

**TLE2161, TLE2161A, TLE2161B**  
**EXCALIBUR JFET-INPUT HIGH-OUTPUT-DRIVE**  
**μPOWER OPERATIONAL AMPLIFIERS**  
 SLOS049D – NOVEMBER 1989 – REVISED MAY 1996

- **Excellent Output Drive Capability**  
 $V_O = \pm 2.5 \text{ V Min at } R_L = 100 \, \Omega$ ,  
 $V_{CC\pm} = \pm 5 \text{ V}$   
 $V_O = \pm 12.5 \text{ V Min at } R_L = 600 \, \Omega$ ,  
 $V_{CC\pm} = \pm 15 \text{ V}$
- **Low Supply Current . . . 280 μA Typ**
- **Decompensated for High Slew Rate and Gain-Bandwidth Product**  
 $A_{VD} = 0.5 \text{ Min}$   
**Slew Rate = 10 V/μs Typ**  
**Gain-Bandwidth Product = 6.5 MHz Typ**

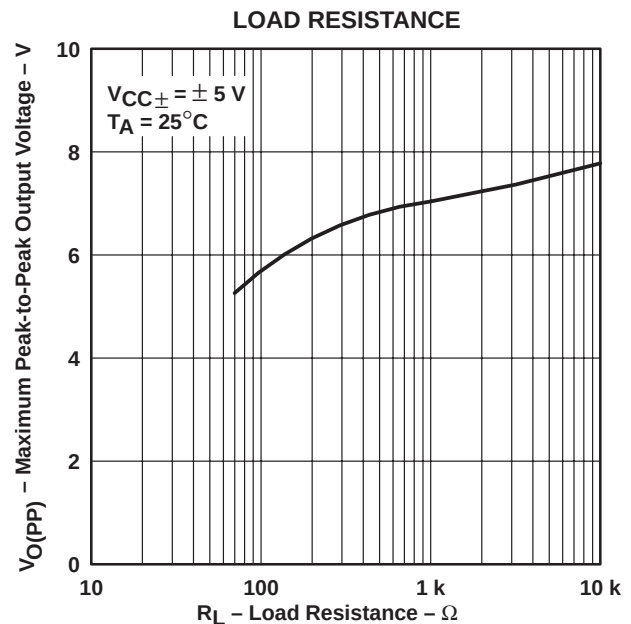
- **Wide Operating Supply Voltage Range**  
 $V_{CC\pm} = \pm 3.5 \text{ V to } \pm 18 \text{ V}$
- **High Open-Loop Gain . . . 280 V/mV Typ**
- **Low Offset Voltage . . . 500 μV Max**
- **Low Offset Voltage Drift With Time**  
**0.04 μV/Month Typ**
- **Low Input Bias Current . . . 5 pA Typ**

## 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**



**AVAILABLE OPTIONS**

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

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



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

PRODUCTION DATA information is current as of publication date. Products conform to specifications per the terms of Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.

**TEXAS  
INSTRUMENTS**

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# TLE2161, TLE2161A, TLE2161B

## EXCALIBUR JFET-INPUT HIGH-OUTPUT-DRIVE

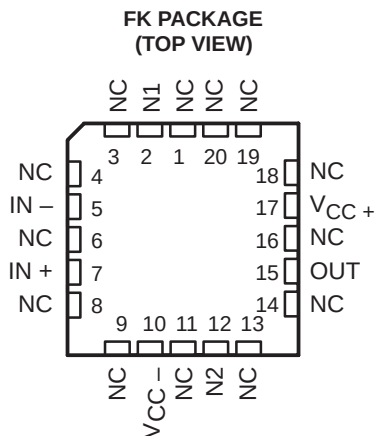
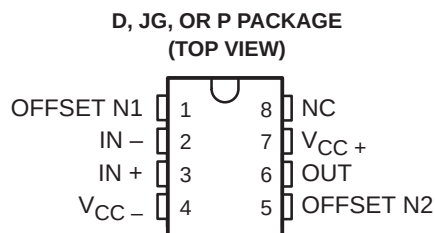
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#### description (continued)

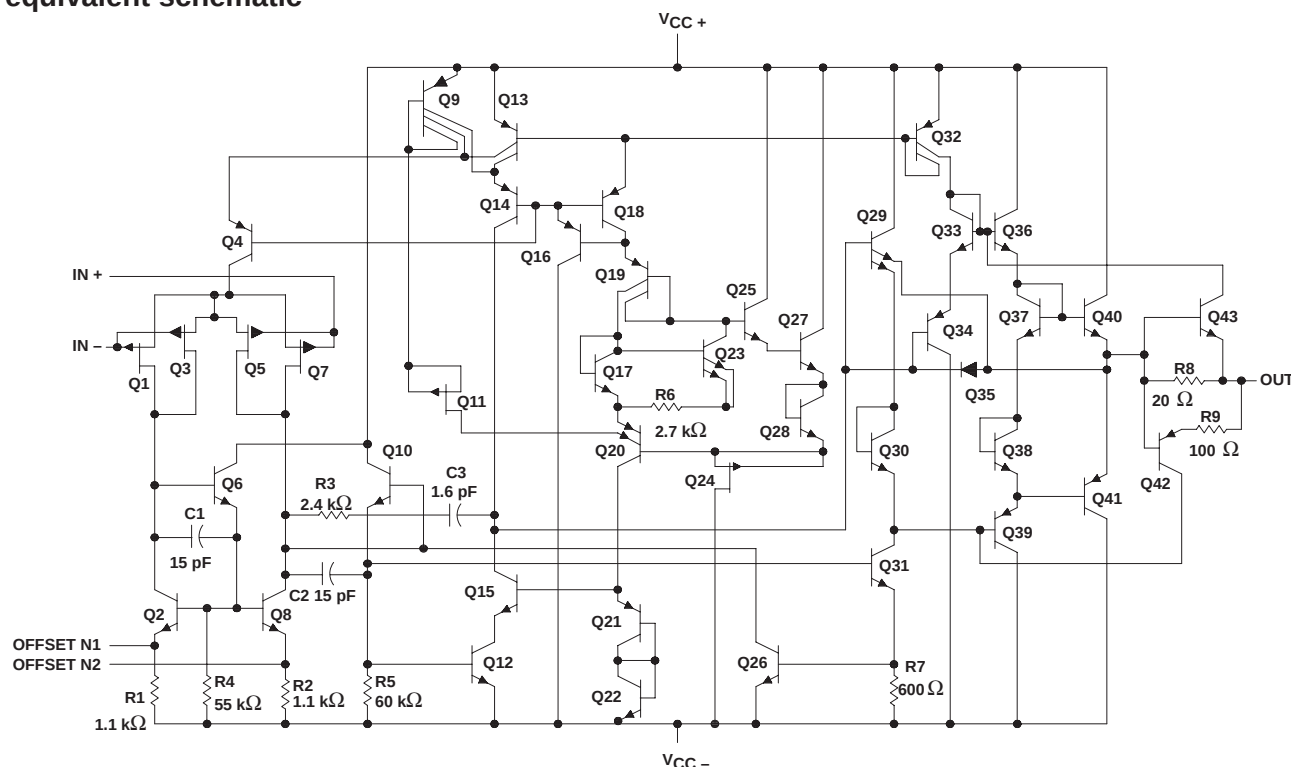
A variety of available options includes small-outline packages and chip-carrier versions for high-density system applications.

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.



NC – No internal connection

#### equivalent schematic



All component values are nominal.

**absolute maximum ratings over operating free-air temperature range (unless otherwise noted)<sup>†</sup>**

|                                                                              |                              |
|------------------------------------------------------------------------------|------------------------------|
| 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)                                       | $V_{CC+}$ to $V_{CC-}$       |
| 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                        |

<sup>†</sup> 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 | $T_A \leq 25^\circ\text{C}$<br>POWER RATING | DERATING FACTOR<br>ABOVE $T_A = 25^\circ\text{C}$ | $T_A = 70^\circ\text{C}$<br>POWER RATING | $T_A = 85^\circ\text{C}$<br>POWER RATING | $T_A = 125^\circ\text{C}$<br>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, $V_{IC}$   | $V_{CC+} \pm \pm 5\text{ V}$  | –1.6     | 4   | –1.6     | 4   | –1.6     | 4   | V    |
|                                       | $V_{CC+} \pm \pm 15\text{ V}$ | –11      | 13  | –11      | 13  | –11      | 13  |      |
| Operating free-air temperature, $T_A$ |                               | 0        | 70  | –40      | 85  | –55      | 125 | °C   |

# TLE2161, TLE2161A, TLE2161B

## EXCALIBUR JFET-INPUT HIGH-OUTPUT-DRIVE

### μPOWER OPERATIONAL AMPLIFIERS

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

| PARAMETER                                                                              |                                                                   | TEST CONDITIONS                                             | T <sub>A</sub> <sup>†</sup> | TLE2161C, TLE2161AC<br>TLE2161BC |      |       | UNIT |
|----------------------------------------------------------------------------------------|-------------------------------------------------------------------|-------------------------------------------------------------|-----------------------------|----------------------------------|------|-------|------|
|                                                                                        |                                                                   |                                                             |                             | MIN                              | TYP  | MAX   |      |
| V <sub>IO</sub> Input offset voltage                                                   | TLE2161C                                                          | V <sub>IC</sub> = 0,                  R <sub>S</sub> = 50 Ω | 25°C                        | 0.8      3.1                     |      | mV    |      |
|                                                                                        | TLE2161AC                                                         |                                                             | Full range                  | 4                                |      |       |      |
|                                                                                        |                                                                   |                                                             | 25°C                        | 0.6      2.6                     |      |       |      |
|                                                                                        | TLE2161BC                                                         |                                                             | Full range                  | 3.5                              |      |       |      |
| 25°C                                                                                   |                                                                   |                                                             | 0.5      1.9                |                                  |      |       |      |
|                                                                                        | Full range                                                        |                                                             | 2.4                         |                                  |      |       |      |
| α <sub>VIO</sub> 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 <sub>IO</sub> Input offset current                                                   |                                                                   |                                                             | 25°C                        | 1                                |      | pA    |      |
|                                                                                        |                                                                   |                                                             | Full range                  | 0.8                              |      | nA    |      |
|                                                                                        |                                                                   |                                                             | 25°C                        | 3                                |      | pA    |      |
| I <sub>IB</sub> Input bias current                                                     |                                                                   |                                                             | Full range                  | 2                                |      | nA    |      |
| V <sub>ICR</sub> Common-mode input voltage range                                       |                                                                   | 25°C                                                        | −1.6<br>to 4                | −2<br>to 6                       | V    |       |      |
|                                                                                        |                                                                   | Full range                                                  | −1.6<br>to 4                |                                  | V    |       |      |
| V <sub>OM</sub> +      Maximum positive peak output voltage swing                      | R <sub>L</sub> = 10 kΩ                                            | 25°C                                                        | 3.5                         | 3.7                              | V    |       |      |
|                                                                                        |                                                                   | Full range                                                  | 3.3                         |                                  |      |       |      |
|                                                                                        | R <sub>L</sub> = 100 Ω                                            | 25°C                                                        | 2.5                         | 3.1                              |      |       |      |
|                                                                                        |                                                                   | Full range                                                  | 2                           |                                  |      |       |      |
| V <sub>OM</sub> −      Maximum negative peak output voltage swing                      | R <sub>L</sub> = 10 kΩ                                            | 25°C                                                        | −3.7                        | −3.9                             | V    |       |      |
|                                                                                        |                                                                   | Full range                                                  | −3.3                        |                                  |      |       |      |
|                                                                                        | R <sub>L</sub> = 100 Ω                                            | 25°C                                                        | −2.5                        | −2.7                             |      |       |      |
|                                                                                        |                                                                   | Full range                                                  | −2                          |                                  |      |       |      |
| A <sub>VD</sub> Large-signal differential voltage amplification                        | V <sub>O</sub> = ±2.8 V,      R <sub>L</sub> = 10 kΩ              | 25°C                                                        | 15                          | 80                               | V/mV |       |      |
|                                                                                        |                                                                   | Full range                                                  | 2                           |                                  |      |       |      |
|                                                                                        | V <sub>O</sub> = 0 to 2 V,      R <sub>L</sub> = 100 Ω            | 25°C                                                        | 0.75                        | 45                               |      |       |      |
|                                                                                        |                                                                   | Full range                                                  | 0.5                         |                                  |      |       |      |
|                                                                                        | V <sub>O</sub> = 0 to −2 V,      R <sub>L</sub> = 100 Ω           | 25°C                                                        | 0.5                         | 3                                |      |       |      |
|                                                                                        |                                                                   | Full range                                                  | 0.25                        |                                  |      |       |      |
| r <sub>i</sub> Input resistance                                                        |                                                                   | 25°C                                                        | 10 <sup>12</sup>            |                                  | Ω    |       |      |
| c <sub>i</sub> Input capacitance                                                       |                                                                   | 25°C                                                        | 4                           |                                  | pF   |       |      |
| z <sub>O</sub> Open-loop output impedance                                              | I <sub>O</sub> = 0                                                | 25°C                                                        | 280                         |                                  | Ω    |       |      |
| CMRR      Common-mode rejection ratio                                                  | V <sub>IC</sub> =V <sub>ICRmin</sub> ,      R <sub>S</sub> = 50 Ω | 25°C                                                        | 65                          | 82                               | dB   |       |      |
|                                                                                        |                                                                   | Full range                                                  | 65                          |                                  |      |       |      |
| k <sub>SVR</sub> Supply-voltage rejection ratio (ΔV <sub>CC±</sub> /ΔV <sub>IO</sub> ) | V <sub>CC±</sub> = ±5 V to ±15 V,<br>R <sub>S</sub> = 50 Ω        | 25°C                                                        | 75                          | 93                               | dB   |       |      |
|                                                                                        |                                                                   | Full range                                                  | 75                          |                                  |      |       |      |
| I <sub>CC</sub> Supply current                                                         | V <sub>O</sub> = 0,                  No load                      | 25°C                                                        | 280                         | 325                              | μA   |       |      |
|                                                                                        |                                                                   | Full range                                                  | 350                         |                                  |      |       |      |
| ΔI <sub>CC</sub> Supply-current change over operating temperature range                |                                                                   |                                                             | Full range                  | 29                               |      | μA    |      |

$^\dagger$  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  $T_A = 150^\circ\text{C}$  extrapolated to  $T_A = 25^\circ\text{C}$  using the Arrhenius equation and assuming an activation energy of 0.96 eV.



