm 5$ V (unless otherwise noted)

| PARAMETER | | | TEST CONDITIONS | $T_A$† | TLE2161C, TLE2161AC TLE2161BC MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|---|---|
| $V_{IO}$ | Input offset voltage | TLE2161C | $V_{IC} = 0$, $R_S = 50\ \Omega$ | 25°C | | 0.8 | 3.1 | mV |
| | | | | Full range | | | 4 | |
| | | TLE2161AC | | 25°C | | 0.6 | 2.6 | |
| | | | | Full range | | | 3.5 | |
| | | TLE2161BC | | 25°C | | 0.5 | 1.9 | |
| | | | | Full range | | | 2.4 | |
| $\alpha_{VIO}$ | Temperature coefficient of input offset voltage | | | Full range | | 6 | | μV/°C |
| | Input offset voltage long-term drift (see Note 4) | | | 25°C | | 0.04 | | μV/mo |
| $I_{IO}$ | Input offset current | | | 25°C | | 1 | | pA |
| | | | | Full range | | | 0.8 | nA |
| $I_{IB}$ | Input bias current | | | 25°C | | 3 | | pA |
| | | | | Full range | | | 2 | nA |
| $V_{ICR}$ | Common-mode input voltage range | | | 25°C | –1.6 to 4 | –2 to 6 | | V |
| | | | | Full range | –1.6 to 4 | | | V |
| $V_{OM+}$ | Maximum positive peak output voltage swing | | $R_L = 10\ k\Omega$ | 25°C | 3.5 | 3.7 | | V |
| | | | | Full range | 3.3 | | | |
| | | | $R_L = 100\ \Omega$ | 25°C | 2.5 | 3.1 | | |
| | | | | Full range | 2 | | | |
| $V_{OM-}$ | Maximum negative peak output voltage swing | | $R_L = 10\ k\Omega$ | 25°C | –3.7 | –3.9 | | V |
| | | | | Full range | –3.3 | | | |
| | | | $R_L = 100\ \Omega$ | 25°C | –2.5 | –2.7 | | |
| | | | | Full range | –2 | | | |
| $A_{VD}$ | Large-signal differential voltage amplification | | $V_O = \pm 2.8$ V, $R_L = 10\ k\Omega$ | 25°C | 15 | 80 | | V/mV |
| | | | | Full range | 2 | | | |
| | | | $V_O = 0$ to 2 V, $R_L = 100\ \Omega$ | 25°C | 0.75 | 45 | | |
| | | | | Full range | 0.5 | | | |
| | | | $V_O = 0$ to –2 V, $R_L = 100\ \Omega$ | 25°C | 0.5 | 3 | | |
| | | | | Full range | 0.25 | | | |
| $r_i$ | Input resistance | | | 25°C | | $10^{12}$ | | Ω |
| $c_i$ | Input capacitance | | | 25°C | | 4 | | pF |
| $z_o$ | Open-loop output impedance | | $I_O = 0$ | 25°C | | 280 | | Ω |
| CMRR | Common-mode rejection ratio | | $V_{IC} = V_{ICR}$min, $R_S = 50\ \Omega$ | 25°C | 65 | 82 | | dB |
| | | | | Full range | 65 | | | |
| $k_{SVR}$ | Supply-voltage rejection ratio ($\Delta V_{CC\pm}/\Delta V_{IO}$) | | $V_{CC\pm} = \pm 5$ V to $\pm 15$ V, $R_S = 50\ \Omega$ | 25°C | 75 | 93 | | dB |
| | | | | Full range | 75 | | | |
| $I_{CC}$ | Supply current | | $V_O = 0$, No load | 25°C | | 280 | 325 | μA |
| | | | | Full range | | | 350 | |
| $\Delta I_{CC}$ | Supply-current change over operating temperature range | | | Full range | | 29 | | μA |

† Full range is 0°C to 70°C.

NOTE 4: Typical values are based on the input offset voltage shift observed through 168 hours of operating life test at $T_A = 150°C$ extrapolated to $T_A = 25°C$ using the Arrhenius equation and assuming an activation energy of 0.96 eV.

## operating characteristics at specified free-air temperature, $V_{CC\pm} = \pm 5$ V (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | $T_A$† | TLE2161C, TLE2161AC TLE2161BC | | | UNIT |
|---|---|---|---|---|---|---|---|
| | | | | MIN | TYP | MAX | |
| SR | Slew rate (see Figure 1) | $A_{VD} = 5$, $R_L = 10$ kΩ, $C_L = 100$ pF | 25°C | 7 | 10 | | V/μs |
| | | | Full range | 5 | | | |
| $V_n$ | Equivalent input noise voltage (see Figure 2) | $R_S = 20$ Ω, f = 10 Hz | 25°C | | 59 | 100 | nV/√Hz |
| | | $R_S = 20$ Ω, f = 1 kHz | | | 43 | 60 | |
| $V_{n(PP)}$ | Peak-to-peak equivalent input noise voltage | f = 0.1 Hz to 10 Hz | 25°C | | 1.1 | | μV |
| $I_n$ | Equivalent input noise current | f = 1 kHz | 25°C | | 1 | | fA/√Hz |
| THD | Total harmonic distortion | $V_{O(PP)} = 2$ V, $A_{VD} = 5$, f = 10 kHz, $R_L = 10$ kΩ | 25°C | | 0.025% | | |
| | Gain-bandwidth product (see Figure 3) | f = 100 kHz, $R_L = 10$ kΩ, $C_L = 100$ pF | 25°C | | 5.8 | | MHz |
| | | f = 100 kHz, $R_L = 100$ kΩ, $C_L = 100$ pF | | | 4.3 | | |
| $t_s$ | Settling time | ε = 0.1% | 25°C | | 5 | | μs |
| | | ε = 0.01% | | | 10 | | |
| $B_{OM}$ | Maximum output-swing bandwidth | $A_{VD} = 5$, $R_L = 10$ kΩ | 25°C | | 420 | | kHz |
| $\phi_m$ | Phase margin (see Figure 3) | $A_{VD} = 5$, $R_L = 10$ kΩ, $C_L = 100$ pF | 25°C | | 70° | | |
| | | $A_{VD} = 5$, $R_L = 100$ Ω, $C_L = 100$ pF | | | 84° | | |

† Full range is 0°C to 70°C.

## electrical characteristics at specified free-air temperature, $V_{CC\pm} = \pm 15$ V (unless otherwise noted)

| PARAMETER | | | TEST CONDITIONS | $T_A$† | TLE2161C, TLE2161AC TLE2161BC MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|---|---|
| $V_{IO}$ | Input offset voltage | TLE2161C | $V_{IC} = 0$, $R_S = 50\ \Omega$ | 25°C | | 0.6 | 3 | mV |
| | | | | Full range | | | 3.9 | |
| | | TLE2161AC | | 25°C | | 0.5 | 1.5 | |
| | | | | Full range | | | 2.5 | |
| | | TLE2161BC | | 25°C | | 0.3 | 0.5 | |
| | | | | Full range | | | 1 | |
| $\alpha_{VIO}$ | Temperature coefficient of input offset voltage | | | Full range | | 6 | | μV/°C |
| | Input offset voltage long-term drift (see Note 4) | | | 25°C | | 0.04 | | μV/mo |
| $I_{IO}$ | Input offset current | | | 25°C | | 2 | | pA |
| | | | | Full range | | | 1 | nA |
| $I_{IB}$ | Input bias current | | | 25°C | | 4 | | pA |
| | | | | Full range | | | 3 | nA |
| $V_{ICR}$ | Common-mode input voltage range | | | 25°C | –11 to 13 | –12 to 16 | | V |
| | | | | Full range | –11 to 13 | | | V |
| $V_{OM+}$ | Maximum positive peak output voltage swing | | $R_L = 10\ k\Omega$ | 25°C | 13.2 | 13.7 | | V |
| | | | | Full range | 13 | | | |
| | | | $R_L = 600\ \Omega$ | 25°C | 12.5 | 13.2 | | |
| | | | | Full range | 12 | | | |
| $V_{OM-}$ | Maximum negative peak output voltage swing | | $R_L = 10\ k\Omega$ | 25°C | –13.2 | –13.7 | | V |
| | | | | Full range | –13 | | | |
| | | | $R_L = 600\ \Omega$ | 25°C | –12.5 | –13 | | |
| | | | | Full range | –12 | | | |
| $A_{VD}$ | Large-signal differential voltage amplification | | $V_O = \pm 10$ V, $R_L = 10\ k\Omega$ | 25°C | 30 | 230 | | V/mV |
| | | | | Full range | 20 | | | |
| | | | $V_O = 0$ to 8 V, $R_L = 600\ \Omega$ | 25°C | 25 | 100 | | |
| | | | | Full range | 10 | | | |
| | | | $V_O = 0$ to – 8 V, $R_L = 600\ \Omega$ | 25°C | 3 | 25 | | |
| | | | | Full range | 1 | | | |
| $r_i$ | Input resistance | | | 25°C | | $10^{12}$ | | Ω |
| $c_i$ | Input capacitance | | | 25°C | | 4 | | pF |
| $z_o$ | Open-loop output impedance | | $I_O = 0$ | 25°C | | 280 | | Ω |
| CMRR | Common-mode rejection ratio | | $V_{IC} = V_{ICR}$min, $R_S = 50\ \Omega$ | 25°C | 72 | 90 | | dB |
| | | | | Full range | 70 | | | |
| $k_{SVR}$ | Supply-voltage rejection ratio ($\Delta V_{CC\pm} / \Delta V_{IO}$) | | $V_{CC\pm} = \pm 5$ V to $\pm 15$ V, RS = 50 Ω | 25°C | 75 | 93 | | dB |
| | | | | Full range | 75 | | | |
| $I_{CC}$ | Supply current | | VO = 0, No load | 25°C | | 290 | 350 | μA |
| | | | | Full range | | | 375 | |
| $\Delta I_{CC}$ | Supply-current change over operating temperature range | | | Full range | | 34 | | μA |

† Full range is 0°C to 70°C.

NOTE 4: Typical values are based on the input offset voltage shift observed through 168 hours of operating life test at $T_A = 150$°C extrapolated to $T_A = 25$°C using the Arrhenius equation and assuming an activation energy of 0.96 eV.

## operating characteristics at specified free-air temperature, $V_{CC\pm} = \pm15$ V (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | $T_A$† | TLE2161C, TLE2161AC TLE2161BC MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|---|
| SR | Slew rate (see Figure 1) | $A_{VD} = 5$, $R_L = 10$ kΩ, $C_L = 100$ pF | 25°C | 7 | 10 | | V/μs |
| | | | Full range | 5 | | | |
| $V_n$ | Equivalent input noise voltage (see Figure 2) | $R_S = 20$ Ω, f = 10 Hz | 25°C | | 70 | 100 | nV/√Hz |
| | | $R_S = 20$ Ω, f = 1 kHz | | | 40 | 60 | |
| $V_{n(PP)}$ | Peak-to-peak equivalent input noise voltage | f = 0.1 Hz to 10 Hz | 25°C | | 1.1 | | μV |
| $I_n$ | Equivalent input noise current | f = 1 kHz | 25°C | | 1.1 | | fA/√Hz |
| THD | Total harmonic distortion | $V_{O(PP)} = 2$ V, $A_{VD} = 5$, f = 10 kHz, $R_L = 10$ kΩ | 25°C | | 0.025% | | |
| | Gain-bandwidth product (see Figure 3) | f = 100 kHz, $R_L = 10$ kΩ, $C_L = 100$ pF | 25°C | | 6.4 | | MHz |
| | | f = 100 kHz, $R_L = 600$ Ω, $C_L = 100$ pF | | | 5.6 | | |
| $t_s$ | Settling time | ε = 0.1% | 25°C | | 5 | | μs |
| | | ε = 0.01% | | | 10 | | |
| $B_{OM}$ | Maximum output-swing bandwidth | $A_{VD} = 5$, $R_L = 10$ kΩ | 25°C | | 116 | | kHz |
| $\phi_m$ | Phase margin (see Figure 3) | $A_{VD} = 5$, $R_L = 10$ kΩ, $C_L = 100$ pF | 25°C | | 72° | | |
| | | $A_{VD} = 5$, $R_L = 600$ Ω, $C_L = 100$ pF | | | 78° | | |

† Full range is 0°C to 70°C.

## electrical characteristics at specified free-air temperature, $V_{CC\pm} = \pm 5$ V (unless otherwise noted)

| PARAMETER | | | TEST CONDITIONS | $T_A$† | TLE2161I, TLE2161AI TLE2161BI MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|---|---|
| $V_{IO}$ | Input offset voltage | TLE2161I | $V_{IC} = 0$, $R_S = 50\ \Omega$ | 25°C | | 0.8 | 3.1 | mV |
| | | | | Full range | | | 4.4 | |
| | | TLE2161AI | | 25°C | | 0.6 | 2.6 | |
| | | | | Full range | | | 3.9 | |
| | | TLE2161BI | | 25°C | | 0.5 | 1.9 | |
| | | | | Full range | | | 2.7 | |
| $\alpha_{VIO}$ | Temperature coefficient of input offset voltage | | | Full range | | 6 | | μV/°C |
| | Input offset voltage long-term drift (see Note 4) | | | 25°C | | 0.04 | | μV/mo |
| $I_{IO}$ | Input offset current | | | 25°C | | 1 | | pA |
| | | | | Full range | | | 2 | nA |
| $I_{IB}$ | Input bias current | | | 25°C | | 3 | | pA |
| | | | | Full range | | | 4 | nA |
| $V_{ICR}$ | Common-mode input voltage range | | | 25°C | –1.6 to 4 | –2 to 6 | | V |
| | | | | Full range | –1.6 to 4 | | | |
| $V_{OM+}$ | Maximum positive peak output voltage | | $R_L = 10\ k\Omega$ | 25°C | 3.5 | 3.7 | | V |
| | | | | Full range | 3.1 | | | |
| | | | $R_L = 100\ \Omega$ | 25°C | 2.5 | 3.1 | | |
| | | | | Full range | 2 | | | |
| $V_{OM-}$ | Maximum negative peak output voltage swing | | $R_L = 10\ k\Omega$ | 25°C | –3.7 | –3.9 | | V |
| | | | | Full range | –3.1 | | | |
| | | | $R_L = 100\ \Omega$ | 25°C | –2.5 | –2.7 | | |
| | | | | Full range | –2 | | | |
| $A_{VD}$ | Large-signal differential voltage amplification | | $V_O = \pm 2.8$ V, $R_L = 10\ k\Omega$ | 25°C | 15 | 80 | | V/mV |
| | | | | Full range | 2 | | | |
| | | | $V_O = 0$ to 2 V, $R_L = 100\ \Omega$ | 25°C | 0.75 | 45 | | |
| | | | | Full range | 0.5 | | | |
| | | | $V_O = 0$ to –2 V, $R_L = 100\ \Omega$ | 25°C | 0.5 | 3 | | |
| | | | | Full range | 0.25 | | | |
| $r_i$ | Input resistance | | | 25°C | | $10^{12}$ | | Ω |
| $c_i$ | Input capacitance | | | 25°C | | 4 | | pF |
| $z_o$ | Open-loop output impedance | | $I_O = 0$ | 25°C | | 280 | | Ω |
| CMRR | Common-mode rejection ratio | | $V_{IC} = V_{ICR}$min, $R_S = 50\ \Omega$ | 25°C | 65 | 82 | | dB |
| | | | | Full range | 65 | | | |
| $k_{SVR}$ | Supply-voltage rejection ratio ($\Delta V_{CC\pm} / \Delta V_{IO}$) | | $V_{CC\pm} = \pm 5$ V to $\pm 15$ V, $R_S = 50\ \Omega$ | 25°C | 75 | 93 | | dB |
| | | | | Full range | 65 | | | |
| $I_{CC}$ | Supply current | | $V_O = 0$, No load | 25°C | | 280 | 325 | μA |
| | | | | Full range | | | 350 | |
| $\Delta I_{CC}$ | Supply-current change over operating temperature range | | | Full range | | 29 | | μA |

† Full range is – 40°C to 85°C.

NOTE 4: Typical values are based on the input offset voltage shift observed through 168 hours of operating life test at $T_A = 150°C$ extrapolated to $T_A = 25°C$ using the Arrhenius equation and assuming an activation energy of 0.96 eV.

## operating characteristics at specified free-air temperature, $V_{CC\pm} = \pm 5$ V (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | $T_A$† | TLE2161I, TLE2161AI TLE2161BI | | | UNIT |
|---|---|---|---|---|---|---|---|
| | | | | MIN | TYP | MAX | |
| SR | Slew rate (see Figure 1) | $A_{VD} = 5$, $R_L = 10$ kΩ, $C_L = 100$ pF | 25°C | 7 | 10 | | V/μs |
| | | | Full range | 5 | | | |
| $V_n$ | Equivalent input noise voltage (see Figure 2) | $R_S = 20$ Ω, f = 10 Hz | 25°C | | 59 | 100 | nV/√Hz |
| | | $R_S = 20$ Ω, f = 1 kHz | | | 43 | 60 | |
| $V_{n(PP)}$ | Peak-to-peak equivalent input noise voltage | f = 0.1 Hz to 10 Hz | 25°C | | 1.1 | | μV |
| $I_n$ | Equivalent input noise current | f = 1 kHz | 25°C | | 1 | | fA/√Hz |
| THD | Total harmonic distortion | $V_{O(PP)} = 2$ V, $A_{VD} = 5$, f = 10 kHz, $R_L = 10$ kΩ | 25°C | | 0.025% | | |
| | Gain-bandwidth product (see Figure 3) | f = 100 kHz, $R_L = 10$ kΩ, $C_L = 100$ pF | 25°C | | 5.8 | | MHz |
| | | f = 100 kHz, $R_L = 100$ Ω, $C_L = 100$ pF | | | 4.3 | | |
| $t_s$ | Settling time | ε = 0.1% | 25°C | | 5 | | μs |
| | | ε = 0.01% | | | 10 | | |
| $B_{OM}$ | Maximum output-swing bandwidth | $A_{VD} = 5$, $R_L = 10$ kΩ | 25°C | | 420 | | kHz |
| $\phi_m$ | Phase margin (see Figure 3) | $A_{VD} = 5$, $R_L = 10$ kΩ, $C_L = 100$ pF | 25°C | | 70° | | |
| | | $A_{VD} = 5$, $R_L = 100$ Ω, $C_L = 100$ pF | | | 84° | | |

† Full range is – 40°C to 85°C.

## electrical characteristics at specified free-air temperature, $V_{CC\pm} = \pm 15$ V (unless otherwise noted)

| PARAMETER | | | TEST CONDITIONS | $T_A$† | TLE2161I, TLE2161AI TLE2161BI MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|---|---|
| $V_{IO}$ | Input offset voltage | TLE2161I | $V_{IC} = 0$, $R_S = 50\ \Omega$ | 25°C | | 0.6 | 3 | mV |
| | | | | Full range | | | 4.3 | |
| | | TLE2161AI | | 25°C | | 0.5 | 1.5 | |
| | | | | Full range | | | 2.9 | |
| | | TLE2161BI | | 25°C | | 0.3 | 0.5 | |
| | | | | Full range | | | 1.3 | |
| $\alpha_{VIO}$ | Temperature coefficient of input offset voltage | | | Full range | | 6 | | μV/°C |
| | Input offset voltage long-term drift (see Note 4) | | | 25°C | | 0.04 | | μV/mo |
| $I_{IO}$ | Input offset current | | | 25°C | | 2 | | pA |
| | | | | Full range | | | 3 | nA |
| $I_{IB}$ | Input bias current | | | 25°C | | 4 | | pA |
| | | | | Full range | | | 5 | nA |
| $V_{ICR}$ | Common-mode input voltage range | | | 25°C | –11 to 13 | –12 to 16 | | V |
| | | | | Full range | –11 to 13 | | | V |
| $V_{OM+}$ | Maximum positive peak output voltage swing | | $R_L = 10\ k\Omega$ | 25°C | 13.2 | 13.7 | | V |
| | | | | Full range | 13 | | | |
| | | | $R_L = 600\ \Omega$ | 25°C | 12.5 | 13.2 | | |
| | | | | Full range | 12 | | | |
| $V_{OM-}$ | Maximum negative peak output voltage swing | | $R_L = 10\ k\Omega$ | 25°C | –13.2 | –13.7 | | V |
| | | | | Full range | –13 | | | |
| | | | $R_L = 600\ \Omega$ | 25°C | –12.5 | –13 | | |
| | | | | Full range | –12 | | | |
| $A_{VD}$ | Large-signal differential voltage amplification | | $V_O = \pm 10$ V, $R_L = 10\ k\Omega$ | 25°C | 30 | 230 | | V/mV |
| | | | | Full range | 20 | | | |
| | | | $V_O = 0$ to 8 V, $R_L = 600\ \Omega$ | 25°C | 25 | 100 | | |
| | | | | Full range | 10 | | | |
| | | | $V_O = 0$ to – 8 V, $R_L = 600\ \Omega$ | 25°C | 3 | 25 | | |
| | | | | Full range | 1 | | | |
| $r_i$ | Input resistance | | | 25°C | | $10^{12}$ | | Ω |
| $c_i$ | Input capacitance | | | 25°C | | 4 | | pF |
| $z_o$ | Open-loop output impedance | | $I_O = 0$ | 25°C | | 280 | | Ω |
| CMRR | Common-mode rejection ratio | | $V_{IC} = V_{ICR}\text{min}$, $R_S = 50\ \Omega$ | 25°C | 72 | 90 | | dB |
| | | | | Full range | 65 | | | |
| $k_{SVR}$ | Supply-voltage rejection ratio ($\Delta V_{CC\pm} / \Delta V_{IO}$) | | $V_{CC\pm} = \pm 5$ V to $\pm 15$ V, $R_S = 50\ \Omega$ | 25°C | 75 | 93 | | dB |
| | | | | Full range | 65 | | | |
| $I_{CC}$ | Supply current | | $V_O = 0$, No load | 25°C | | 290 | 350 | μA |
| | | | | Full range | | | 375 | |
| $\Delta I_{CC}$ | Supply-current change over operating temperature range | | | Full range | | 34 | | μA |

† Full range is – 40°C to 85°C.

NOTE 4: Typical values are based on the input offset voltage shift observed through 168 hours of operating life test at $T_A = 150°C$ extrapolated to $T_A = 25°C$ using the Arrhenius equation and assuming an activation energy of 0.96 eV.

## operating characteristics at specified free-air temperature, $V_{CC\pm} = \pm$ 15 V (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | $T_A$† | TLE2161I, TLE2161AI TLE2161IB | | | UNIT |
|---|---|---|---|---|---|---|---|
| | | | | MIN | TYP | MAX | |
| SR | Slew rate (see Figure 1) | $A_{VD}$ = 5, $R_L$ = 10 kΩ, $C_L$ = 100 pF | 25°C | 7 | 10 | | V/μs |
| | | | Full range | 5 | | | |
| $V_n$ | Equivalent input noise voltage (see Figure 2) | $R_S$ = 20 Ω, f = 10 Hz | 25°C | | 70 | 100 | nV/√Hz |
| | | $R_S$ = 20 Ω, f = 1 kHz | | | 40 | 60 | |
| $V_{n(PP)}$ | Peak-to-peak equivalent input noise voltage | f = 0.1 Hz to 10 Hz | 25°C | | 1.1 | | μV |
| $I_n$ | Equivalent input noise current | f = 1 kHz | 25°C | | 1.1 | | fA/√Hz |
| THD | Total harmonic distortion | $V_{O(PP)}$ = 2 V, $A_{VD}$ = 5, f = 10 kHz, $R_L$ = 10 kΩ | 25°C | | 0.025% | | |
| | Gain-bandwidth product (see Figure 3) | f = 100 kHz, $R_L$ = 10 kΩ, $C_L$ = 100 pF | 25°C | | 6.4 | | MHz |
| | | f = 100 kHz, $R_L$ = 600 Ω, $C_L$ = 100 pF | | | 5.6 | | |
| $t_s$ | Settling time | ε = 0.1% | 25°C | | 5 | | μs |
| | | ε = 0.01% | | | 10 | | |
| $B_{OM}$ | Maximum output-swing bandwidth | $A_{VD}$ = 5, $R_L$ = 10 kΩ | 25°C | | 116 | | kHz |
| $\phi_m$ | Phase margin (see Figure 3) | $A_{VD}$ = 5, $R_L$ = 10 kΩ, $C_L$ = 100 pF | 25°C | | 72° | | |
| | | $A_{VD}$ = 5, $R_L$ = 600 Ω, $C_L$ = 100 pF | | | 78° | | |

† Full range is – 40°C to 85°C.