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

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

$^\dagger$  Full range is 0°C to 70°C.

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

| PARAMETER                                         |                                                                       | TEST CONDITIONS                                                    | T <sub>A</sub> <sup>†</sup> | TLE2161C, TLE2161AC<br>TLE2161BC |           |       | UNIT |     |
|---------------------------------------------------|-----------------------------------------------------------------------|--------------------------------------------------------------------|-----------------------------|----------------------------------|-----------|-------|------|-----|
|                                                   |                                                                       |                                                                    |                             | MIN                              | TYP       | MAX   |      |     |
| V <sub>IO</sub>                                   | Input offset voltage                                                  | TLE2161C                                                           | 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         |       |      |     |
| αV <sub>IO</sub>                                  | Temperature coefficient of input offset voltage                       | V <sub>IC</sub> = 0,      R <sub>S</sub> = 50 Ω                    | Full range                  | 6                                |           | μV/°C |      |     |
| Input offset voltage long-term drift (see Note 4) |                                                                       |                                                                    | 25°C                        | 0.04                             |           | μV/mo |      |     |
| I <sub>IO</sub>                                   | Input offset current                                                  |                                                                    | 25°C                        | 2                                |           | pA    |      |     |
|                                                   |                                                                       |                                                                    | Full range                  | 1                                |           | nA    |      |     |
| I <sub>IB</sub>                                   | Input bias current                                                    |                                                                    | 25°C                        | 4                                |           | pA    |      |     |
|                                                   |                                                                       |                                                                    | Full range                  | 3                                |           | nA    |      |     |
| V <sub>ICR</sub>                                  | Common-mode input voltage range                                       |                                                                    | 25°C                        | −11 to 13                        | −12 to 16 | V     |      |     |
|                                                   |                                                                       |                                                                    | Full range                  | −11 to 13                        |           | V     |      |     |
| V <sub>OM</sub> +                                 | Maximum positive peak output voltage swing                            | R <sub>L</sub> = 10 kΩ                                             | 25°C                        | 13.2                             | 13.7      | V     |      |     |
|                                                   |                                                                       |                                                                    | Full range                  | 13                               |           |       |      |     |
|                                                   |                                                                       | R <sub>L</sub> = 600 Ω                                             | 25°C                        | 12.5                             | 13.2      |       |      |     |
|                                                   |                                                                       |                                                                    | Full range                  | 12                               |           |       |      |     |
| V <sub>OM</sub> −                                 | Maximum negative peak output voltage swing                            | R <sub>L</sub> = 10 kΩ                                             | 25°C                        | −13.2                            | −13.7     | V     |      |     |
|                                                   |                                                                       |                                                                    | Full range                  | −13                              |           |       |      |     |
|                                                   |                                                                       | R <sub>L</sub> = 600 Ω                                             | 25°C                        | −12.5                            | −13       |       |      |     |
|                                                   |                                                                       |                                                                    | Full range                  | −12                              |           |       |      |     |
| A <sub>VD</sub>                                   | Large-signal differential voltage amplification                       | V <sub>O</sub> = ±10 V,      R <sub>L</sub> = 10 kΩ                | 25°C                        | 30                               | 230       | V/mV  |      |     |
|                                                   |                                                                       |                                                                    | Full range                  | 20                               |           |       |      |     |
|                                                   |                                                                       | V <sub>O</sub> = 0 to 8 V,      R <sub>L</sub> = 600 Ω             | 25°C                        | 25                               | 100       |       |      |     |
|                                                   |                                                                       |                                                                    | Full range                  | 10                               |           |       |      |     |
|                                                   |                                                                       | V <sub>O</sub> = 0 to −8 V,      R <sub>L</sub> = 600 Ω            | 25°C                        | 3                                | 25        |       |      |     |
|                                                   |                                                                       |                                                                    | Full range                  | 1                                |           |       |      |     |
| r <sub>i</sub>                                    | Input resistance                                                      |                                                                    | 25°C                        | 10 <sup>12</sup>                 |           | Ω     |      |     |
| c <sub>i</sub>                                    | Input capacitance                                                     |                                                                    | 25°C                        | 4                                |           | pF    |      |     |
| z <sub>o</sub>                                    | Open-loop output impedance                                            | I <sub>O</sub> = 0                                                 | 25°C                        | 280                              |           | Ω     |      |     |
| CMRR                                              | Common-mode rejection ratio                                           | V <sub>IC</sub> = V <sub>ICRmin</sub> ,      R <sub>S</sub> = 50 Ω | 25°C                        | 72                               | 90        | dB    |      |     |
|                                                   |                                                                       |                                                                    | Full range                  | 70                               |           |       |      |     |
| k <sub>SVR</sub>                                  | Supply-voltage rejection ratio (ΔV <sub>CC±</sub> /ΔV <sub>IO</sub> ) | V <sub>CC±</sub> = ±5 V to ±15 V,      R <sub>S</sub> = 50 Ω       | 25°C                        | 75                               | 93        | dB    |      |     |
|                                                   |                                                                       |                                                                    | Full range                  | 75                               |           |       |      |     |
| I <sub>CC</sub>                                   | Supply current                                                        | V <sub>O</sub> = 0,      No load                                   | 25°C                        | 290                              | 350       | μA    |      |     |
|                                                   |                                                                       |                                                                    | Full range                  | 375                              |           |       |      |     |
| ΔI <sub>CC</sub>                                  | Supply-current change over operating temperature range                |                                                                    |                             | Full range                       | 34        |       | μA   |     |

$^\dagger$  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  $T_A = 150^\circ\text{C}$  extrapolated to  $T_A = 25^\circ\text{C}$  using the Arrhenius equation and assuming an activation energy of 0.96 eV.



**TLE2161, TLE2161A, TLE2161B**  
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operating characteristics at specified free-air temperature,  $V_{CC\pm} = \pm 15$  V (unless otherwise noted)

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

<sup>†</sup> Full range is 0°C to 70°C.

**TLE2161, TLE2161A, TLE2161B**  
**EXCALIBUR JFET-INPUT HIGH-OUTPUT-DRIVE**  
**μPOWER OPERATIONAL AMPLIFIERS**

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

| PARAMETER                                         |                                                                       | TEST CONDITIONS                                                  | T <sub>A</sub> <sup>†</sup> | TLE2161I, TLE2161AI<br>TLE2161BI |         |       | UNIT |
|---------------------------------------------------|-----------------------------------------------------------------------|------------------------------------------------------------------|-----------------------------|----------------------------------|---------|-------|------|
|                                                   |                                                                       |                                                                  |                             | MIN                              | TYP     | MAX   |      |
| V <sub>IO</sub>                                   | Input offset voltage                                                  | V <sub>IC</sub> = 0,      R <sub>S</sub> = 50 Ω                  | 25°C                        | 0.8                              |         | 3.1   | mV   |
|                                                   |                                                                       |                                                                  | Full range                  | 4.4                              |         |       |      |
|                                                   |                                                                       |                                                                  | 25°C                        | 0.6                              |         | 2.6   |      |
|                                                   |                                                                       |                                                                  | Full range                  | 3.9                              |         |       |      |
|                                                   |                                                                       |                                                                  | 25°C                        | 0.5                              |         | 1.9   |      |
|                                                   |                                                                       |                                                                  | Full range                  | 2.7                              |         |       |      |
| α <sub>VIO</sub>                                  | Temperature coefficient of input offset voltage                       | V <sub>IC</sub> = 0,      R <sub>S</sub> = 50 Ω                  | Full range                  | 6                                |         | μV/°C |      |
| Input offset voltage long-term drift (see Note 4) |                                                                       |                                                                  | 25°C                        | 0.04                             |         | μV/mo |      |
| I <sub>IO</sub>                                   | Input offset current                                                  |                                                                  | 25°C                        | 1                                |         | pA    |      |
|                                                   |                                                                       |                                                                  | Full range                  | 2                                |         | nA    |      |
| I <sub>IB</sub>                                   | Input bias current                                                    |                                                                  | 25°C                        | 3                                |         | pA    |      |
|                                                   |                                                                       |                                                                  | Full range                  | 4                                |         | nA    |      |
| V <sub>ICR</sub>                                  | Common-mode input voltage range                                       |                                                                  | 25°C                        | −1.6 to 4                        | −2 to 6 | V     |      |
|                                                   |                                                                       |                                                                  | Full range                  | −1.6 to 4                        |         |       |      |
| V <sub>OM</sub> +                                 | Maximum positive peak output voltage                                  | R <sub>L</sub> = 10 kΩ                                           | 25°C                        | 3.5                              | 3.7     | V     |      |
|                                                   |                                                                       |                                                                  | Full range                  | 3.1                              |         |       |      |
|                                                   |                                                                       | R <sub>L</sub> = 100 Ω                                           | 25°C                        | 2.5                              | 3.1     |       |      |
|                                                   |                                                                       |                                                                  | Full range                  | 2                                |         |       |      |
| V <sub>OM</sub> −                                 | Maximum negative peak output voltage swing                            | R <sub>L</sub> = 10 kΩ                                           | 25°C                        | −3.7                             | −3.9    | V     |      |
|                                                   |                                                                       |                                                                  | Full range                  | −3.1                             |         |       |      |
|                                                   |                                                                       | R <sub>L</sub> = 100 Ω                                           | 25°C                        | −2.5                             | −2.7    |       |      |
|                                                   |                                                                       |                                                                  | Full range                  | −2                               |         |       |      |
| A <sub>VD</sub>                                   | Large-signal differential voltage amplification                       | V <sub>O</sub> = ±2.8 V,    R <sub>L</sub> = 10 kΩ               | 25°C                        | 15                               | 80      | V/mV  |      |
|                                                   |                                                                       |                                                                  | Full range                  | 2                                |         |       |      |
|                                                   |                                                                       | V <sub>O</sub> = 0 to 2 V,    R <sub>L</sub> = 100 Ω             | 25°C                        | 0.75                             | 45      |       |      |
|                                                   |                                                                       |                                                                  | Full range                  | 0.5                              |         |       |      |
|                                                   |                                                                       | V <sub>O</sub> = 0 to −2 V,    R <sub>L</sub> = 100 Ω            | 25°C                        | 0.5                              | 3       |       |      |
|                                                   |                                                                       |                                                                  | Full range                  | 0.25                             |         |       |      |
| r <sub>i</sub>                                    | Input resistance                                                      |                                                                  | 25°C                        | 10 <sup>12</sup>                 |         | Ω     |      |
| c <sub>i</sub>                                    | Input capacitance                                                     |                                                                  | 25°C                        | 4                                |         | pF    |      |
| z <sub>o</sub>                                    | Open-loop output impedance                                            | I <sub>O</sub> = 0                                               | 25°C                        | 280                              |         | Ω     |      |
| CMRR                                              | Common-mode rejection ratio                                           | V <sub>IC</sub> = V <sub>ICRmin</sub> ,    R <sub>S</sub> = 50 Ω | 25°C                        | 65                               | 82      | dB    |      |
|                                                   |                                                                       |                                                                  | Full range                  | 65                               |         |       |      |
| k <sub>SVR</sub>                                  | Supply-voltage rejection ratio (ΔV <sub>CC±</sub> /ΔV <sub>IO</sub> ) | V <sub>CC±</sub> = ±5 V to ± 15 V,    R <sub>S</sub> = 50 Ω      | 25°C                        | 75                               | 93      | dB    |      |
|                                                   |                                                                       |                                                                  | Full range                  | 65                               |         |       |      |
| I <sub>CC</sub>                                   | Supply current                                                        | V <sub>O</sub> = 0,      No load                                 | 25°C                        | 280                              | 325     | μA    |      |
|                                                   |                                                                       |                                                                  | Full range                  | 350                              |         |       |      |
| ΔI <sub>CC</sub>                                  | Supply-current change over operating temperature range                |                                                                  |                             | Full range                       | 29      |       | μA   |

<sup>†</sup> 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  $T_A = 150^\circ\text{C}$  extrapolated to  $T_A = 25^\circ\text{C}$  using the Arrhenius equation and assuming an activation energy of 0.96 eV.