## electrical characteristics at specified free-air temperature, $V_{CC\pm} = \pm 5$ V (unless otherwise noted)

| PARAMETER | | | TEST CONDITIONS | $T_A$† | TLE2161M, TLE2161AM, TLE2161BM | | | UNIT |
|---|---|---|---|---|---|---|---|---|
| | | | | | MIN | TYP | MAX | |
| $V_{IO}$ | Input offset voltage | TLE2161M | $V_{IC} = 0$, $R_S = 50\ \Omega$ | 25°C | | 0.8 | 3.1 | mV |
| | | | | Full range | | | 6 | |
| | | TLE2161AM | | 25°C | | 0.6 | 2.6 | |
| | | | | Full range | | | 4.6 | |
| | | TLE2161BM | | 25°C | | 0.5 | 1.9 | |
| | | | | Full range | | | 3.1 | |
| $\alpha_{VIO}$ | Temperature coefficient of input offset voltage | | $V_{IC} = 0$, $R_S = 50\ \Omega$ | Full range | | 6 | | μV/°C |
| | Input offset voltage long-term drift (see Note 4) | | $V_{IC} = 0$, $R_S = 50\ \Omega$ | 25°C | | 0.04 | | μV/mo |
| $I_{IO}$ | Input offset current | | $V_{IC} = 0$, $R_S = 50\ \Omega$ | 25°C | | 1 | | pA |
| | | | | Full range | | | 15 | nA |
| $I_{IB}$ | Input bias current | | $V_{IC} = 0$, $R_S = 50\ \Omega$ | 25°C | | 3 | | pA |
| | | | | Full range | | | 30 | nA |
| $V_{ICR}$ | Common-mode input voltage range | | | 25°C | −1.6 to 4 | −2 to 6 | | V |
| | | | | Full range | −1.6 to 4 | | | V |
| $V_{OM+}$ | Maximum positive peak output voltage swing | All packages | $R_L = 10\ k\Omega$ | 25°C | 3.5 | 3.7 | | V |
| | | | | Full range | 3 | | | |
| | | FK and JG packages | $R_L = 600\ \Omega$ | 25°C | 2.5 | 3.6 | | V |
| | | | | Full range | 2 | | | |
| | | D and P packages | $R_L = 100\ \Omega$ | 25°C | 2.5 | 3.1 | | |
| | | | | Full range | 2 | | | |
| $V_{OM-}$ | Maximum negative peak output voltage swing | All packages | $R_L = 10\ k\Omega$ | 25°C | −3.7 | −3.9 | | V |
| | | | | Full range | −3 | | | |
| | | FK and JG packages | $R_L = 600\ \Omega$ | 25°C | −2.5 | −3.5 | | |
| | | | | Full range | −2 | | | |
| | | D and P packages | $R_L = 100\ \Omega$ | 25°C | −2.5 | −2.7 | | |
| | | | | Full range | −2 | | | |
| $A_{VD}$ | Large-signal differential voltage amplification | All packages | $V_O = \pm 2.8$ V, $R_L = 10\ k\Omega$ | 25°C | 15 | 80 | | V/mV |
| | | | | Full range | 2 | | | |
| | | FK and JG packages | $V_O = 0$ to 2.5 V, $R_L = 600\ \Omega$ | 25°C | 1 | 65 | | |
| | | | | Full range | 0.5 | | | |
| | | | $V_O = 0$ to −2.5 V, $R_L = 600\ \Omega$ | 25°C | 1 | 16 | | |
| | | | | Full range | 0.5 | | | |
| | | D and P packages | $V_O = 0$ to 2 V, $R_L = 100\ \Omega$ | 25°C | 0.75 | 45 | | |
| | | | | Full range | 0.5 | | | |
| | | | $V_O = 0$ to −2 V, $R_L = 100\ \Omega$ | 25°C | 0.5 | 3 | | |
| | | | | Full range | 0.25 | | | |

† Full range is – 55°C to 125°C.

NOTE 4: Typical values are based on the input offset voltage shift observed through 168 hours of operating life test at $T_A$ = 150°C extrapolated to $T_A$ = 25°C using the Arrhenius equation and assuming an activation energy of 0.96 eV.

## electrical characteristics at specified free-air temperature, $V_{CC\pm} = \pm 5$ V (unless otherwise noted continued)

| PARAMETER | | TEST CONDITIONS | $T_A$† | TLE2161M TLE2161AM TLE2161BM | | | UNIT |
|---|---|---|---|---|---|---|---|
| | | | | MIN | TYP | MAX | |
| $r_i$ | Input resistance | | 25°C | | $10^{12}$ | | Ω |
| $c_i$ | Input capacitance | | 25°C | | 4 | | pF |
| $z_o$ | Open-loop output impedance | $I_O = 0$ | 25°C | | 280 | | Ω |
| CMRR | Common-mode rejection ratio | $V_{IC} = V_{ICR}$min, $R_S = 50\ \Omega$ | 25°C | 65 | 82 | | dB |
| | | | Full range | 60 | | | |
| $k_{SVR}$ | Supply-voltage rejection ratio ($\Delta V_{CC\pm}/\Delta V_{IO}$) | $V_{CC\pm} = \pm 5$ V to $\pm 15$ V, $R_S = 50\ \Omega$ | 25°C | 75 | 93 | | dB |
| | | | Full range | 65 | | | |
| $I_{CC}$ | Supply current | $V_O = 0$, No load | 25°C | | 280 | 325 | μA |
| | | | Full range | | | 350 | |
| $\Delta I_{CC}$ | Supply-current change over operating temperature range | | Full range | | 39 | | μA |

† Full range is – 55°C to 125°C.

## operating characteristics, $V_{CC\pm} = \pm 5$ V, $T_A = 25°C$

| PARAMETER | | TEST CONDITIONS | TLE2161M TLE2161AM TLE2161BM | | | UNIT |
|---|---|---|---|---|---|---|
| | | | MIN | TYP | MAX | |
| SR | Slew rate (see Figure 1) | $A_{VD} = 5$, $R_L = 10\ k\Omega$, $C_L = 100$ pF | | 10 | | V/μs |
| $V_n$ | Equivalent input noise voltage (see Figure 2) | $R_S = 20\ \Omega$, f = 10 Hz | | 59 | | nV/√Hz |
| | | $R_S = 20\ \Omega$, f = 1 kHz | | 43 | | |
| $V_{n(PP)}$ | Peak-to-peak equivalent input noise voltage | f = 0.1 Hz to 10 Hz | | 1.1 | | μV |
| $I_n$ | Equivalent input noise current | f = 1 kHz | | 1 | | fA/√Hz |
| THD | Total harmonic distortion | $A_{VD} = 5$, $V_{O(PP)} = 2$ V, f = 10 kHz, $R_L = 10\ k\Omega$ | | 0.025% | | |
| | Gain-bandwidth product (see Figure 3) | f = 100 kHz, $R_L = 10\ k\Omega$, $C_L = 100$ pF | | 5.8 | | MHz |
| | | f = 100 kHz, $R_L = 600\ k\Omega$, $C_L = 100$ pF | | 4.3 | | |
| $t_s$ | Settling time | ε = 0.1% | | 5 | | μs |
| | | ε = 0.01% | | 10 | | |
| $B_{OM}$ | Maximum output-swing bandwidth | $A_{VD} = 5$, $R_L = 10\ k\Omega$ | | 420 | | kHz |
| $\phi_m$ | Phase margin (see Figure 3) | $A_{VD} = 5$, $R_L = 10\ k\Omega$, $C_L = 100$ pF | | 70° | | |
| | | $A_{VD} = 5$, $R_L = 600\ \Omega$, $C_L = 100$ pF | | 84° | | |

## electrical characteristics at specified free-air temperature, $V_{CC\pm} = \pm15$ V (unless otherwise noted)

| PARAMETER | | | TEST CONDITIONS | $T_A$† | TLE2161M TLE2161AM TLE2161BM MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|---|---|
| $V_{IO}$ | Input offset voltage | TLE2161M | $V_{IC} = 0$, $R_S = 50\ \Omega$ | 25°C | | 0.6 | 3 | mV |
| | | | | Full range | | | 6 | |
| | | TLE2161AM | | 25°C | | 0.5 | 1.5 | |
| | | | | Full range | | | 3.6 | |
| | | TLE2161BM | | 25°C | | 0.3 | 0.5 | |
| | | | | Full range | | | 1.7 | |
| $\alpha_{VIO}$ | Temperature coefficient of input offset voltage | | | Full range | | 6 | | μV/°C |
| | Input offset voltage long-term drift (see Note 4) | | | 25°C | | 0.04 | | μV/mo |
| $I_{IO}$ | Input offset current | | | 25°C | | 2 | | pA |
| | | | | Full range | | | 20 | nA |
| $I_{IB}$ | Input bias current | | | 25°C | | 4 | | pA |
| | | | | Full range | | | 40 | nA |
| $V_{ICR}$ | Common-mode input voltage range | | | 25°C | –11 to 13 | –12 to 16 | | V |
| | | | | Full range | –11 to 13 | | | V |
| $V_{OM+}$ | Maximum positive peak output voltage swing | | $R_L = 10\ k\Omega$ | 25°C | 13.2 | 13.7 | | V |
| | | | | Full range | 12.5 | | | |
| | | | $R_L = 600\ \Omega$ | 25°C | 12.5 | 13.2 | | |
| | | | | Full range | 12 | | | |
| $V_{OM-}$ | Maximum negative peak output voltage swing | | $R_L = 10\ k\Omega$ | 25°C | –13.2 | –13.7 | | V |
| | | | | Full range | –12.5 | | | |
| | | | $R_L = 600\ \Omega$ | 25°C | –12.5 | –13 | | |
| | | | | Full range | –12 | | | |
| $A_{VD}$ | Large-signal differential voltage amplification | | $V_O = \pm10$ V, $R_L = 10\ k\Omega$ | 25°C | 30 | 230 | | V/mV |
| | | | | Full range | 20 | | | |
| | | | $V_O = 0$ to 8 V, $R_L = 600\ \Omega$ | 25°C | 25 | 100 | | |
| | | | | Full range | 7 | | | |
| | | | $V_O = 0$ to –8 V, $R_L = 600\ \Omega$ | 25°C | 3 | 25 | | |
| | | | | Full range | 1 | | | |
| $r_i$ | Input resistance | | | 25°C | | $10^{12}$ | | Ω |
| $c_i$ | Input capacitance | | | 25°C | | 4 | | pF |
| $z_o$ | Open-loop output impedance | | $I_O = 0$ | 25°C | | 280 | | Ω |
| CMRR | Common-mode rejection ratio | | $V_{IC} = V_{ICR}$min, $R_S = 50\ \Omega$ | 25°C | 72 | 90 | | dB |
| | | | | Full range | 65 | | | |
| $k_{SVR}$ | Supply-voltage rejection ratio ($\Delta V_{CC\pm}/\Delta V_{IO}$) | | $V_{CC\pm} = \pm5$ V to $\pm15$ V, $R_S = 50\ \Omega$ | 25°C | 75 | 93 | | dB |
| | | | | Full range | 65 | | | |
| $I_{CC}$ | Supply current | | $V_O = 0$, No load | 25°C | | 290 | 350 | μA |
| | | | | Full range | | | 375 | |
| $\Delta I_{CC}$ | Supply-current change over operating temperature range | | | Full range | | 46 | | μA |

† Full range is – 55°C to 125°C.

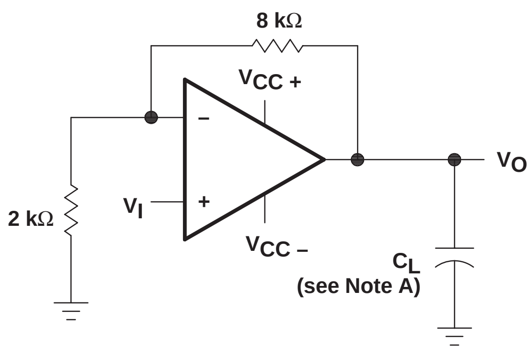
NOTE 4: Typical values are based on the input offset voltage shift observed through 168 hours of operating life test at $T_A = 150°C$ extrapolated to $T_A = 25°C$ using the Arrhenius equation and assuming an activation energy of 0.96 eV.

## operating characteristics at specified free-air temperature, $V_{CC\pm} = \pm 15$ V (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | $T_A$† | TLE2161M TLE2161AM TLE2161BM MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|---|
| SR | Slew rate (see Figure 1) | $A_{VD}$ = 5, $R_L$ = 10 kΩ, $C_L$ = 100 pF | 25°C | 7 | 10 | | V/μs |
| | | | Full range | 5 | | | |
| $V_n$ | Equivalent input noise voltage (see Figure 2) | $R_S$ = 20 Ω, f = 10 Hz | 25°C | | 70 | | nV/√Hz |
| | | $R_S$ = 20 Ω, f = 1 kHz | | | 40 | | |
| $V_{N(PP)}$ | Peak-to-peak equivalent input noise voltage | f = 0.1 Hz to 10 Hz | 25°C | | 1.1 | | μV |
| $I_n$ | Equivalent input noise current | f = 1 Hz | 25°C | | 1.1 | | fA/√Hz |
| THD | Total harmonic distortion | $V_{O(PP)}$ = 2 V, $A_{VD}$ = 5, f = 10 kHz, $R_L$ = 10 kΩ | 25°C | | 0.025% | | |
| | Gain-bandwidth product (see Figure 3) | f = 100 kHz, $R_L$ = 10 kΩ, $C_L$ = 100 pF | 25°C | | 6.4 | | MHz |
| | | f = 100 kHz, $R_L$ = 600 Ω, $C_L$ = 100 pF | | | 5.6 | | |
| $t_s$ | Settling time | ε = 0.1% | 25°C | | 5 | | μs |
| | | ε = 0.01% | | | 10 | | |
| $B_{OM}$ | Maximum output-swing bandwidth | $A_{VD}$ = 5, $R_L$ = 10 kΩ | 25°C | | 116 | | kHz |
| $\phi_m$ | Phase margin (see Figure 3) | $A_{VD}$ = 5, $R_L$ = 10 kΩ, $C_L$ = 100 pF | 25°C | | 72° | | |
| | | $A_{VD}$ = 5, $R_L$ = 600 Ω, $C_L$ = 100 pF | | | 78° | | |

† Full range is – 55°C to 125°C.

## PARAMETER MEASUREMENT INFORMATION




NOTE A: $C_L$ includes fixture capacitance.