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

| PARAMETER   |                                               | TEST CONDITIONS                                                                              | $T_A^\dagger$ | TLE2161, TLE2161AI<br>TLE2161BI |        |     | UNIT                         |
|-------------|-----------------------------------------------|----------------------------------------------------------------------------------------------|---------------|---------------------------------|--------|-----|------------------------------|
|             |                                               |                                                                                              |               | MIN                             | TYP    | MAX |                              |
| SR          | Slew rate (see Figure 1)                      | $A_{VD} = 5$ , $R_L = 10 \text{ k}\Omega$ , $C_L = 100 \text{ pF}$                           | 25°C          | 7                               | 10     |     | V/ $\mu\text{s}$             |
|             |                                               |                                                                                              | Full range    | 5                               |        |     |                              |
| $V_n$       | Equivalent input noise voltage (see Figure 2) | $R_S = 20 \text{ }\Omega$ , $f = 10 \text{ Hz}$                                              | 25°C          |                                 | 59     | 100 | $\text{nV}/\sqrt{\text{Hz}}$ |
|             |                                               | $R_S = 20 \text{ }\Omega$ , $f = 1 \text{ kHz}$                                              |               |                                 | 43     | 60  |                              |
| $V_{n(PP)}$ | Peak-to-peak equivalent input noise voltage   | $f = 0.1 \text{ Hz to } 10 \text{ Hz}$                                                       | 25°C          |                                 | 1.1    |     | $\mu\text{V}$                |
| $I_n$       | Equivalent input noise current                | $f = 1 \text{ kHz}$                                                                          | 25°C          |                                 | 1      |     | $\text{fA}/\sqrt{\text{Hz}}$ |
| THD         | Total harmonic distortion                     | $V_{O(PP)} = 2 \text{ V}$ , $A_{VD} = 5$ , $f = 10 \text{ kHz}$ , $R_L = 10 \text{ k}\Omega$ | 25°C          |                                 | 0.025% |     |                              |
|             | Gain-bandwidth product (see Figure 3)         | $f = 100 \text{ kHz}$ , $R_L = 10 \text{ k}\Omega$ , $C_L = 100 \text{ pF}$                  | 25°C          |                                 | 5.8    |     | MHz                          |
|             |                                               | $f = 100 \text{ kHz}$ , $R_L = 100 \text{ }\Omega$ , $C_L = 100 \text{ pF}$                  |               |                                 | 4.3    |     |                              |
| $t_s$       | Settling time                                 | $\epsilon = 0.1\%$                                                                           | 25°C          |                                 | 5      |     | $\mu\text{s}$                |
|             |                                               | $\epsilon = 0.01\%$                                                                          |               |                                 | 10     |     |                              |
| $B_{OM}$    | Maximum output-swing bandwidth                | $A_{VD} = 5$ , $R_L = 10 \text{ k}\Omega$                                                    | 25°C          |                                 | 420    |     | kHz                          |
| $\phi_m$    | Phase margin (see Figure 3)                   | $A_{VD} = 5$ , $R_L = 10 \text{ k}\Omega$ , $C_L = 100 \text{ pF}$                           | 25°C          |                                 | 70°    |     |                              |
|             |                                               | $A_{VD} = 5$ , $R_L = 100 \text{ }\Omega$ , $C_L = 100 \text{ pF}$                           |               |                                 | 84°    |     |                              |

<sup>†</sup> Full range is – 40°C to 85°C.

**TLE2161, TLE2161A, TLE2161B**  
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**electrical characteristics at specified free-air temperature,  $V_{CC} \pm \pm 15$  V (unless otherwise noted)**

| PARAMETER                                         |                                                                       | TEST CONDITIONS                                                 | T <sub>A</sub> <sup>†</sup>                              | TLE2161I, TLE2161AI<br>TLE2161BI |                 |      | UNIT  |    |
|---------------------------------------------------|-----------------------------------------------------------------------|-----------------------------------------------------------------|----------------------------------------------------------|----------------------------------|-----------------|------|-------|----|
|                                                   |                                                                       |                                                                 |                                                          | MIN                              | TYP             | MAX  |       |    |
| V <sub>IO</sub>                                   | Input offset voltage                                                  | V <sub>IC</sub> = 0,      R <sub>S</sub> = 50 Ω                 | 25°C                                                     | 0.6                              |                 | 3    | mV    |    |
|                                                   |                                                                       |                                                                 | Full range                                               | 4.3                              |                 |      |       |    |
|                                                   |                                                                       |                                                                 | 25°C                                                     | 0.5                              |                 | 1.5  |       |    |
|                                                   |                                                                       |                                                                 | Full range                                               | 2.9                              |                 |      |       |    |
|                                                   |                                                                       |                                                                 | 25°C                                                     | 0.3                              |                 | 0.5  |       |    |
|                                                   |                                                                       |                                                                 | Full range                                               | 1.3                              |                 |      |       |    |
| αV <sub>IO</sub>                                  | 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 <sub>IO</sub>                                   | Input offset current                                                  |                                                                 | 25°C                                                     | 2                                |                 |      | pA    |    |
|                                                   |                                                                       |                                                                 | Full range                                               | 3                                |                 |      | nA    |    |
|                                                   |                                                                       |                                                                 | 25°C                                                     | 4                                |                 |      | pA    |    |
| I <sub>IB</sub>                                   | Input bias current                                                    |                                                                 | Full range                                               | 5                                |                 |      | nA    |    |
| V <sub>ICR</sub>                                  | Common-mode input voltage range                                       |                                                                 | 25°C                                                     | –11<br>to<br>13                  | –12<br>to<br>16 |      | V     |    |
|                                                   |                                                                       |                                                                 | Full range                                               | –11<br>to<br>13                  |                 |      | V     |    |
| V <sub>OM</sub> +                                 | Maximum positive peak output voltage swing                            | R <sub>L</sub> = 10 kΩ                                          | 25°C                                                     | 13.2                             | 13.7            |      | V     |    |
|                                                   |                                                                       |                                                                 | Full range                                               | 13                               |                 |      |       |    |
|                                                   |                                                                       |                                                                 | R <sub>L</sub> = 600 Ω                                   | 25°C                             | 12.5            | 13.2 |       |    |
|                                                   |                                                                       |                                                                 |                                                          | Full range                       | 12              |      |       |    |
| V <sub>OM</sub> –                                 | Maximum negative peak output voltage swing                            | R <sub>L</sub> = 10 kΩ                                          | 25°C                                                     | –13.2                            | –13.7           |      | V     |    |
|                                                   |                                                                       |                                                                 | Full range                                               | –13                              |                 |      |       |    |
|                                                   |                                                                       |                                                                 | R <sub>L</sub> = 600 Ω                                   | 25°C                             | –12.5           | –13  |       |    |
|                                                   |                                                                       |                                                                 |                                                          | Full range                       | –12             |      |       |    |
| A <sub>VD</sub>                                   | Large-signal differential voltage amplification                       | V <sub>O</sub> = ±10 V,      R <sub>L</sub> = 10 kΩ             | 25°C                                                     | 30                               | 230             |      | V/mV  |    |
|                                                   |                                                                       |                                                                 | Full range                                               | 20                               |                 |      |       |    |
|                                                   |                                                                       |                                                                 | V <sub>O</sub> = 0 to 8 V,      R <sub>L</sub> = 600 Ω   | 25°C                             | 25              | 100  |       |    |
|                                                   |                                                                       |                                                                 |                                                          | Full range                       | 10              |      |       |    |
|                                                   |                                                                       |                                                                 | V <sub>O</sub> = 0 to – 8 V,      R <sub>L</sub> = 600 Ω | 25°C                             | 3               | 25   |       |    |
|                                                   |                                                                       |                                                                 |                                                          | Full range                       | 1               |      |       |    |
| r <sub>i</sub>                                    | Input resistance                                                      |                                                                 | 25°C                                                     | 10 <sup>12</sup>                 |                 |      | Ω     |    |
| c <sub>i</sub>                                    | Input capacitance                                                     |                                                                 | 25°C                                                     | 4                                |                 |      | pF    |    |
| z <sub>O</sub>                                    | Open-loop output impedance                                            | I <sub>O</sub> = 0                                              | 25°C                                                     | 280                              |                 |      | Ω     |    |
| CMRR                                              | Common-mode rejection ratio                                           | V <sub>IC</sub> =V <sub>ICRmin</sub> ,    R <sub>S</sub> = 50 Ω | 25°C                                                     | 72                               | 90              |      | dB    |    |
|                                                   |                                                                       |                                                                 | Full range                                               | 65                               |                 |      |       |    |
| k <sub>SVR</sub>                                  | Supply-voltage rejection ratio (ΔV <sub>CC±</sub> /ΔV <sub>IO</sub> ) | V <sub>CC±</sub> = ±5 V to ±15 V,<br>R <sub>S</sub> = 50 Ω      | 25°C                                                     | 75                               | 93              |      | dB    |    |
|                                                   |                                                                       |                                                                 | Full range                                               | 65                               |                 |      |       |    |
| I <sub>CC</sub>                                   | Supply current                                                        | V <sub>O</sub> = 0,      No load                                | 25°C                                                     | 290                              | 350             |      | μA    |    |
|                                                   |                                                                       |                                                                 | Full range                                               | 375                              |                 |      |       |    |
| ΔI <sub>CC</sub>                                  | Supply-current change over operating temperature range                |                                                                 |                                                          | Full range                       | 34              |      |       | μA |

$^\dagger$  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  $T_A = 150^\circ C$  extrapolated to  $T_A = 25^\circ C$  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                                                       | $T_A^\dagger$ | TLE2161, TLE2161A<br>TLE2161B |        |     | UNIT                   |
|-------------|-----------------------------------------------|-----------------------------------------------------------------------|---------------|-------------------------------|--------|-----|------------------------|
|             |                                               |                                                                       |               | MIN                           | TYP    | MAX |                        |
| SR          | Slew rate (see Figure 1)                      | $A_{VD} = 5$ , $R_L = 10$ k $\Omega$ , $C_L = 100$ pF                 | 25°C          | 7                             | 10     |     | V/ $\mu$ s             |
|             |                                               |                                                                       | Full range    | 5                             |        |     |                        |
| $V_n$       | Equivalent input noise voltage (see Figure 2) | $R_S = 20$ $\Omega$ , $f = 10$ Hz                                     | 25°C          |                               | 70     | 100 | nV/ $\sqrt{\text{Hz}}$ |
|             |                                               | $R_S = 20$ $\Omega$ , $f = 1$ kHz                                     |               |                               | 40     | 60  |                        |
| $V_{n(PP)}$ | Peak-to-peak equivalent input noise voltage   | $f = 0.1$ Hz to 10 Hz                                                 | 25°C          |                               | 1.1    |     | $\mu$ V                |
| $I_n$       | Equivalent input noise current                | $f = 1$ kHz                                                           | 25°C          |                               | 1.1    |     | fA/ $\sqrt{\text{Hz}}$ |
| THD         | Total harmonic distortion                     | $V_{O(PP)} = 2$ V, $A_{VD} = 5$ , $f = 10$ kHz, $R_L = 10$ k $\Omega$ | 25°C          |                               | 0.025% |     |                        |
|             | Gain-bandwidth product (see Figure 3)         | $f = 100$ kHz, $R_L = 10$ k $\Omega$ , $C_L = 100$ pF                 | 25°C          |                               | 6.4    |     | MHz                    |
|             |                                               | $f = 100$ kHz, $R_L = 600$ $\Omega$ , $C_L = 100$ pF                  |               |                               | 5.6    |     |                        |
| $t_s$       | Settling time                                 | $\epsilon = 0.1\%$                                                    | 25°C          |                               | 5      |     | $\mu$ s                |
|             |                                               | $\epsilon = 0.01\%$                                                   |               |                               | 10     |     |                        |
| $B_{OM}$    | Maximum output-swing bandwidth                | $A_{VD} = 5$ , $R_L = 10$ k $\Omega$                                  | 25°C          |                               | 116    |     | kHz                    |
| $\phi_m$    | Phase margin (see Figure 3)                   | $A_{VD} = 5$ , $R_L = 10$ k $\Omega$ , $C_L = 100$ pF                 | 25°C          |                               | 72°    |     |                        |
|             |                                               | $A_{VD} = 5$ , $R_L = 600$ $\Omega$ , $C_L = 100$ pF                  |               |                               | 78°    |     |                        |

$^\dagger$  Full range is – 40°C to 85°C.

**TLE2161, TLE2161A, TLE2161B**  
**EXCALIBUR JFET-INPUT HIGH-OUTPUT-DRIVE**  
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**electrical characteristics at specified free-air temperature,  $V_{CC} \pm \pm 5\text{ V}$  (unless otherwise noted)**

| PARAMETER                                         |                                                 | TEST CONDITIONS                                 | T <sub>A</sub> <sup>†</sup>                               | TLE2161M<br>TLE2161AM<br>TLE2161BM |           |         | UNIT |
|---------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-----------------------------------------------------------|------------------------------------|-----------|---------|------|
|                                                   |                                                 |                                                 |                                                           | MIN                                | TYP       | MAX     |      |
| V <sub>IO</sub>                                   | Input offset voltage                            | TLE2161M                                        | 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       |         |      |
| α <sub>VIO</sub>                                  | Temperature coefficient of input offset voltage | V <sub>IC</sub> = 0,      R <sub>S</sub> = 50 Ω | Full range                                                | 6                                  |           | μV/°C   |      |
| Input offset voltage long-term drift (see Note 4) |                                                 |                                                 | 25°C                                                      | 0.04                               |           | μV/mo   |      |
| I <sub>IO</sub>                                   | Input offset current                            |                                                 | 25°C                                                      | 1                                  |           | pA      |      |
|                                                   |                                                 |                                                 | Full range                                                | 15                                 |           | nA      |      |
| I <sub>IB</sub>                                   | Input bias current                              |                                                 | 25°C                                                      | 3                                  |           | pA      |      |
|                                                   |                                                 |                                                 | Full range                                                | 30                                 |           | nA      |      |
| V <sub>ICR</sub>                                  | Common-mode input voltage range                 |                                                 |                                                           | 25°C                               | −1.6 to 4 | −2 to 6 | V    |
|                                                   |                                                 |                                                 |                                                           | Full range                         | −1.6 to 4 |         | V    |
| V <sub>OM</sub> +                                 | Maximum positive peak output voltage swing      | All packages                                    | 25°C                                                      | 3.5                                | 3.7       | V       |      |
|                                                   |                                                 |                                                 | Full range                                                | 3                                  |           |         |      |
|                                                   |                                                 | FK and JG packages                              | 25°C                                                      | 2.5                                | 3.6       | V       |      |
|                                                   |                                                 |                                                 | Full range                                                | 2                                  |           |         |      |
|                                                   |                                                 | D and P packages                                | 25°C                                                      | 2.5                                | 3.1       |         |      |
|                                                   |                                                 |                                                 | Full range                                                | 2                                  |           |         |      |
| V <sub>OM</sub> −                                 | Maximum negative peak output voltage swing      | All packages                                    | 25°C                                                      | −3.7                               | −3.9      | V       |      |
|                                                   |                                                 |                                                 | Full range                                                | −3                                 |           |         |      |
|                                                   |                                                 | FK and JG packages                              | 25°C                                                      | −2.5                               | −3.5      |         |      |
|                                                   |                                                 |                                                 | Full range                                                | −2                                 |           |         |      |
|                                                   |                                                 | D and P packages                                | 25°C                                                      | −2.5                               | −2.7      |         |      |
|                                                   |                                                 |                                                 | Full range                                                | −2                                 |           |         |      |
| A <sub>VD</sub>                                   | Large-signal differential voltage amplification | All packages                                    | V <sub>0</sub> = ±2.8 V,      R <sub>L</sub> = 10 kΩ      | 25°C                               | 15        | 80      | V/mV |
|                                                   |                                                 |                                                 | Full range                                                | 2                                  |           |         |      |
|                                                   |                                                 | FK and JG packages                              | V <sub>0</sub> = 0 to 2.5 V,      R <sub>L</sub> = 600 Ω  | 25°C                               | 1         | 65      |      |
|                                                   |                                                 |                                                 |                                                           | Full range                         | 0.5       |         |      |
|                                                   |                                                 |                                                 | V <sub>0</sub> = 0 to −2.5 V,      R <sub>L</sub> = 600 Ω | 25°C                               | 1         | 16      |      |
|                                                   |                                                 |                                                 |                                                           | Full range                         | 0.5       |         |      |
|                                                   |                                                 | D and P packages                                | V <sub>0</sub> = 0 to 2 V,      R <sub>L</sub> = 100 Ω    | 25°C                               | 0.75      | 45      |      |
|                                                   |                                                 |                                                 |                                                           | Full range                         | 0.5       |         |      |
|                                                   |                                                 |                                                 | V <sub>0</sub> = 0 to −2 V,      R <sub>L</sub> = 100 Ω   | 25°C                               | 0.5       | 3       |      |
|                                                   |                                                 |                                                 |                                                           | Full range                         | 0.25      |         |      |

$^\dagger$  Full range is  $-55^\circ\text{C}$  to  $125^\circ\text{C}$ .

NOTE 4: Typical values are based on the input offset voltage shift observed through 168 hours of operating life test at  $T_A = 150^\circ\text{C}$  extrapolated to  $T_A = 25^\circ\text{C}$  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                                           | $T_A^\dagger$ | TLE2161M<br>TLE2161AM<br>TLE2161BM |                  |     | UNIT |
|-------------------------------------------------------------------------------|-----------------------------------------------------------|---------------|------------------------------------|------------------|-----|------|
|                                                                               |                                                           |               | MIN                                | TYP              | MAX |      |
| $r_i$ Input resistance                                                        |                                                           | 25°C          |                                    | 10 <sup>12</sup> |     | 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                                              | $V_{IC} = V_{ICRmin}, R_S = 50 \Omega$                    | 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,<br>$R_S = 50 \Omega$ | 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   |

<sup>†</sup> Full range is –55°C to 125°C.

**operating characteristics,  $V_{CC} \pm = \pm 5$  V,  $T_A = 25^\circ\text{C}$**

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

**TLE2161, TLE2161A, TLE2161B**  
**EXCALIBUR JFET-INPUT HIGH-OUTPUT-DRIVE**  
**μPOWER OPERATIONAL AMPLIFIERS**

SLOS049D – NOVEMBER 1989 – REVISED MAY 1996

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

| PARAMETER                                         |                                                                       | TEST CONDITIONS                                                    | T <sub>A</sub> <sup>†</sup> | TLE2161M<br>TLE2161AM<br>TLE2161BM |           |       | UNIT |
|---------------------------------------------------|-----------------------------------------------------------------------|--------------------------------------------------------------------|-----------------------------|------------------------------------|-----------|-------|------|
|                                                   |                                                                       |                                                                    |                             | MIN                                | TYP       | MAX   |      |
| V <sub>IO</sub>                                   | Input offset voltage                                                  | TLE2161M                                                           | 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       |       |      |
| α <sub>VIO</sub>                                  | Temperature coefficient of input offset voltage                       | V <sub>IC</sub> = 0,      R <sub>S</sub> = 50 Ω                    | Full range                  | 6                                  |           | μV/°C |      |
| Input offset voltage long-term drift (see Note 4) |                                                                       |                                                                    | 25°C                        | 0.04                               |           | μV/mo |      |
| I <sub>IO</sub>                                   | Input offset current                                                  |                                                                    | 25°C                        | 2                                  |           | pA    |      |
|                                                   |                                                                       |                                                                    | Full range                  |                                    | 20        | nA    |      |
| I <sub>IB</sub>                                   | Input bias current                                                    |                                                                    | 25°C                        | 4                                  |           | pA    |      |
|                                                   |                                                                       |                                                                    | Full range                  |                                    | 40        | nA    |      |
| V <sub>ICR</sub>                                  | Common-mode input voltage range                                       |                                                                    | 25°C                        | −11 to 13                          | −12 to 16 | V     |      |
|                                                   |                                                                       | Full range                                                         | −11 to 13                   |                                    | V         |       |      |
| V <sub>OM</sub> +                                 | Maximum positive peak output voltage swing                            | R <sub>L</sub> = 10 kΩ                                             | 25°C                        | 13.2                               | 13.7      | V     |      |
|                                                   |                                                                       |                                                                    | Full range                  | 12.5                               |           |       |      |
|                                                   |                                                                       | R <sub>L</sub> = 600 Ω                                             | 25°C                        | 12.5                               | 13.2      |       |      |
|                                                   |                                                                       |                                                                    | Full range                  | 12                                 |           |       |      |
| V <sub>OM</sub> −                                 | Maximum negative peak output voltage swing                            | R <sub>L</sub> = 10 kΩ                                             | 25°C                        | −13.2                              | −13.7     | V     |      |
|                                                   |                                                                       |                                                                    | Full range                  | −12.5                              |           |       |      |
|                                                   |                                                                       | R <sub>L</sub> = 600 Ω                                             | 25°C                        | −12.5                              | −13       |       |      |
|                                                   |                                                                       |                                                                    | Full range                  | −12                                |           |       |      |
| A <sub>VD</sub>                                   | Large-signal differential voltage amplification                       | V <sub>O</sub> = ±10 V,      R <sub>L</sub> = 10 kΩ                | 25°C                        | 30                                 | 230       | V/mV  |      |
|                                                   |                                                                       |                                                                    | Full range                  | 20                                 |           |       |      |
|                                                   |                                                                       | V <sub>O</sub> = 0 to 8 V,      R <sub>L</sub> = 600 Ω             | 25°C                        | 25                                 | 100       |       |      |
|                                                   |                                                                       |                                                                    | Full range                  | 7                                  |           |       |      |
|                                                   |                                                                       | V <sub>O</sub> = 0 to − 8 V,      R <sub>L</sub> = 600 Ω           | 25°C                        | 3                                  | 25        |       |      |
|                                                   |                                                                       |                                                                    | Full range                  | 1                                  |           |       |      |
| r <sub>i</sub>                                    | Input resistance                                                      |                                                                    | 25°C                        | 10 <sup>12</sup>                   |           | Ω     |      |
| c <sub>i</sub>                                    | Input capacitance                                                     |                                                                    | 25°C                        | 4                                  |           | pF    |      |
| z <sub>o</sub>                                    | Open-loop output impedance                                            | I <sub>O</sub> = 0                                                 | 25°C                        | 280                                |           | Ω     |      |
| CMRR                                              | Common-mode rejection ratio                                           | V <sub>IC</sub> = V <sub>ICRmin</sub> ,      R <sub>S</sub> = 50 Ω | 25°C                        | 72                                 | 90        | dB    |      |
|                                                   |                                                                       |                                                                    | Full range                  | 65                                 |           |       |      |
| k <sub>SVR</sub>                                  | Supply-voltage rejection ratio (ΔV <sub>CC±</sub> /ΔV <sub>IO</sub> ) | V <sub>CC±</sub> = ±5 V to ±15 V,      R <sub>S</sub> = 50 Ω       | 25°C                        | 75                                 | 93        | dB    |      |
|                                                   |                                                                       |                                                                    | Full range                  | 65                                 |           |       |      |
| I <sub>CC</sub>                                   | Supply current                                                        | V <sub>O</sub> = 0,      No load                                   | 25°C                        | 290                                | 350       | μA    |      |
|                                                   |                                                                       |                                                                    | Full range                  | 375                                |           |       |      |
| ΔI <sub>CC</sub>                                  | Supply-current change over operating temperature range                |                                                                    | Full range                  | 46                                 |           | μA    |      |

<sup>†</sup> 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  $T_A = 150^\circ\text{C}$  extrapolated to  $T_A = 25^\circ\text{C}$  using the Arrhenius equation and assuming an activation energy of 0.96 eV.

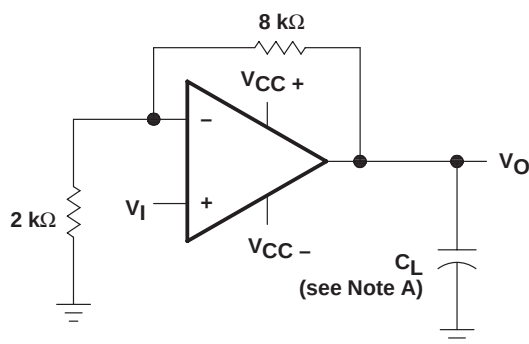


operating characteristics at specified free-air temperature,  $V_{CC} \pm \pm 15$  V (unless otherwise noted)

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

<sup>†</sup> Full range is – 55°C to 125°C.

## PARAMETER MEASUREMENT INFORMATION



NOTE A:  $C_L$  includes fixture capacitance.