**Figure 1. Slew-Rate Test Circuit**

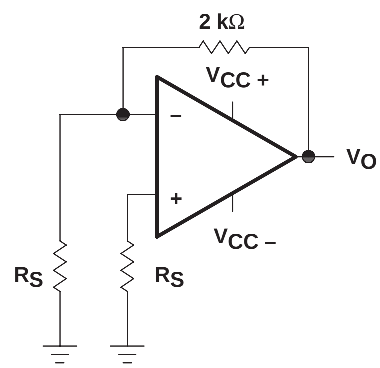
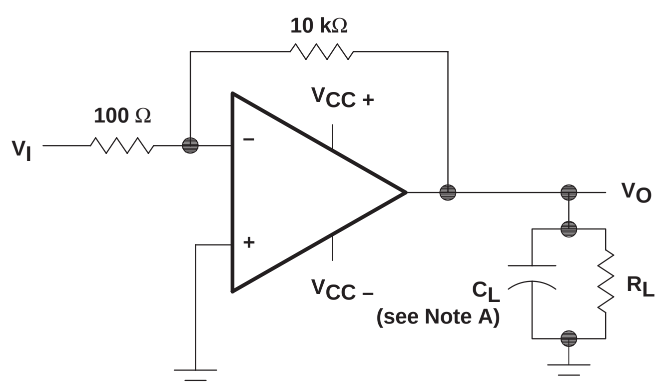



**Figure 2. Noise-Voltage Test Circuit**




NOTE A: $C_L$ includes fixture capacitance.

**Figure 3. Gain-Bandwidth Product and Phase-Margin Test Circuit**

### typical values

Typical values presented in this data sheet represent the median (50% point) of device parametric performance.

### Input bias and offset current

At the picoampere bias-current level typical of the TLE2161, TLE2161A, and TLE2161B, accurate measurement of the bias current becomes difficult. Not only does this measurement require a picoammeter, but test socket leakages can easily exceed the actual device bias currents. To accurately measure these small currents, Texas Instruments uses a two-step process. The socket leakage is measured using picoammeters with bias voltages applied but with no device in the socket. The device is then inserted into the socket, and a second test that measures both the socket leakage and the device input bias current is performed. The two measurements are then subtracted algebraically to determine the bias current of the device.

## TYPICAL CHARACTERISTICS

### Table of Graphs

| | | | FIGURE |
|---|---|---|---|
| $V_{IO}$ | Input offset voltage | Distribution | 4 |
| $I_{IB}$ | Input bias current | vs Common-mode input voltage<br>vs Free-air temperature | 5<br>6 |
| $I_{IO}$ | Input offset current | vs Free-air temperature | 6 |
| $V_{ICR}$ | Common-mode input voltage range limits | vs Free-air temperature | 7 |
| $V_{OM}$ | Maximum positive peak output voltage | vs Output current | 8 |
| $V_{OM}$ | Maximum negative peak output voltage | vs Output current | 9 |
| $V_{OM}$ | Maximum peak output voltage | vs Supply voltage | 10, 11, 12 |
| $V_{O(PP)}$ | Maximum peak-to-peak output voltage | vs Frequency | 13, 14, 15 |
| $A_{VD}$ | Large-signal differential voltage amplification | vs Frequency<br>vs Free-air temperature | 16<br>17 |
| $I_{OS}$ | Short-circuit output current | vs Elapsed time | 18 |
| | Large-signal voltage amplification | vs Free-air temperature | 19 |
| $z_o$ | Output impedance | vs Frequency | 20 |
| CMRR | Common-mode rejection ratio | vs Frequency | 21 |
| $I_{CC}$ | Supply current | vs Supply voltage<br>vs Free-air temperature | 22<br>23 |
| | Pulse response | Small signal<br>Large signal | 24, 25<br>26, 27 |
| | Noise voltage (referred to input) | 0.1 to 10 Hz | 28 |
| $V_n$ | Equivalent input noise voltage | vs Frequency | 29 |
| THD | Total harmonic distortion | vs Frequency | 30, 31 |
| | Gain-bandwidth product | vs Supply voltage<br>vs Free-air temperature | 32<br>33 |
| $\phi_m$ | Phase margin | vs Supply voltage<br>vs Free-air temperature | 34<br>35 |
| | Phase shift | vs Frequency | 16 |