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

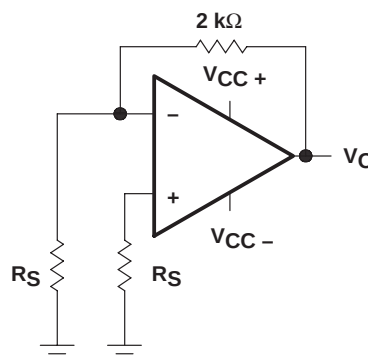
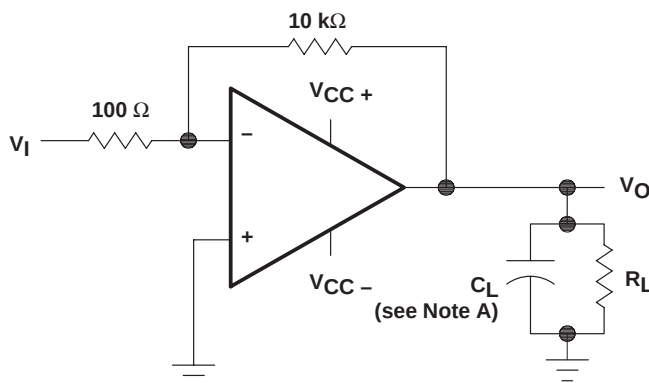