## TYPICAL CHARACTERISTICS†

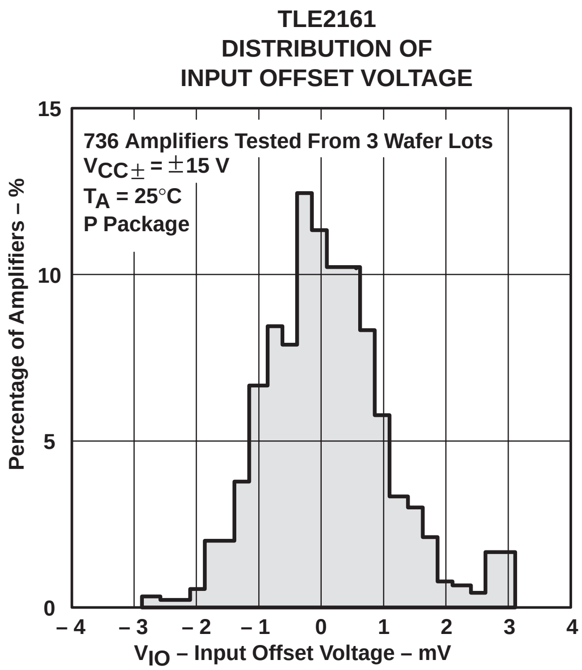



Figure 4

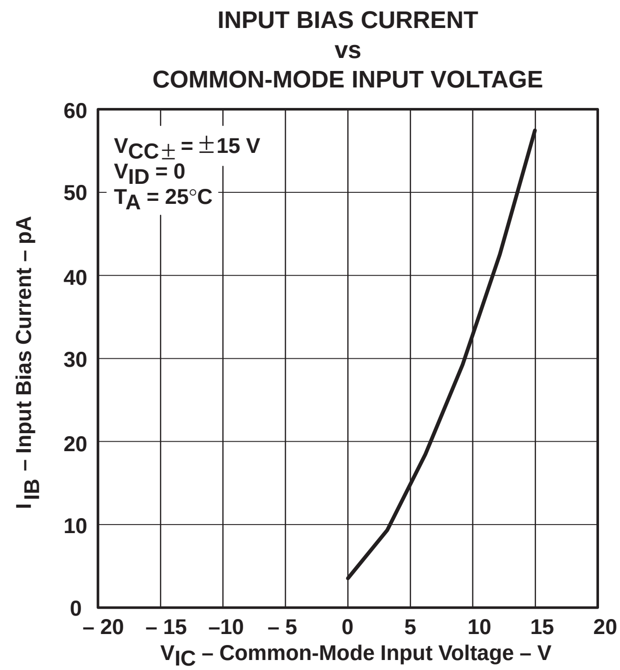



Figure 5

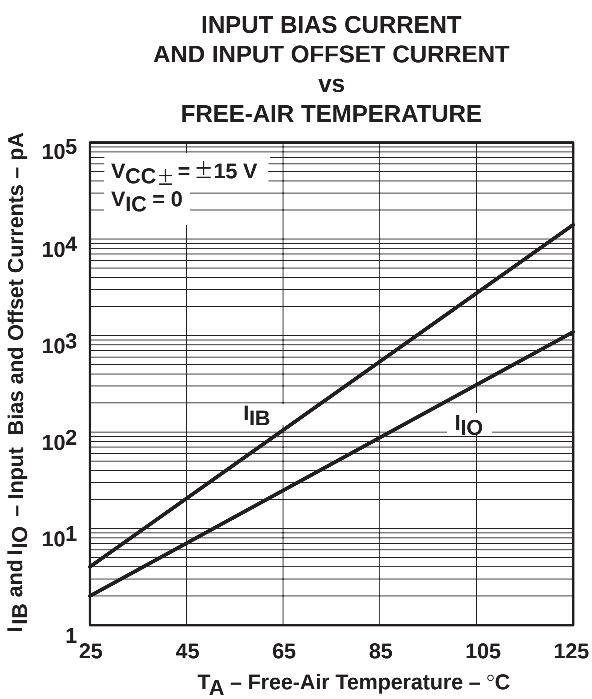



Figure 6

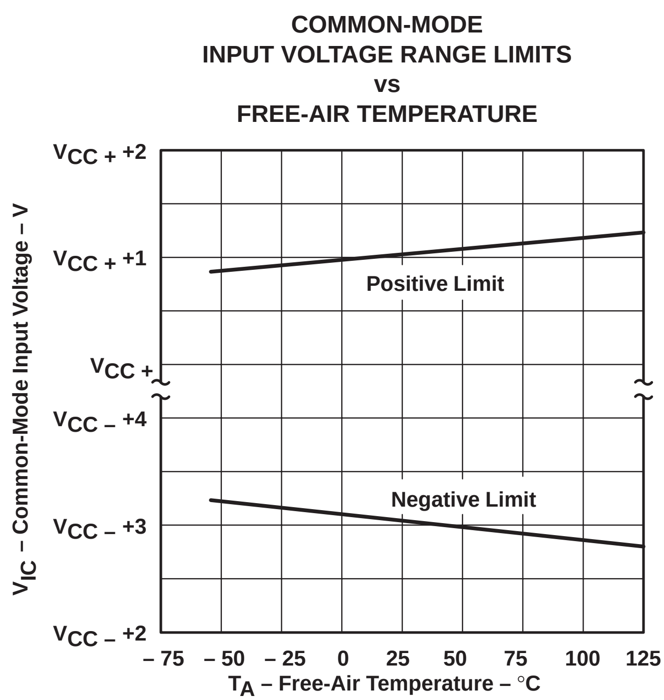



Figure 7

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

## TYPICAL CHARACTERISTICS

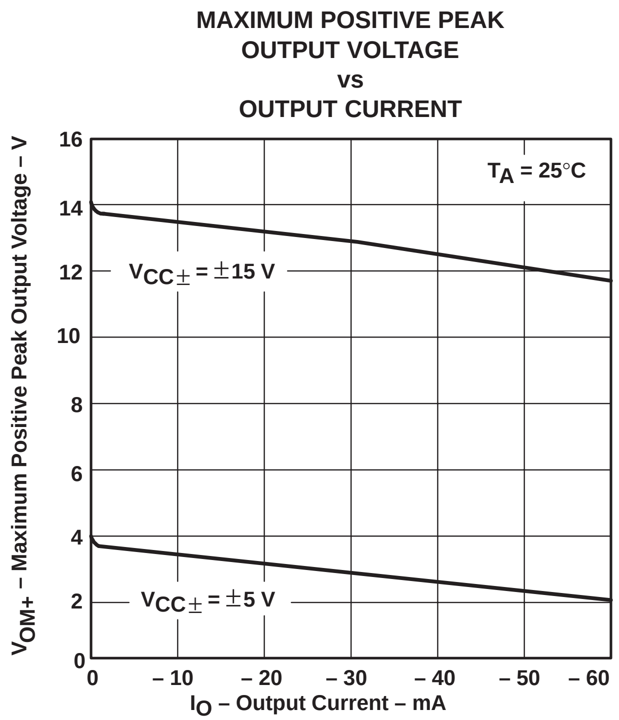



Figure 8

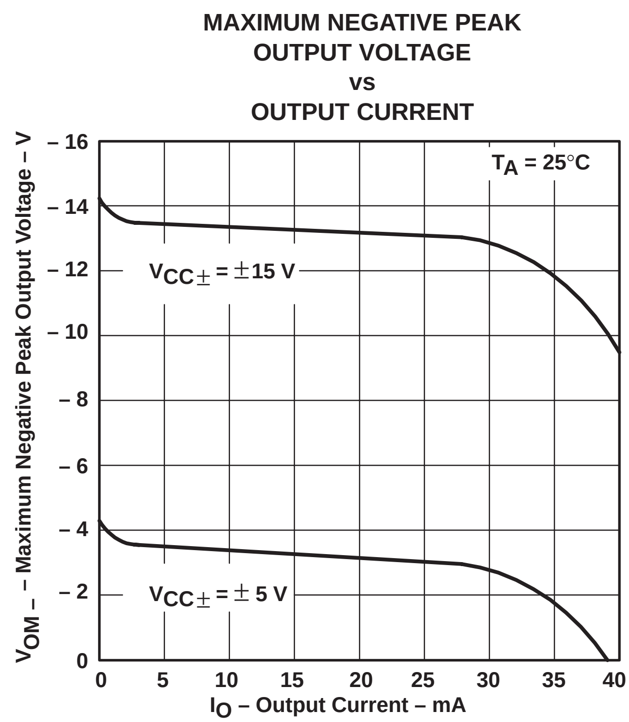



Figure 9

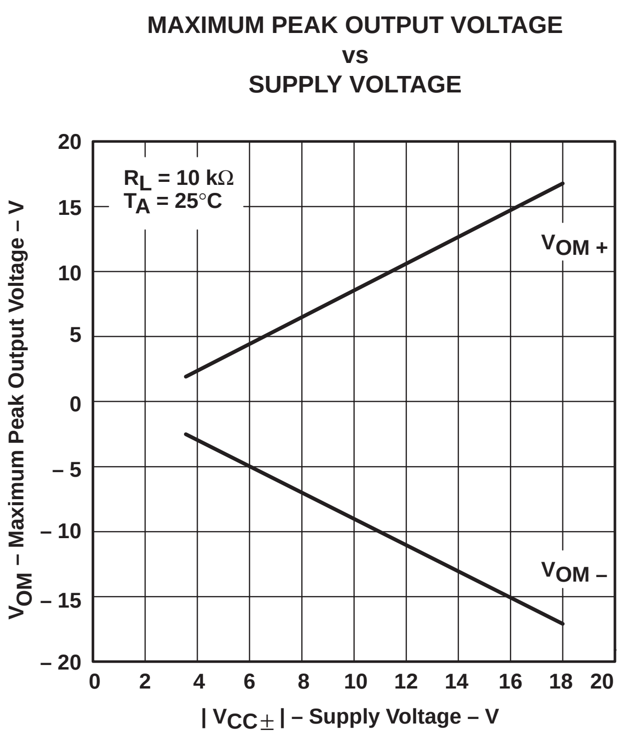



Figure 10

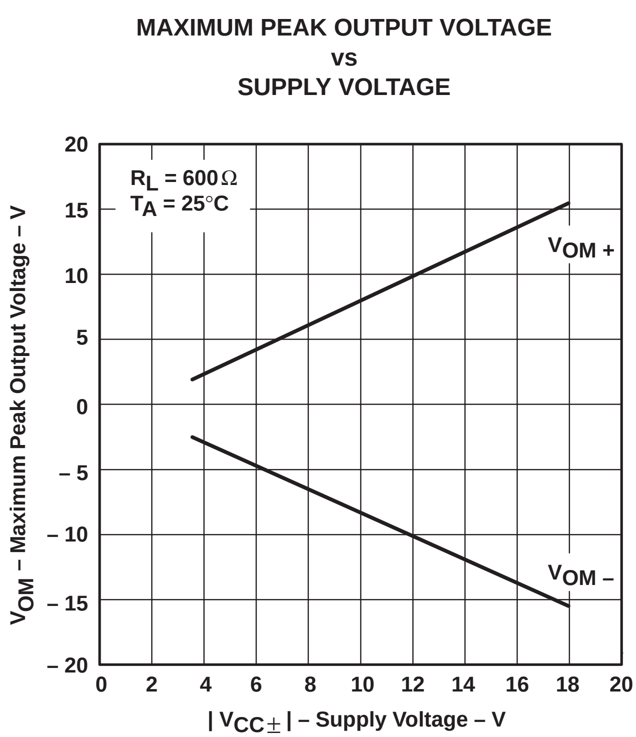



Figure 11

## TYPICAL CHARACTERISTICS

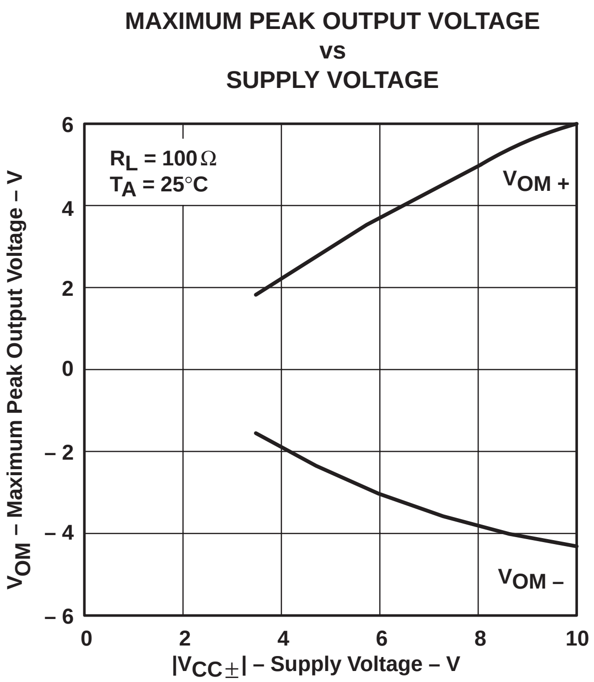



Figure 12

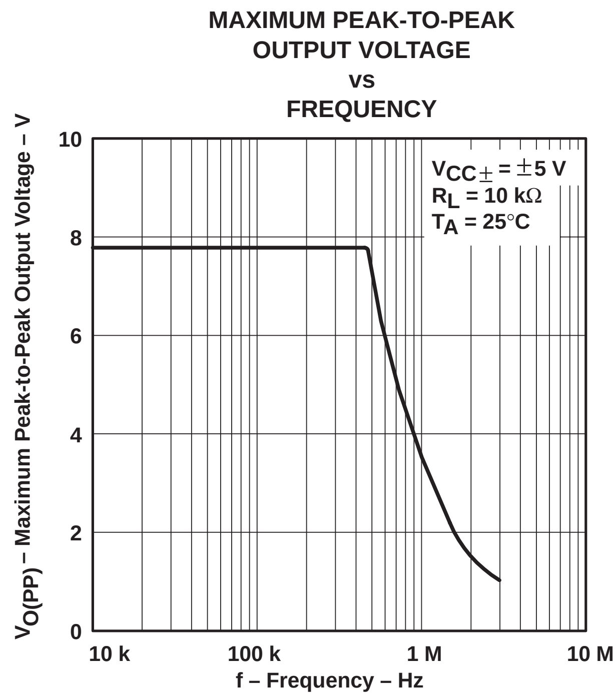



Figure 13

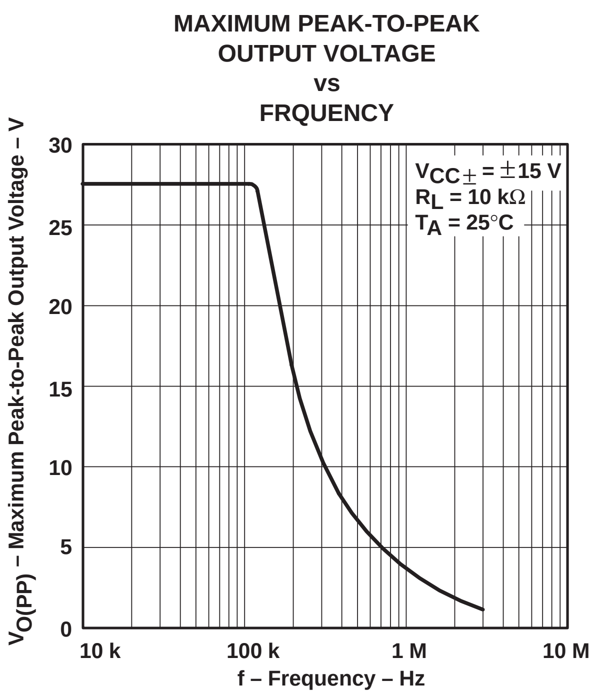



Figure 14

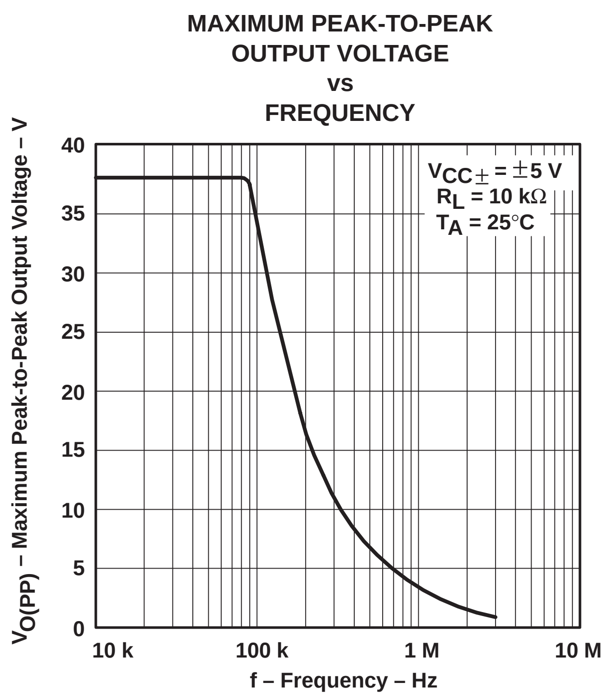



Figure 15

## TYPICAL CHARACTERISTICS†

### LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION AND PHASE SHIFT vs FRQUENCY

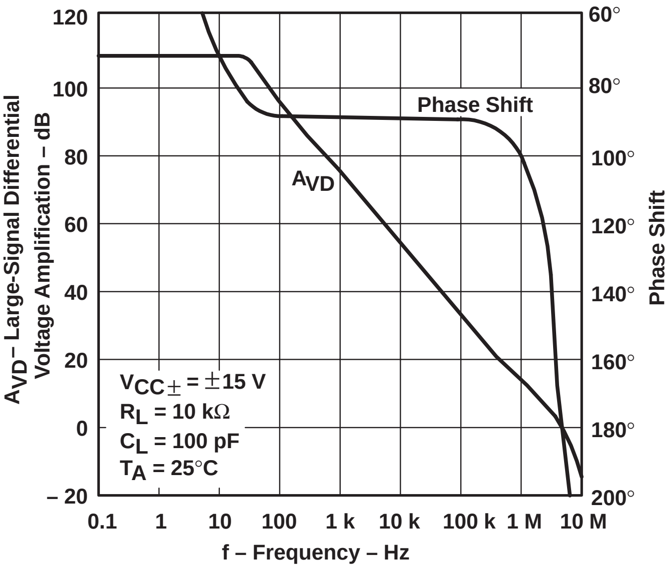



Figure 16

### LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION vs FREE-AIR TEMPERATURE

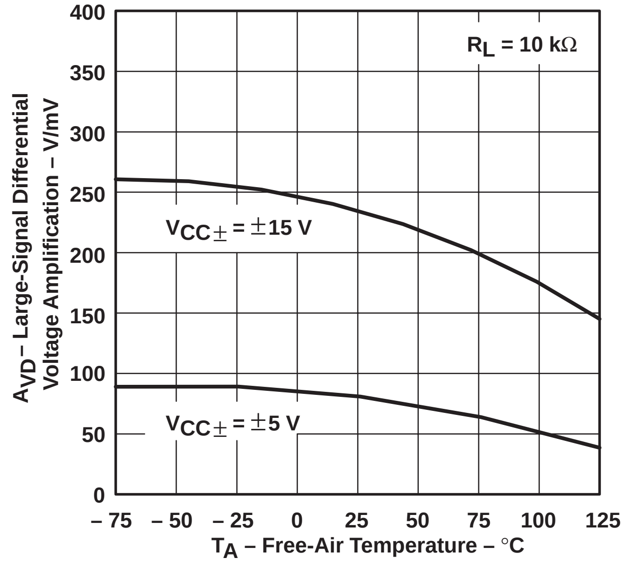



Figure 17

### SHORT-CIRCUIT OUTPUT CURRENT vs ELAPSED TIME

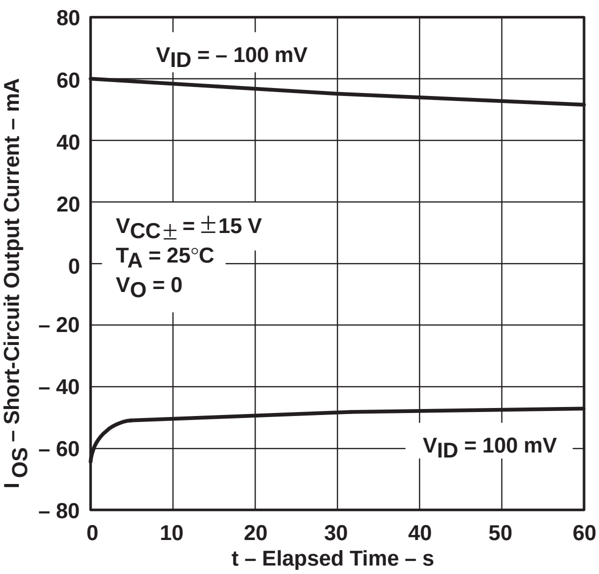



Figure 18

### LARGE-SIGNAL VOLTAGE AMPLIFICATION vs FREE-AIR TEMPERATURE

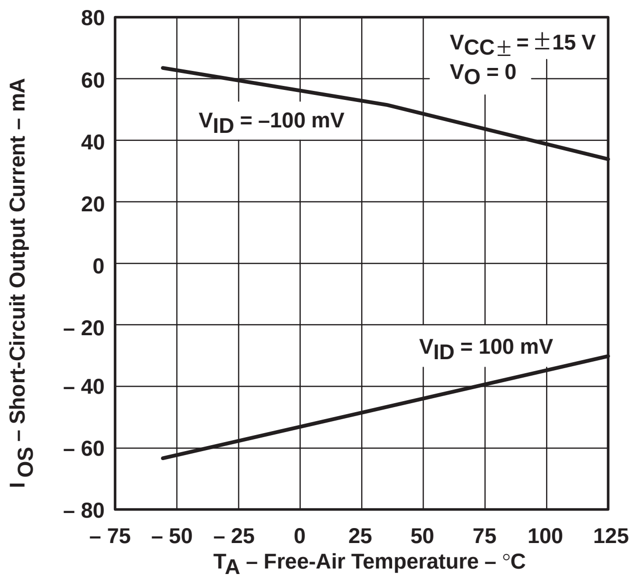



Figure 19

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

## TYPICAL CHARACTERISTICS†

OUTPUT IMPEDANCE
vs
FREQUENCY

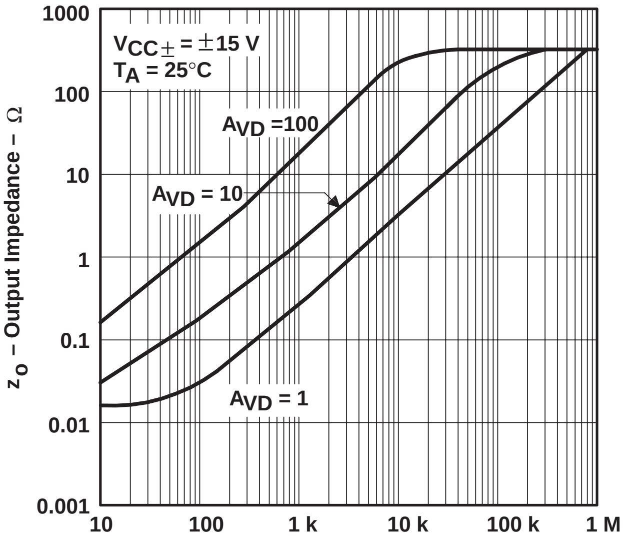



Figure 20

COMMON-MODE REJECTION RATIO
vs
FREQUENCY

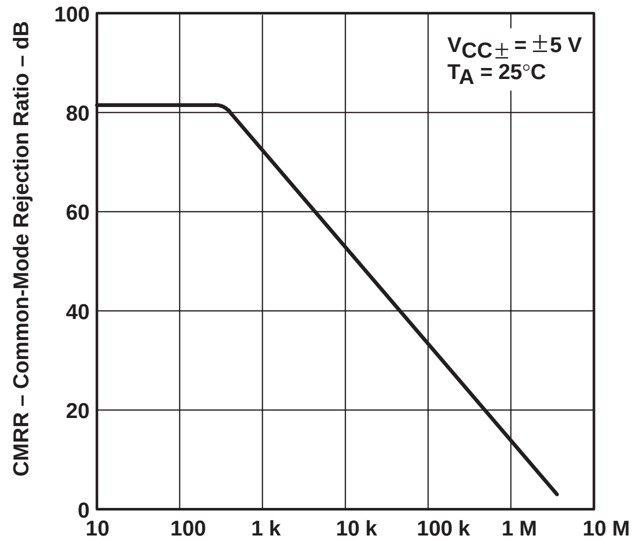



Figure 21

SUPPLY CURRENT
vs
SUPPLY VOLTAGE

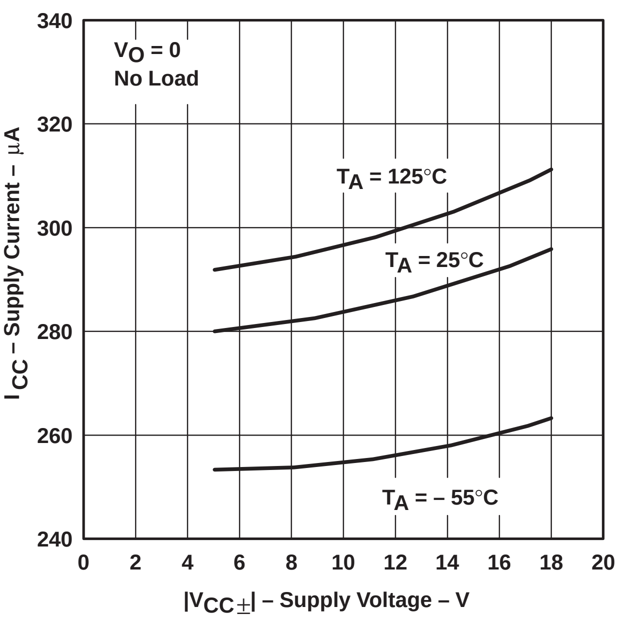



Figure 22

SUPPLY CURRENT
vs