**Figure 2. Noise-Voltage Test Circuit**



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†

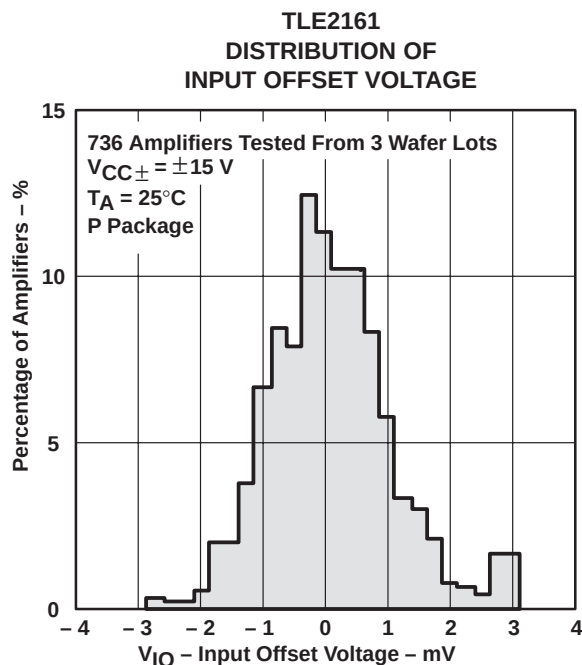


Figure 4

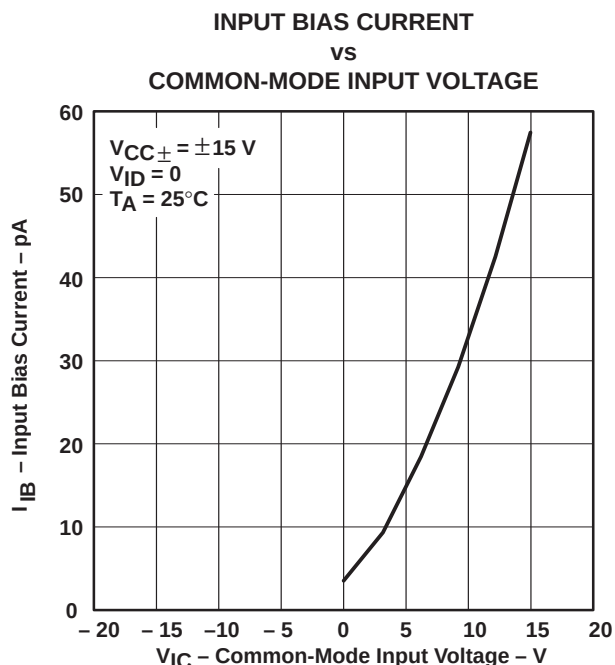


Figure 5

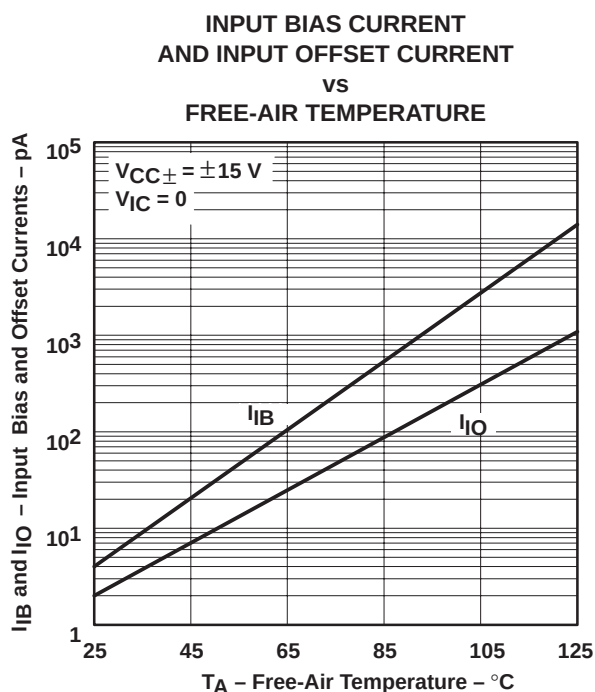


Figure 6

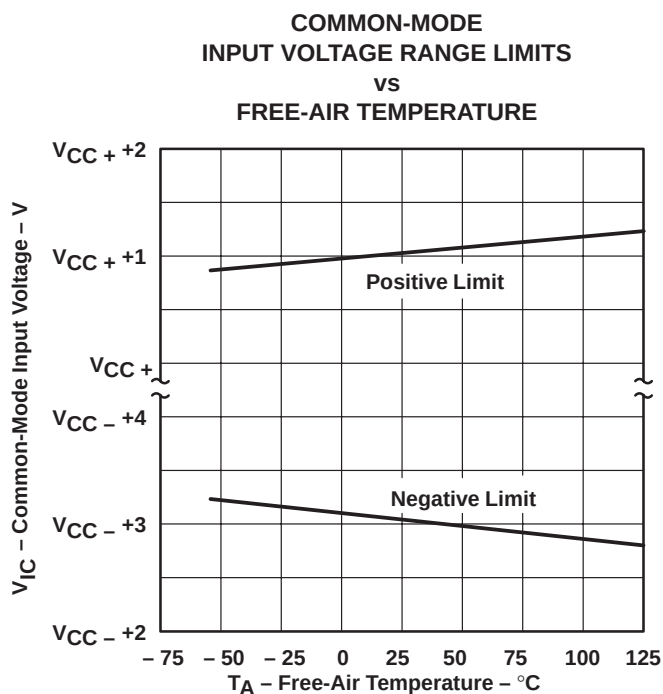


Figure 7

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

## TYPICAL CHARACTERISTICS

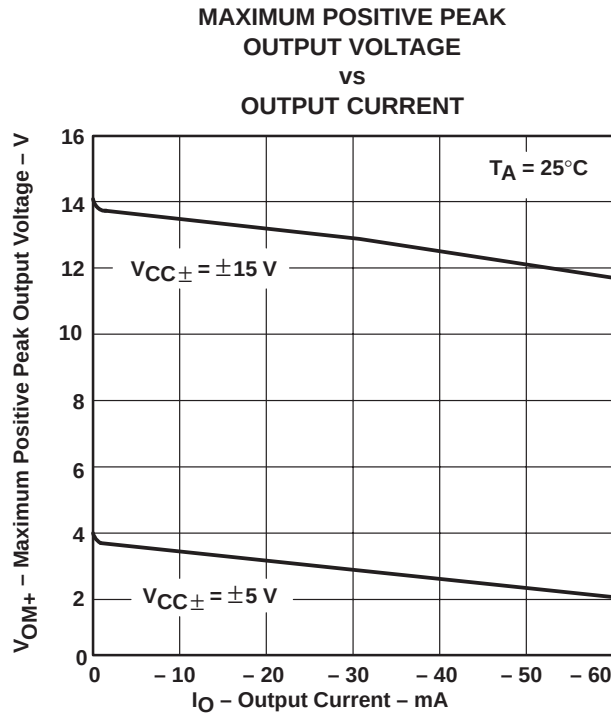


Figure 8

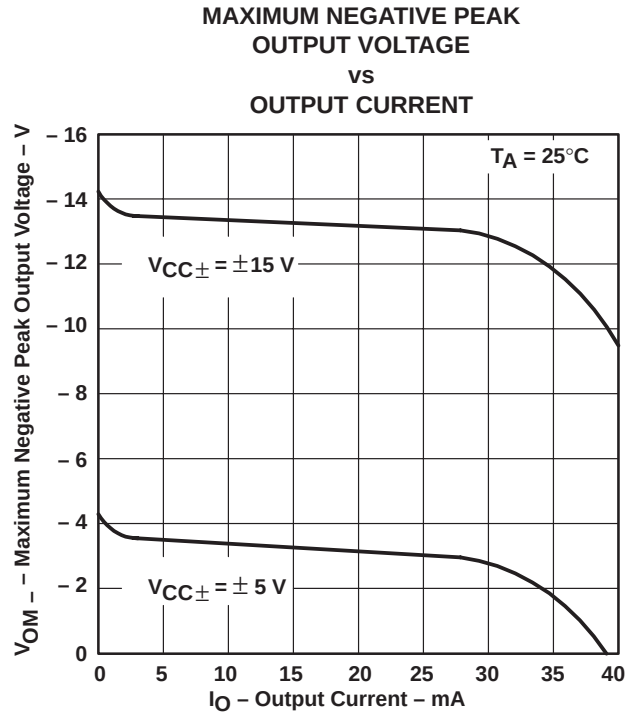


Figure 9

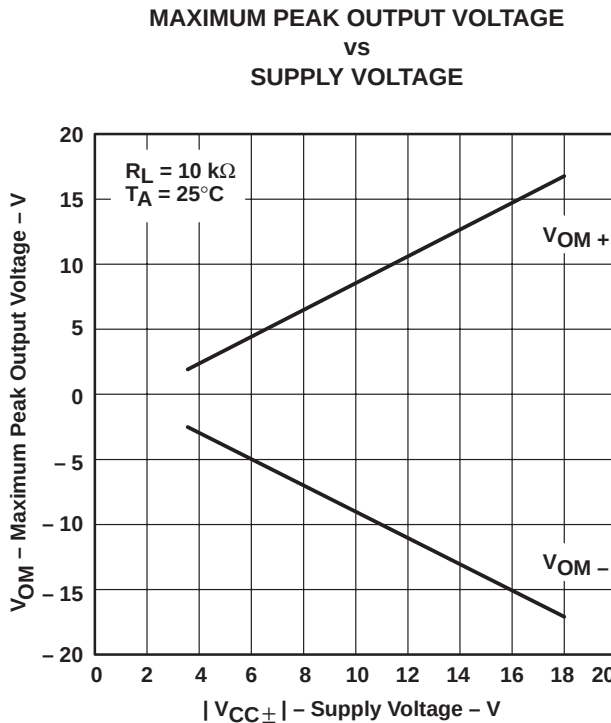


Figure 10

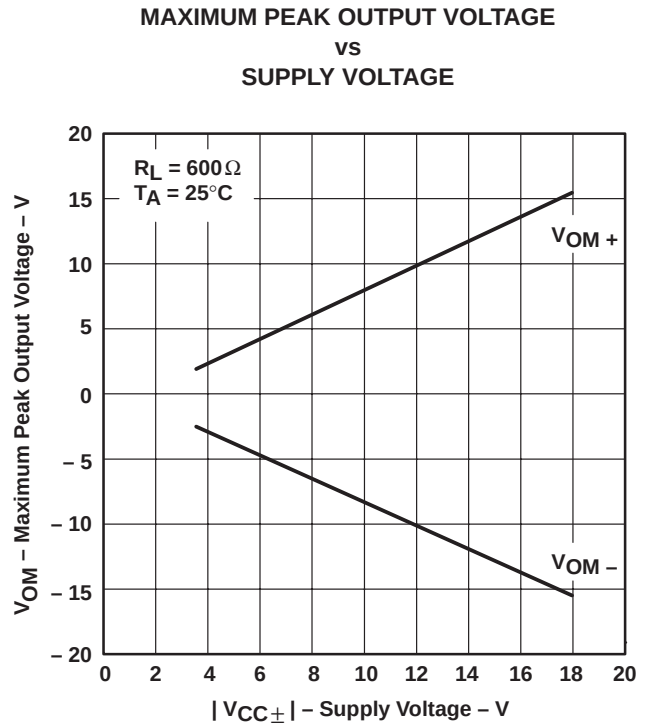