FREE-AIR TEMPERATURE

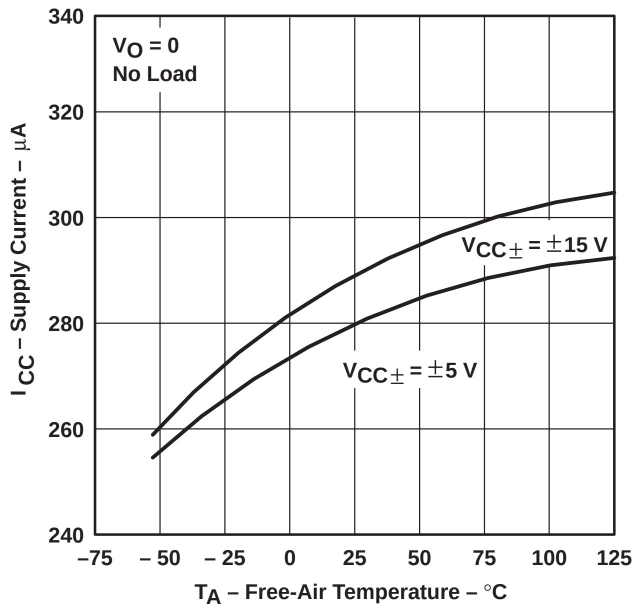



Figure 23

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

## TYPICAL CHARACTERISTICS

SMALL-SIGNAL
PULSE RESPONSE

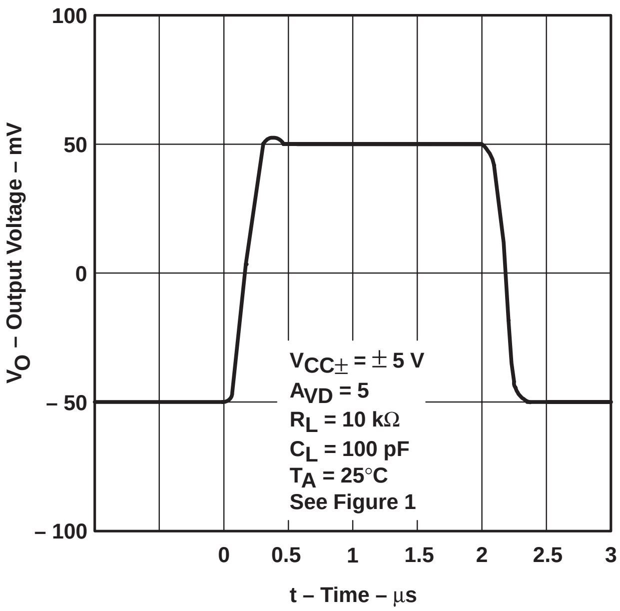



**Figure 24**

SMALL-SIGNAL
PULSE RESPONSE

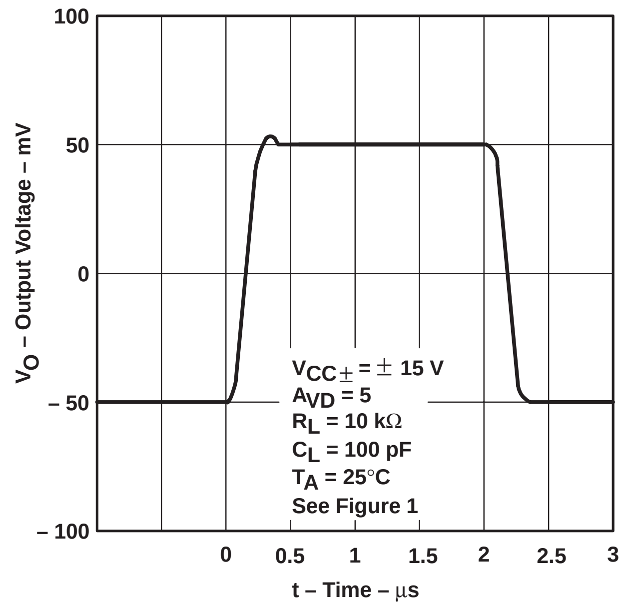



**Figure 25**

LARGE-SIGNAL
PULSE RESPONSE

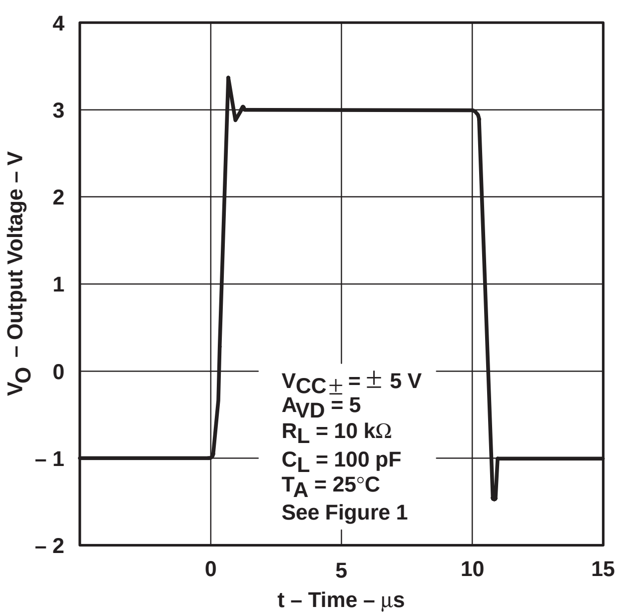



**Figure 26**

LARGE-SIGNAL
PULSE RESPONSE

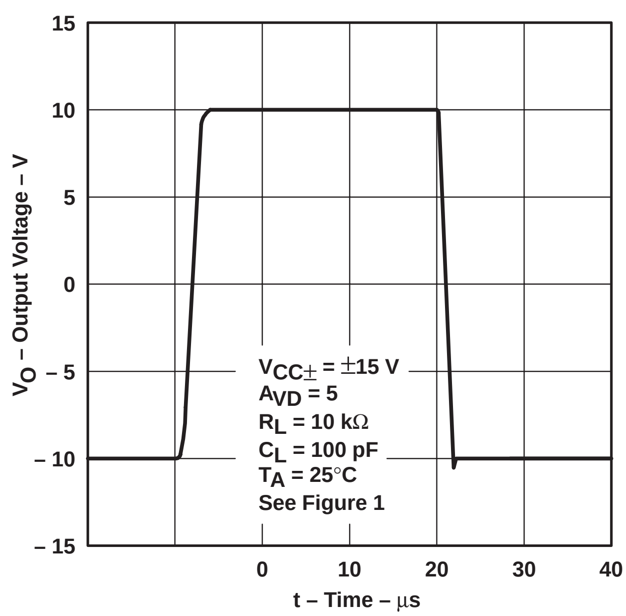



**Figure 27**

## TYPICAL CHARACTERISTICS

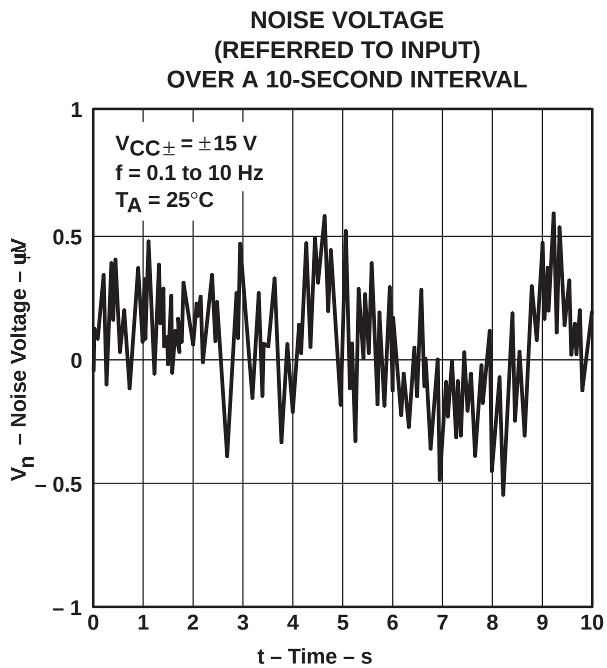



Figure 28

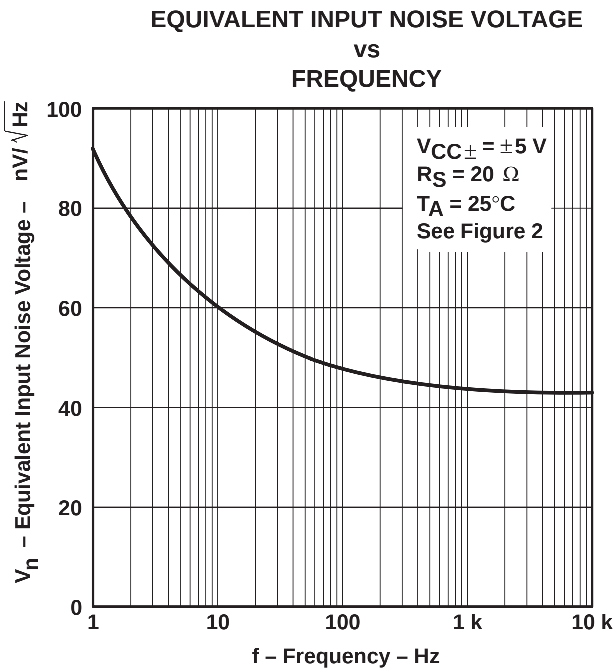



Figure 29

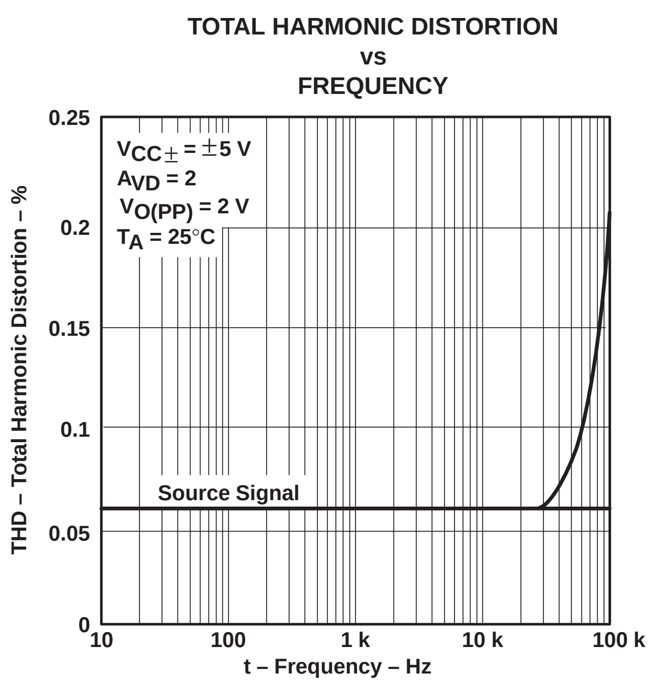



Figure 30

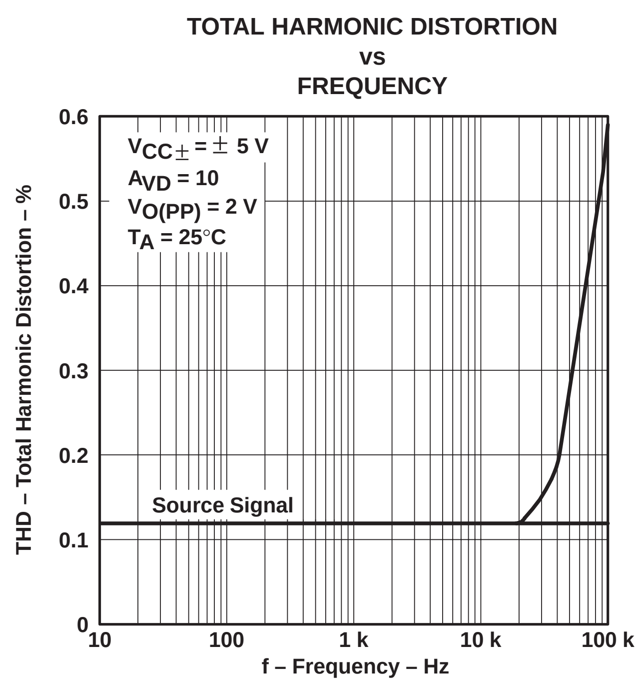



Figure 31

## TYPICAL CHARACTERISTICS

GAIN-BANDWIDTH PRODUCT
vs
SUPPLY VOLTAGE

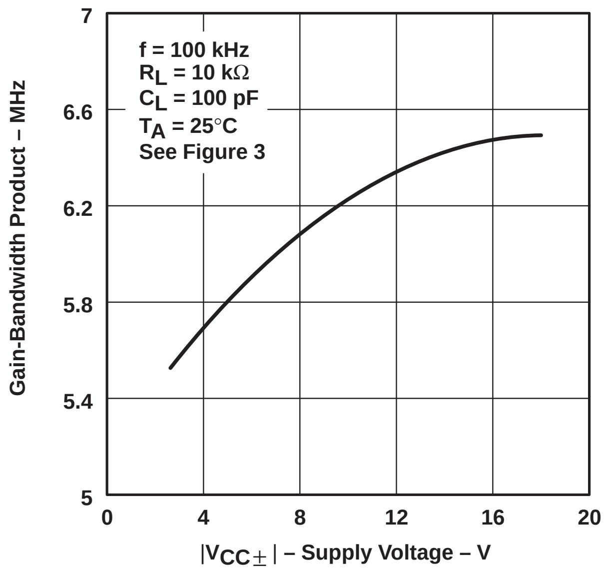



Figure 32

GAIN-BANDWIDTH PRODUCT
vs
FREE-AIR TEMPERATURE

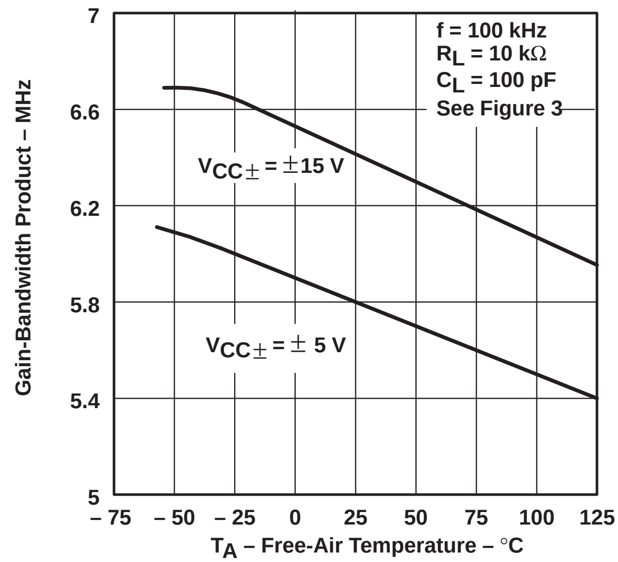



Figure 33

PHASE MARGIN
vs
SUPPLY VOLTAGE

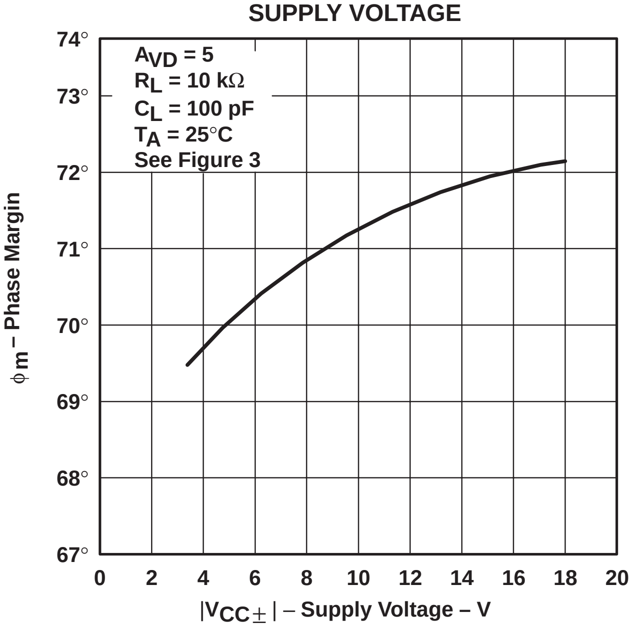



Figure 34

PHASE MARGIN
vs
FREE-AIR TEMPERATURE

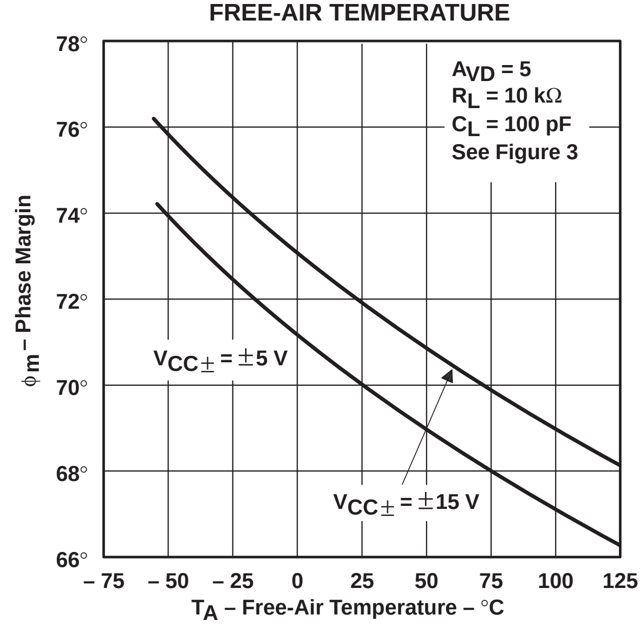



Figure 35

## APPLICATION INFORMATION

### macromodel information

Macromodel information provided was derived using Microsim *Parts*™, the model generation software used with Microsim *PSpice*™. The Boyle macromodel (see Note 5) and subcircuit in Figure 36 and Figure 37 were generated using the TLE2161 typical electrical and operating characteristics at 25°C. Using this information, output simulations of the following key parameters can be generated to a tolerance of 20% (in most cases):

- Maximum positive output voltage swing
- Maximum negative output voltage swing