Figure 11

## TYPICAL CHARACTERISTICS

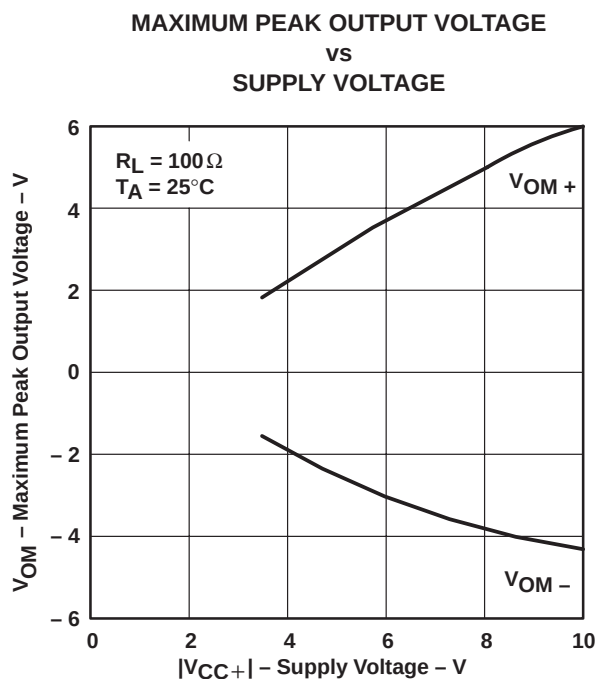


Figure 12

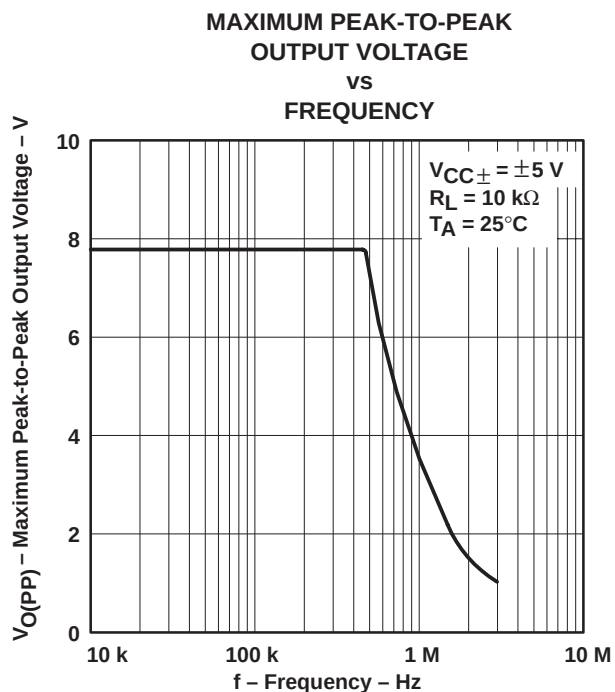


Figure 13

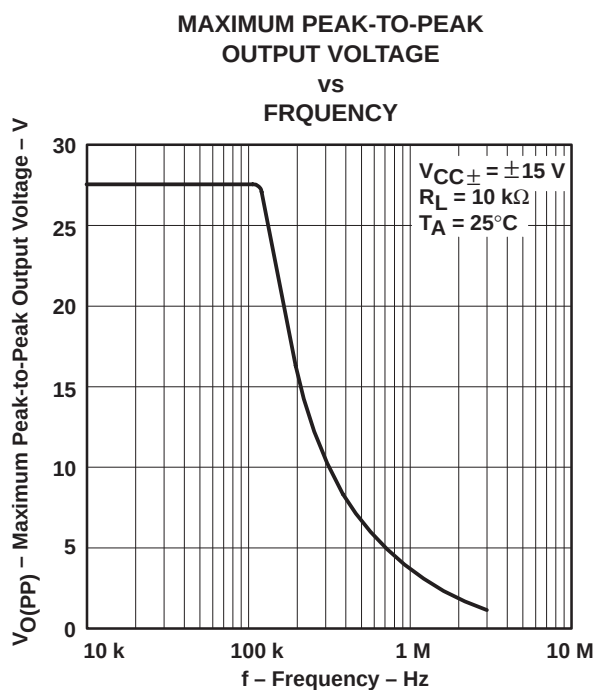


Figure 14

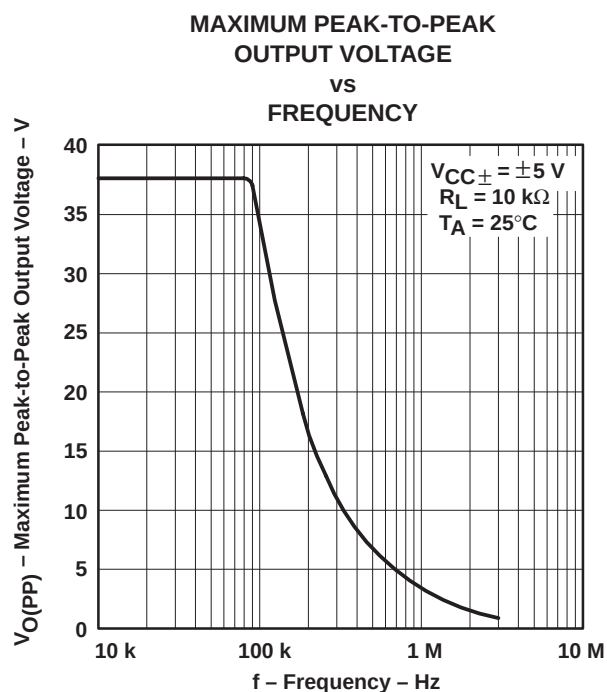
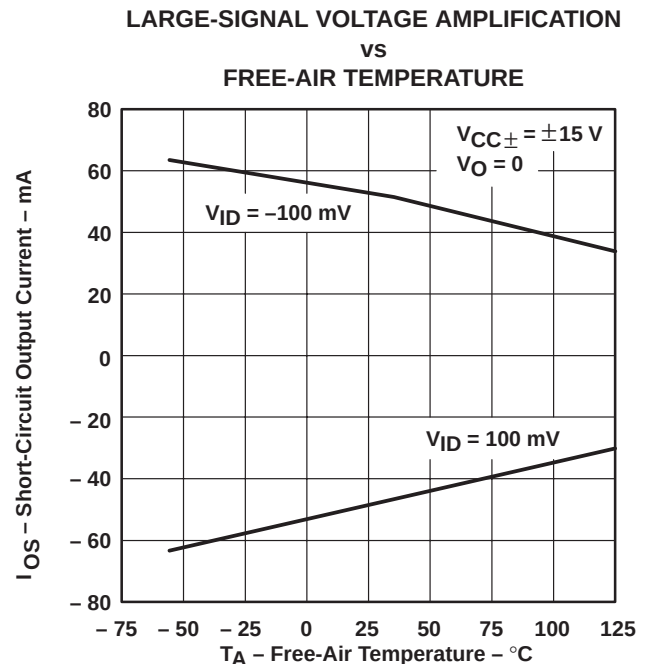
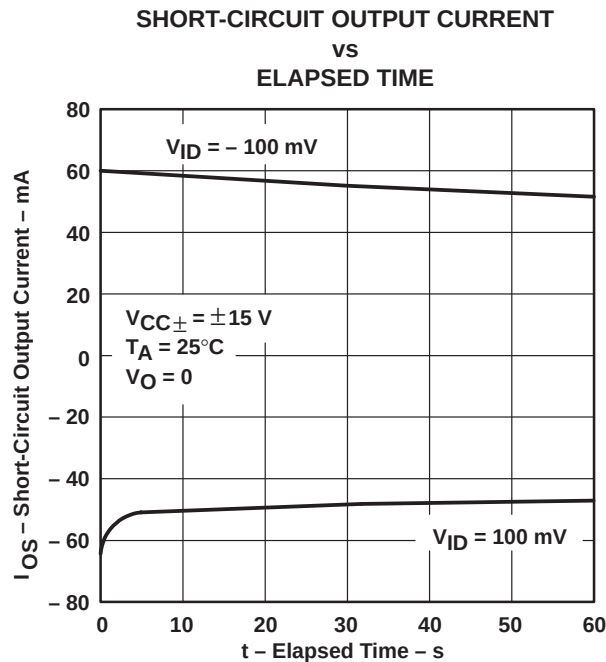
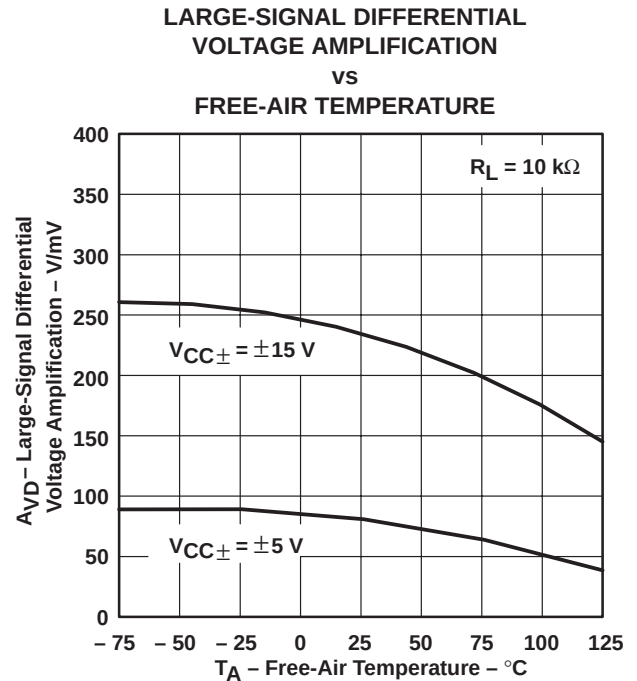
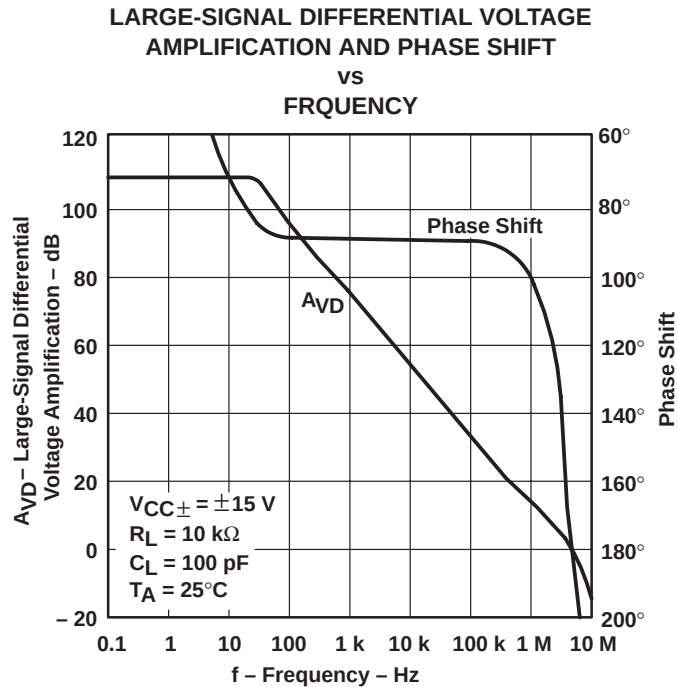


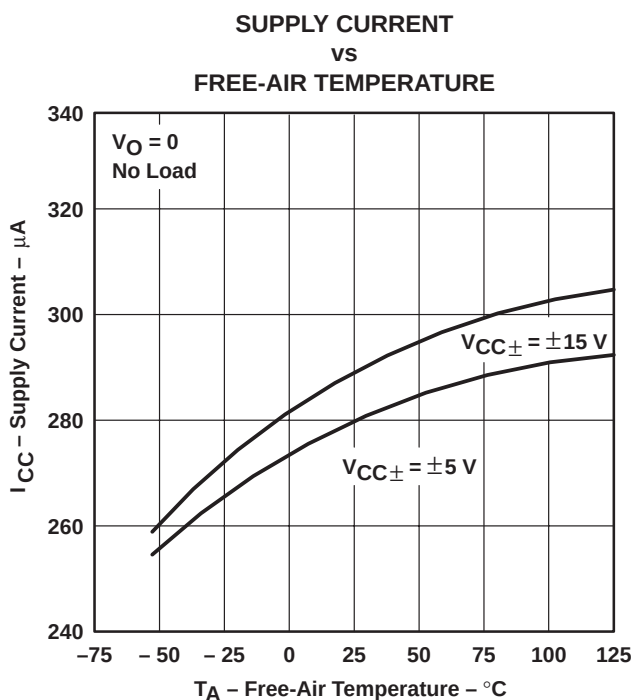
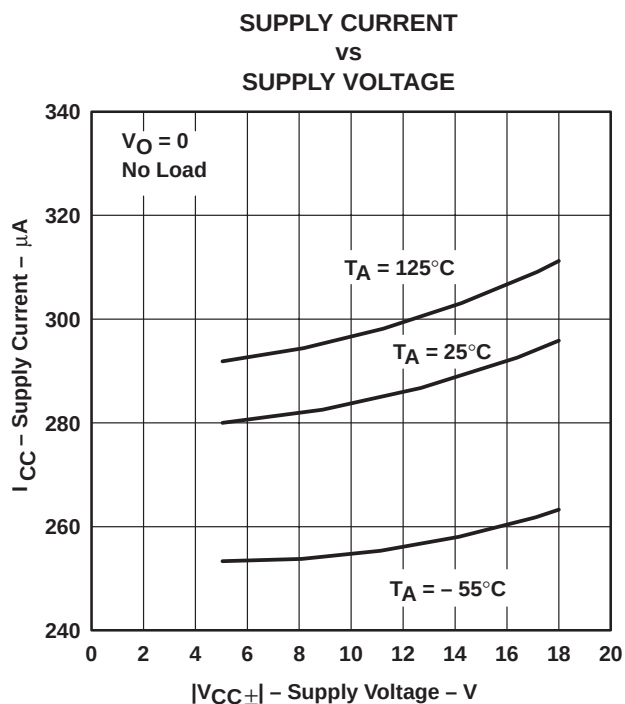
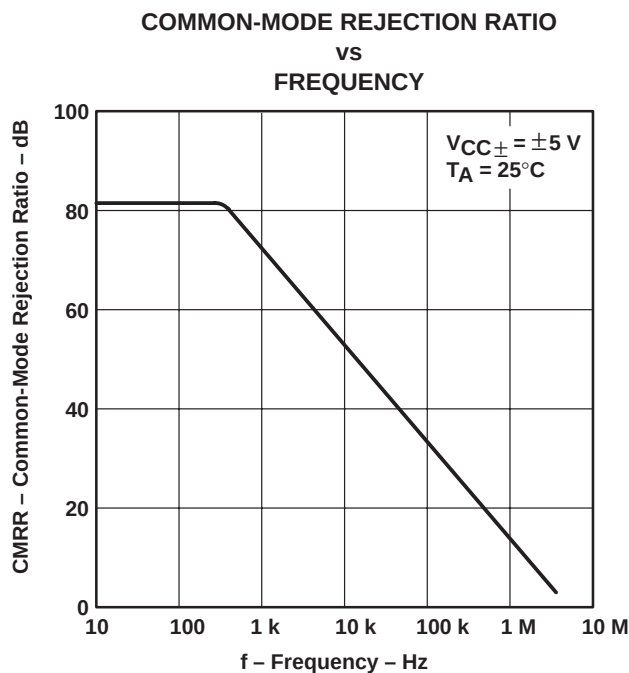
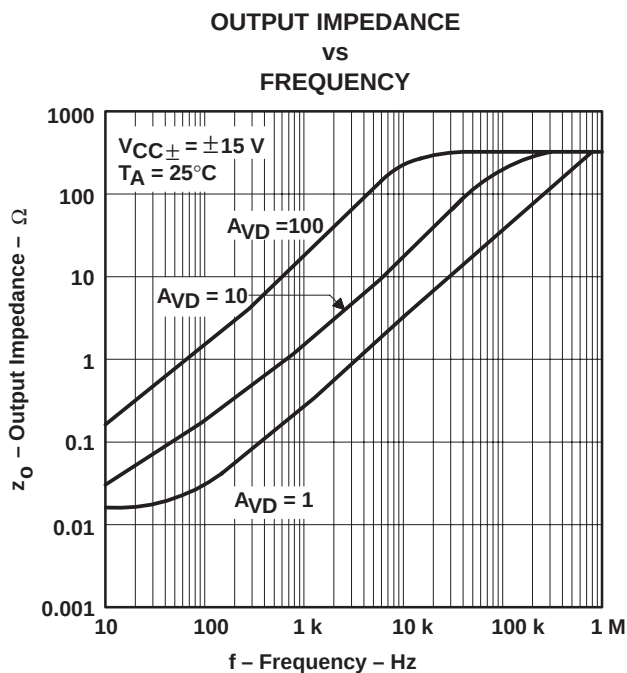
Figure 15