- Slew rate
- Quiescent power dissipation
- Input bias current
- Open-loop voltage amplification
- Gain-bandwidth product
- Common-mode rejection ratio
- Phase margin
- DC output resistance
- AC output resistance
- Short-circuit output current limit

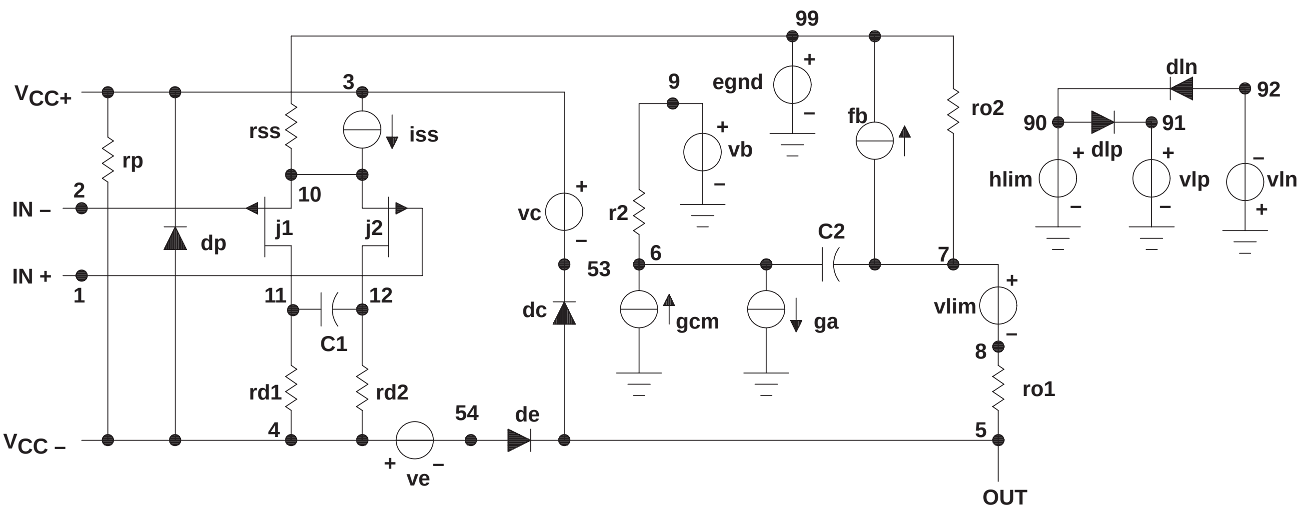



**Figure 36. Boyle Macromodel**

NOTE 5: G. R. Boyle, B. M. Cohn, D. O. Pederson, and J. E. Solomon, "Macromodeling of Integrated Circuit Operational Amplifiers", *IEEE Journal of Solid-State Circuits*, SC-9, 353 (1974).

*PSpice* and *Parts* are trademark of MicroSim Corporation.

## APPLICATION INFORMATION

### macromodel information (continued)

```
.subckt TLE2161 1 2 3 4 5
 c1    11  12  125.4E–14
 c2     6   7  5.000E–12
 dc     5  53  dx
 de    54  5d  x
 dlp   90  91  dx
 dln   92  90  dx
 dp     4   3  dx
 egnd  99   0  poly(2) (3,0) (4,0) 0 .5 .5
 fb     7  99  poly(5) vb vc ve vlp vln 0 4.085E6 –4E6 4E6 4E6 –4E6
 ga     6   0  11 12 201.1E–6
 gcm    0   6  10 99 3.576E–9
 iss    3  10  dc 45.00E–6
 hlim  90   0  vlim 1K
 j1    11   2  10 jx
 j2    12   1  10 jx
 r2     6   9  100.0E3
 rd1    4  11  4.973E3
 rd2    4  12  4.973E3
 ro1    8   5  280
 ro2    7  99  280
 rp     3   4  113.2E3
 rss   10  99  4.444E6
 vb     9   0  dc 0
 vc     3  53  dc 2
 ve    54   4  dc 2
 vlim   7   8  dc 0
 vlp   91   0  dc 50
 vln    0  92  dc 50
.model dx   D  (Is=800.0E–18)
.model jx PJF  (Is=1.000E–12 Beta=480E–6 Vto=–1)
.ends
```

**Figure 37. Macromodel Subcircuit**

## APPLICATION INFORMATION

### input characteristics

The TLE2161, TLE2161A and TLE2161B are specified with a minimum and a maximum input voltage that if exceeded at either input could cause the device to malfunction.

Because of the extremely high input impedance and resulting low bias-current requirements, the TLE2161, TLE2161A, and TLE2161B are well suited for low-level signal processing; however, leakage currents on printed circuit boards and sockets can easily exceed bias-current requirements and cause degradation in system performance. It is a good practice to include guard rings around inputs (see Figure 38). These guards should be driven from a low-impedance source at the same voltage level as the common-mode input.

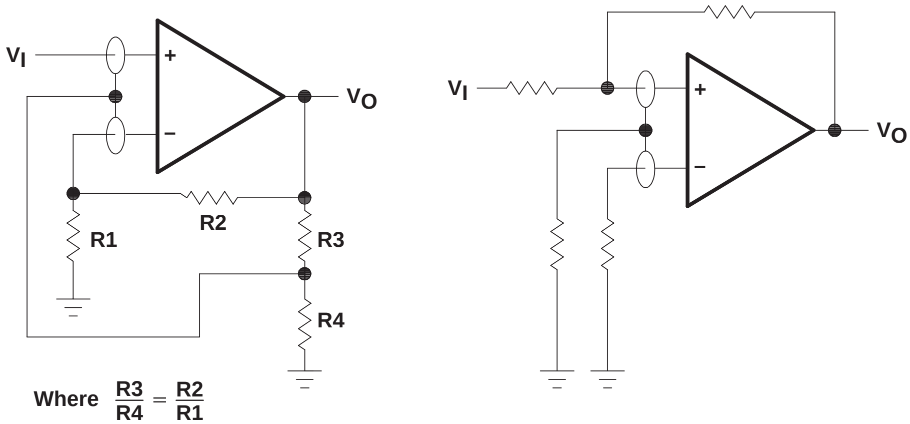



**Figure 38. Use of Guard Rings**

### input offset voltage nulling

The TLE2161 series offers external null pins that can further reduce the input offset voltage. The circuit in Figure 39 can be connected as shown if the feature is desired. When external nulling is not needed, the null pins may be left disconnected.

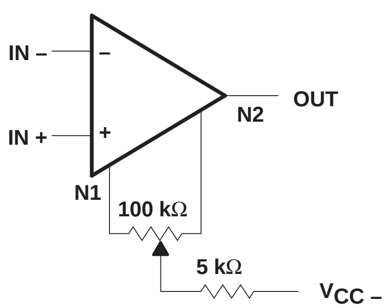



**Figure 39. Input Offset Voltage Nulling**

## PACKAGING INFORMATION

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead/ Ball Finish | MSL Peak Temp (3) | Samples (Requires Login) |
|---|---|---|---|---|---|---|---|---|---|
| 5962-9095801Q2A | ACTIVE | LCCC | FK | 20 | 1 | TBD | Call TI | Call TI | |
| 5962-9095801QPA | ACTIVE | CDIP | JG | 8 | 1 | TBD | Call TI | Call TI | |
| 5962-9095802Q2A | ACTIVE | LCCC | FK | 20 | 1 | TBD | Call TI | Call TI | |
| 5962-9095802QPA | ACTIVE | CDIP | JG | 8 | 1 | TBD | Call TI | Call TI | |
| 5962-9095803Q2A | ACTIVE | LCCC | FK | 20 | 1 | TBD | Call TI | Call TI | |
| 5962-9095803QPA | ACTIVE | CDIP | JG | 8 | 1 | TBD | Call TI | Call TI | |
| TLE2161ACD | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | |
| TLE2161ACDG4 | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | |
| TLE2161ACP | OBSOLETE | PDIP | P | 8 | | TBD | Call TI | Call TI | |
| TLE2161AID | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | |
| TLE2161AIDG4 | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | |
| TLE2161AIDR | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | |
| TLE2161AIDRG4 | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | |
| TLE2161AIP | OBSOLETE | PDIP | P | 8 | | TBD | Call TI | Call TI | |
| TLE2161AMFKB | ACTIVE | LCCC | FK | 20 | 1 | TBD | POST-PLATE | N / A for Pkg Type | |
| TLE2161AMJGB | ACTIVE | CDIP | JG | 8 | 1 | TBD | A42 | N / A for Pkg Type | |
| TLE2161BCP | OBSOLETE | PDIP | P | 8 | | TBD | Call TI | Call TI | |
| TLE2161BIP | OBSOLETE | PDIP | P | 8 | | TBD | Call TI | Call TI | |
| TLE2161BMFKB | ACTIVE | LCCC | FK | 20 | 1 | TBD | POST-PLATE | N / A for Pkg Type | |
| TLE2161BMJG | ACTIVE | CDIP | JG | 8 | 1 | TBD | A42 | N / A for Pkg Type | |
| TLE2161BMJGB | ACTIVE | CDIP | JG | 8 | 1 | TBD | A42 | N / A for Pkg Type | |
| TLE2161BMP | OBSOLETE | PDIP | P | 8 | | TBD | Call TI | Call TI | |
| TLE2161CD | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | |
| TLE2161CDG4 | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | |

| Orderable Device | Status [1] | Package Type | Package Drawing | Pins | Package Qty | Eco Plan [2] | Lead/ Ball Finish | MSL Peak Temp [3] | Samples (Requires Login) |
|---|---|---|---|---|---|---|---|---|---|
| TLE2161CP | OBSOLETE | PDIP | P | 8 | | TBD | Call TI | Call TI | |
| TLE2161ID | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | |
| TLE2161IDG4 | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | |
| TLE2161IDR | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | |
| TLE2161IDRG4 | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM | |
| TLE2161IP | OBSOLETE | PDIP | P | 8 | | TBD | Call TI | Call TI | |
| TLE2161MFKB | ACTIVE | LCCC | FK | 20 | 1 | TBD | POST-PLATE | N / A for Pkg Type | |
| TLE2161MJGB | ACTIVE | CDIP | JG | 8 | 1 | TBD | A42 | N / A for Pkg Type | |
| TLE2161MP | OBSOLETE | PDIP | P | 8 | | TBD | Call TI | Call TI | |

[1] The marketing status values are defined as follows:
**ACTIVE:** Product device recommended for new designs.
**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.
**OBSOLETE:** TI has discontinued the production of the device.

[2] Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
**TBD:** The Pb-Free/Green conversion plan has not been defined.
**Pb-Free (RoHS):** TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
**Pb-Free (RoHS Exempt):** This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

[3] MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

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**OTHER QUALIFIED VERSIONS OF TLE2161, TLE2161A, TLE2161AM, TLE2161B, TLE2161BM, TLE2161M :**

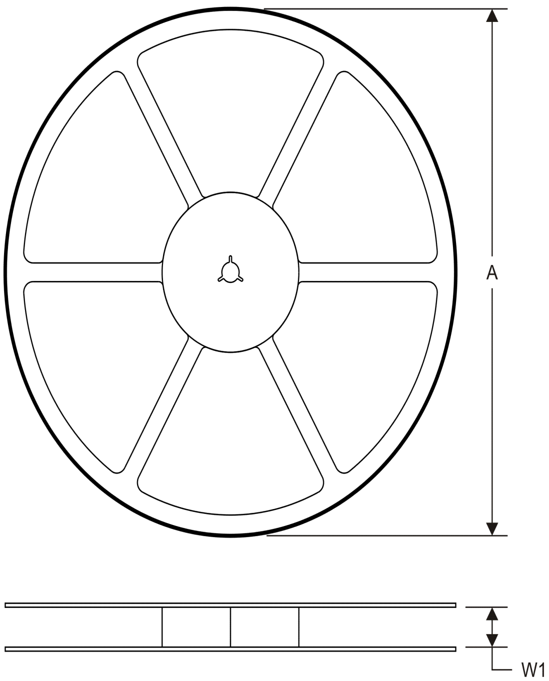
- Catalog: TLE2161A, TLE2161B, TLE2161
- Military: TLE2161M, TLE2161AM, TLE2161BM

NOTE: Qualified Version Definitions:

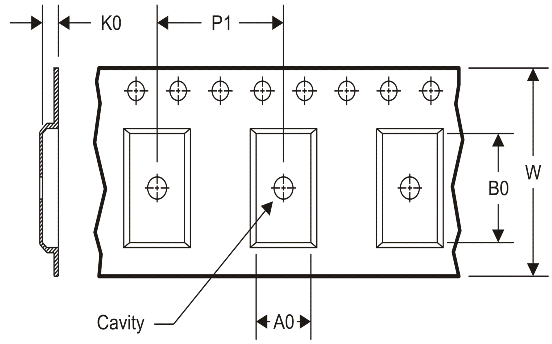
- Catalog - TI's standard catalog product
- Military - QML certified for Military and Defense Applications

## TAPE AND REEL INFORMATION

### REEL DIMENSIONS




### TAPE DIMENSIONS



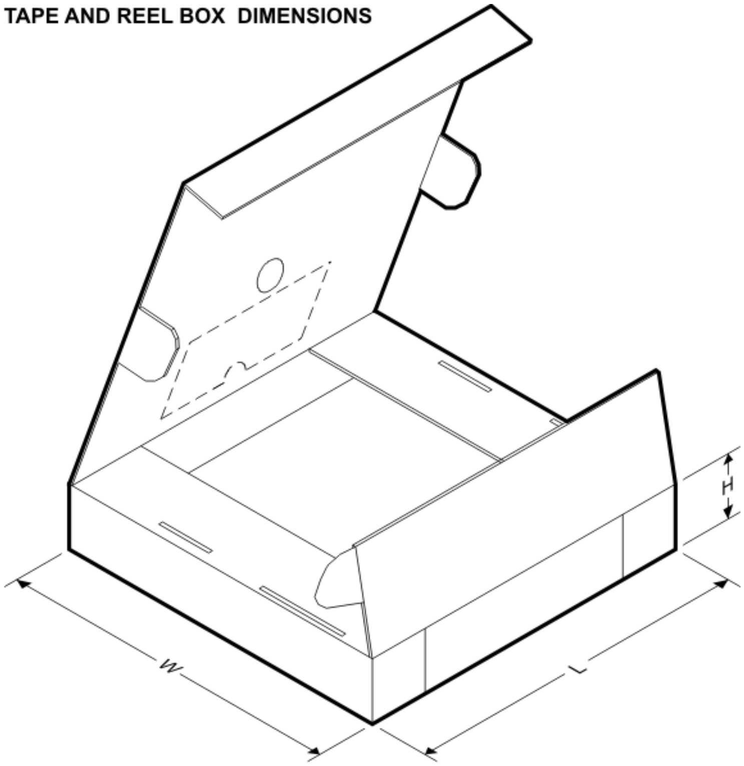

| | |
|---|---|
| A0 | Dimension designed to accommodate the component width |
| B0 | Dimension designed to accommodate the component length |
| K0 | Dimension designed to accommodate the component thickness |
| W | Overall width of the carrier tape |
| P1 | Pitch between successive cavity centers |

### TAPE AND REEL INFORMATION

*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TLE2161AIDR | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.4 | 5.2 | 2.1 | 8.0 | 12.0 | Q1 |
| TLE2161IDR | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.4 | 5.2 | 2.1 | 8.0 | 12.0 | Q1 |
| TLE2161IDR | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.4 | 5.2 | 2.1 | 8.0 | 12.0 | Q1 |

## TAPE AND REEL BOX DIMENSIONS




*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|---|---|---|---|---|---|---|---|
| TLE2161AIDR | SOIC | D | 8 | 2500 | 340.5 | 338.1 | 20.6 |
| TLE2161IDR | SOIC | D | 8 | 2500 | 367.0 | 367.0 | 35.0 |
| TLE2161IDR | SOIC | D | 8 | 2500 | 340.5 | 338.1 | 20.6 |

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- Лицензия ФСБ на осуществление работ с использованием сведений, составляющих государственную тайну;
- Поставка специализированных компонентов (Xilinx, Altera, Analog Devices, Intersil, Interpoint, Microsemi, Aeroflex, Peregrine, Syfer, Eurofarad, Texas Instrument, Miteq, Cobham, E2V, MA-COM, Hittite, Mini-Circuits,General Dynamics и др.);

Помимо этого, одним из направлений компании «ЭлектроПласт» является направление «Источники питания». Мы предлагаем Вам помощь Конструкторского отдела:

- Подбор оптимального решения, техническое обоснование при выборе компонента;
- Подбор аналогов;
- Консультации по применению компонента;
- Поставка образцов и прототипов;
- Техническая поддержка проекта;
- Защита от снятия компонента с производства.


### Как с нами связаться

**Телефон:** 8 (812) 309 58 32 (многоканальный)
**Факс:** 8 (812) 320-02-42
**Электронная почта:** org@eplast1.ru
**Адрес:** 198099, г. Санкт-Петербург, ул. Калинина, дом 2, корпус 4, литера А.