## TYPICAL CHARACTERISTICS†



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

# TYPICAL CHARACTERISTICS†



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

## TYPICAL CHARACTERISTICS

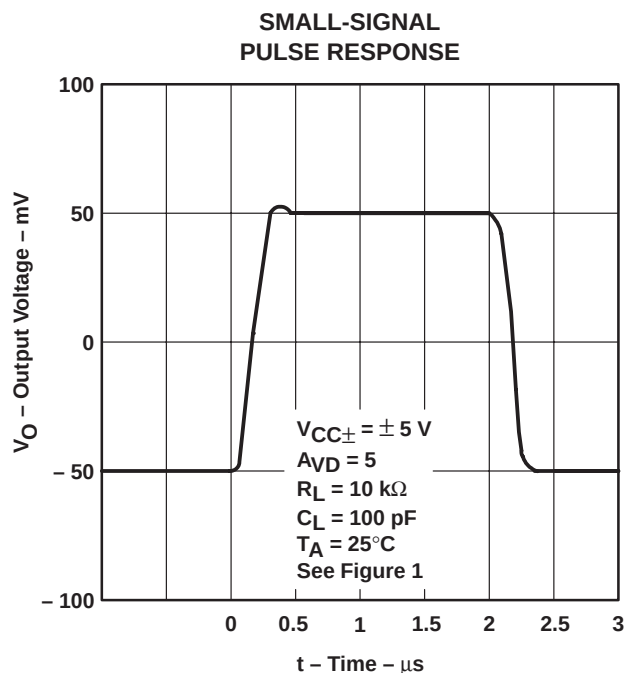


Figure 24

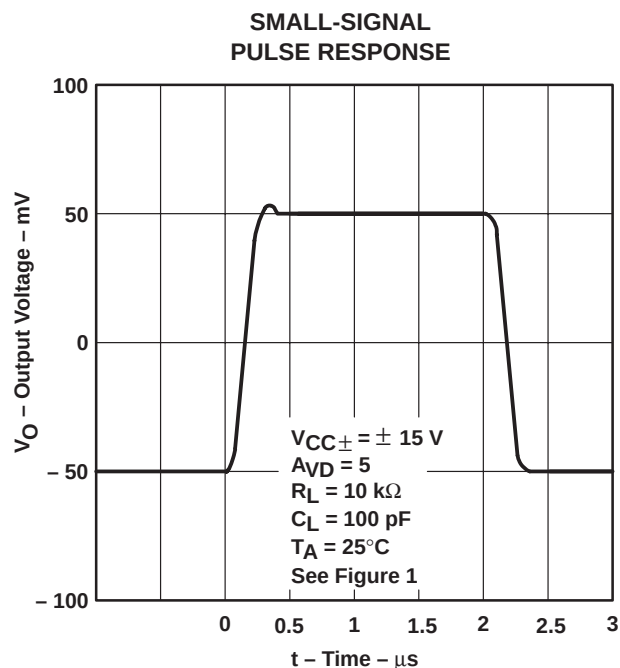


Figure 25

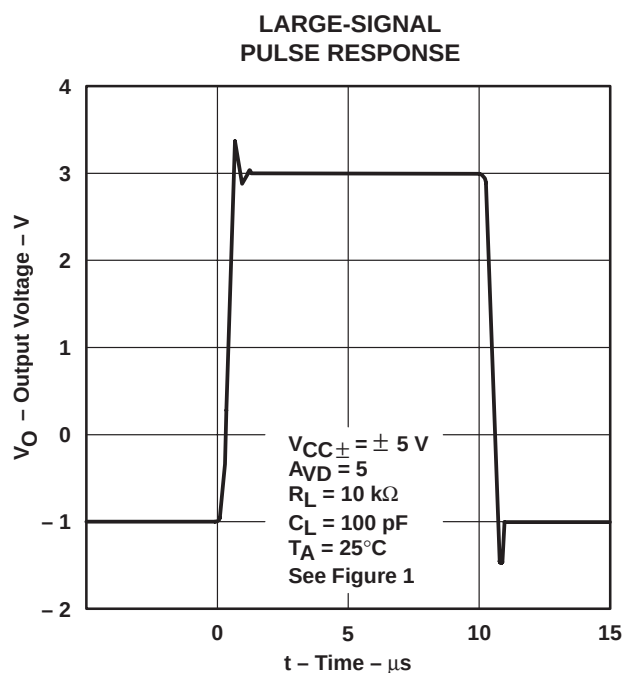


Figure 26

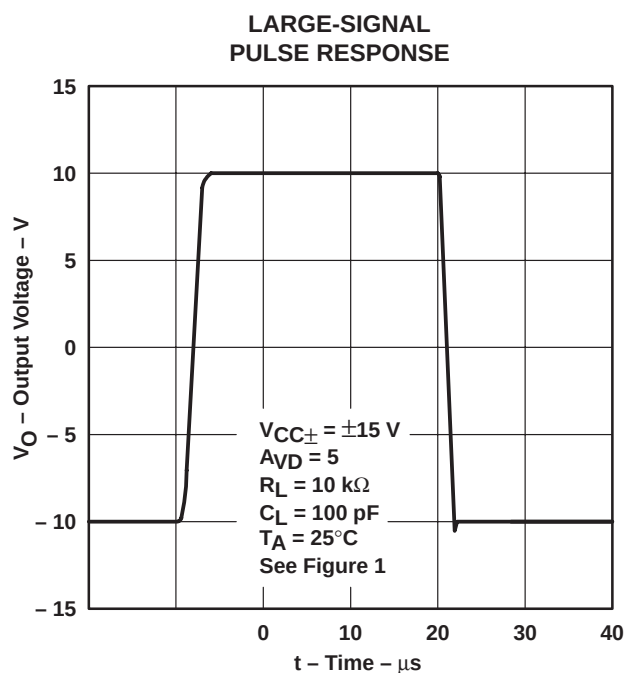


Figure 27

## TYPICAL CHARACTERISTICS

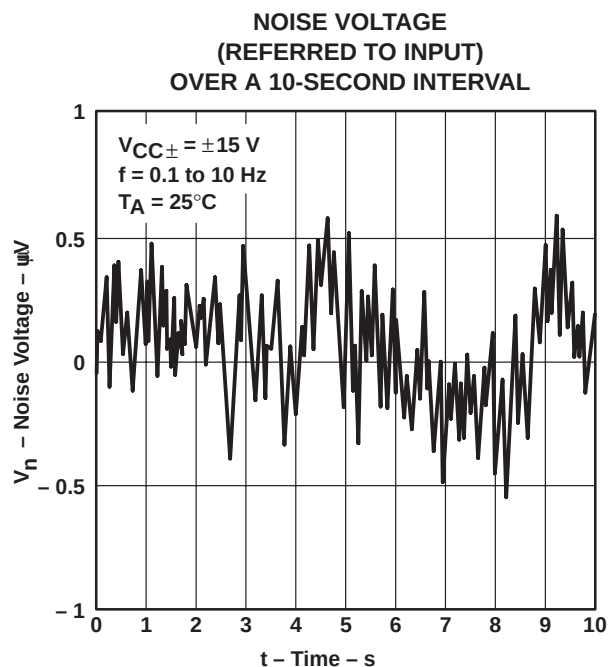


Figure 28

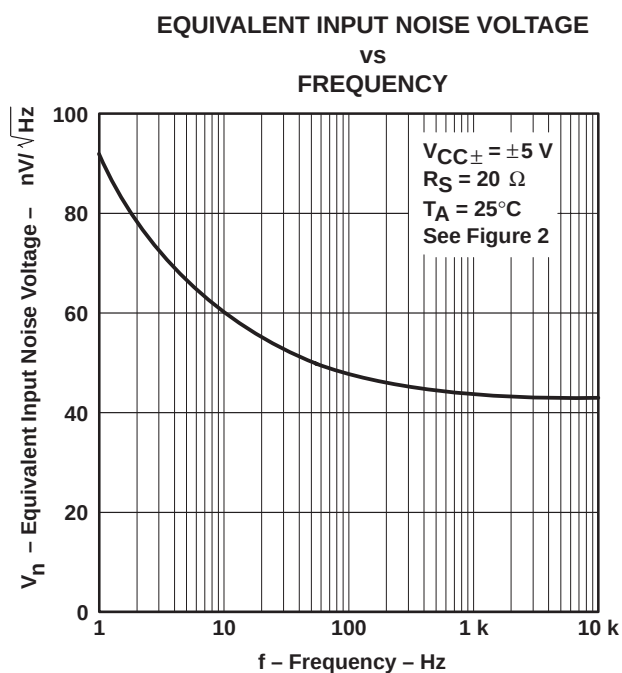


Figure 29

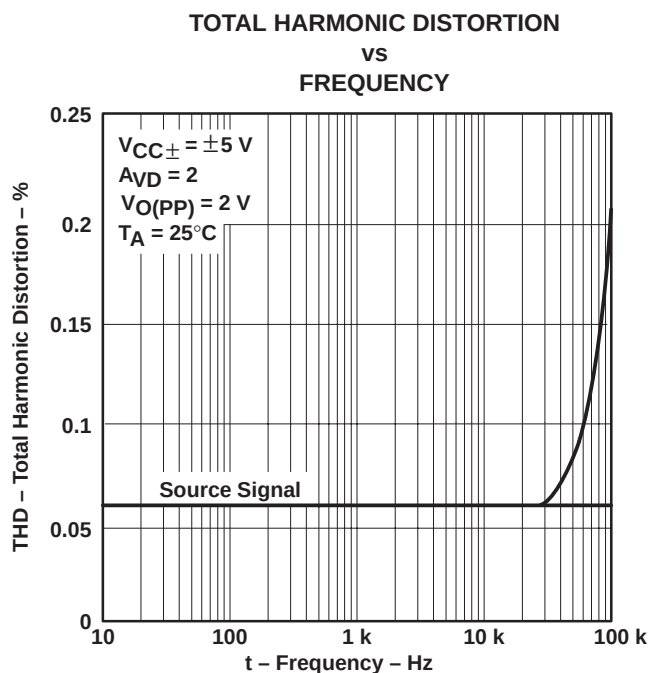


Figure 30

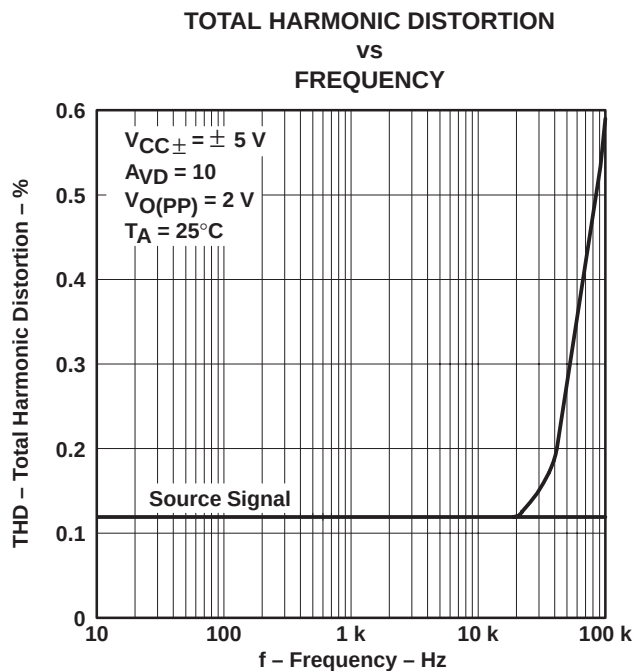


Figure 31

## TYPICAL CHARACTERISTICS

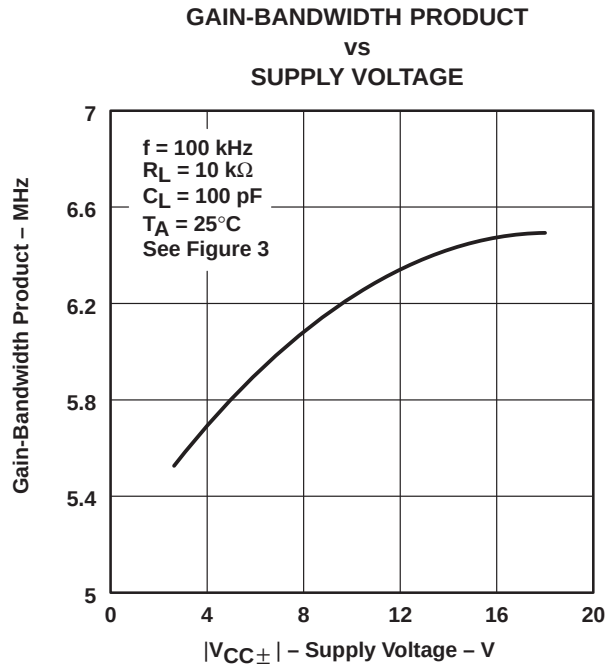


Figure 32

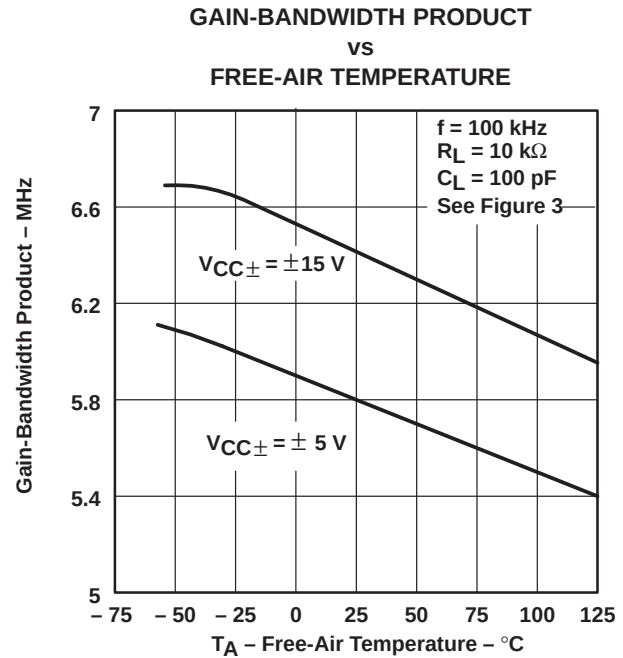


Figure 33

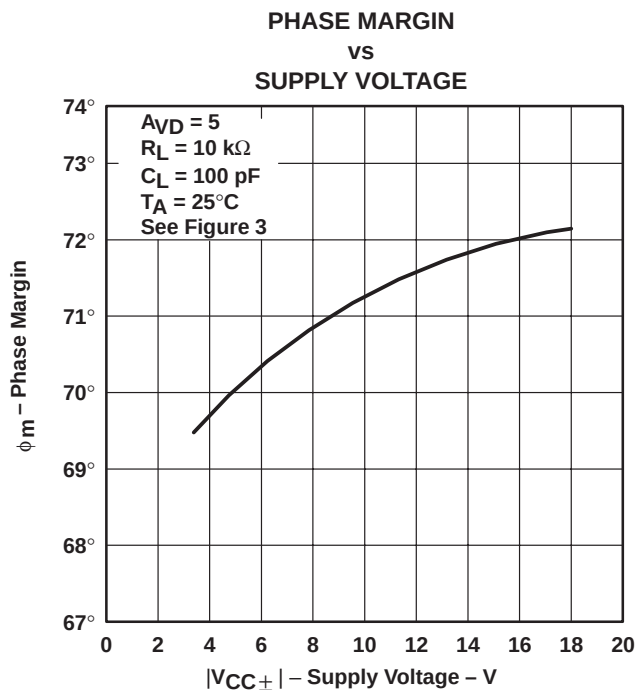


Figure 34

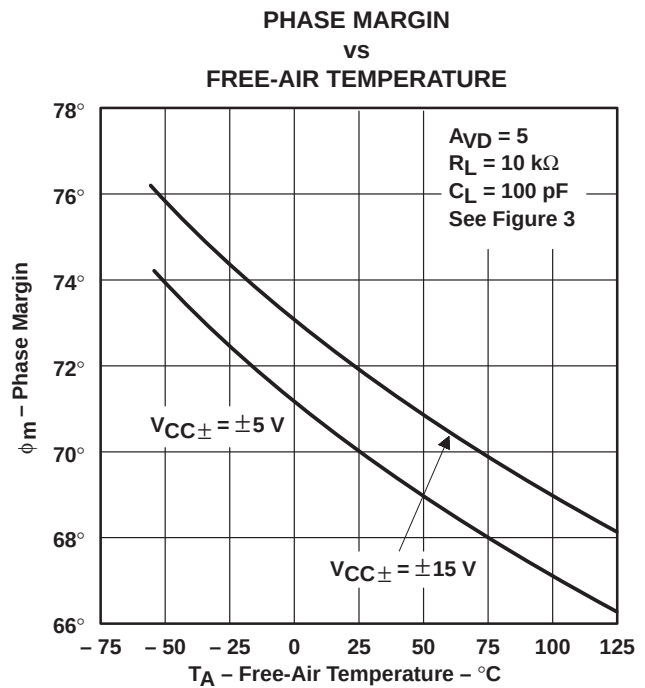


Figure 35

## 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

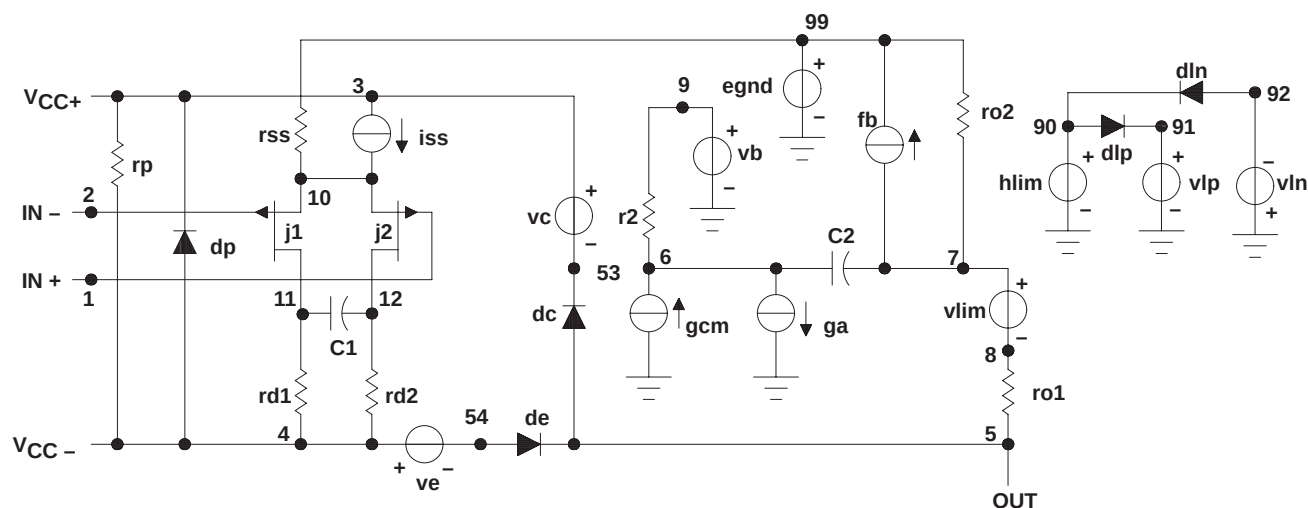


**Figure 36. Boyle Macromodel**

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).

## 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
dlm     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.

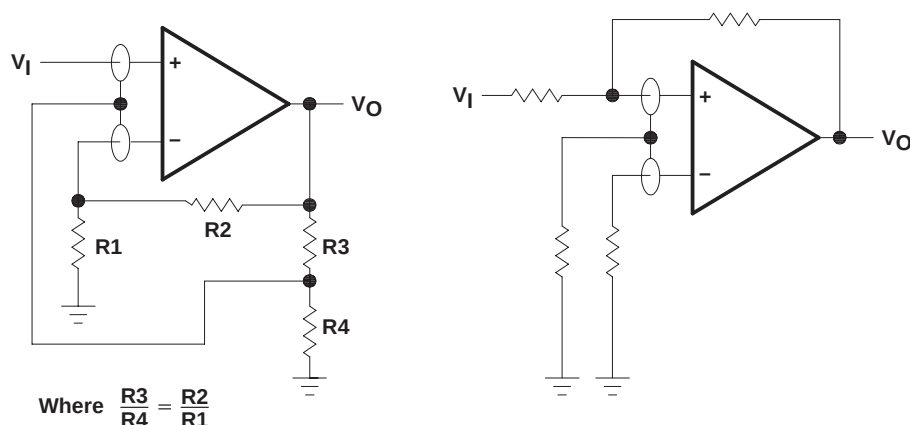


Figure 38. Use of Guard Rings

### 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.

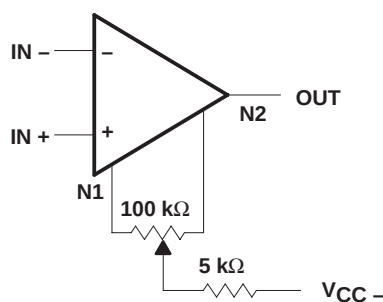


Figure 39. Input Offset Voltage Nulling

## PACKAGING INFORMATION

| Orderable part number           | Status<br>(1) | Material type<br>(2) | Package   Pins | Package qty   Carrier | RoHS<br>(3) | Lead finish/<br>Ball material<br>(4) | MSL rating/<br>Peak reflow<br>(5) | Op temp (°C)   | Part marking<br>(6)     |
|---------------------------------|---------------|----------------------|----------------|-----------------------|-------------|--------------------------------------|-----------------------------------|----------------|-------------------------|
| <a href="#">5962-9095801QPA</a> | Active        | Production           | CDIP (JG)   8  | 50   TUBE             | No          | SNPB                                 | N/A for Pkg Type                  | -55 to 125     | 9095801QPA<br>TLE2161M  |
| <a href="#">5962-9095802QPA</a> | Active        | Production           | CDIP (JG)   8  | 50   TUBE             | No          | SNPB                                 | N/A for Pkg Type                  | -55 to 125     | 9095802QPA<br>TLE2161AM |
| <a href="#">5962-9095803QPA</a> | Active        | Production           | CDIP (JG)   8  | 50   TUBE             | No          | SNPB                                 | N/A for Pkg Type                  | -55 to 125     | 9095803QPA<br>TLE2161BM |
| <a href="#">TLE2161ACD</a>      | Obsolete      | Production           | SOIC (D)   8   | -                     | -           | Call TI                              | Call TI                           | 0 to 70        | 2161AC                  |
| <a href="#">TLE2161AID</a>      | Obsolete      | Production           | SOIC (D)   8   | -                     | -           | Call TI                              | Call TI                           | -              | 2161AI                  |
| <a href="#">TLE2161AIDR</a>     | Active        | Production           | SOIC (D)   8   | 2500   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -              | 2161AI                  |
| TLE2161AIDR.A                   | Active        | Production           | SOIC (D)   8   | 2500   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | 0 to 70        | 2161AI                  |
| <a href="#">TLE2161AMJGB</a>    | Active        | Production           | CDIP (JG)   8  | 50   TUBE             | No          | SNPB                                 | N/A for Pkg Type                  | -55 to 125     | 9095802QPA<br>TLE2161AM |
| TLE2161AMJGB.A                  | Active        | Production           | CDIP (JG)   8  | 50   TUBE             | No          | SNPB                                 | N/A for Pkg Type                  | -55 to 125     | 9095802QPA<br>TLE2161AM |
| <a href="#">TLE2161BMJGB</a>    | Active        | Production           | CDIP (JG)   8  | 50   TUBE             | No          | SNPB                                 | N/A for Pkg Type                  | -55 to 125     | 9095803QPA<br>TLE2161BM |
| TLE2161BMJGB.A                  | Active        | Production           | CDIP (JG)   8  | 50   TUBE             | No          | SNPB                                 | N/A for Pkg Type                  | -55 to 125     | 9095803QPA<br>TLE2161BM |
| <a href="#">TLE2161CD</a>       | Obsolete      | Production           | SOIC (D)   8   | -                     | -           | Call TI                              | Call TI                           | 0 to 70        | 2161C                   |
| <a href="#">TLE2161ID</a>       | Obsolete      | Production           | SOIC (D)   8   | -                     | -           | Call TI                              | Call TI                           | -              | 2161I                   |
| <a href="#">TLE2161IDR</a>      | Active        | Production           | SOIC (D)   8   | 2500   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | -              | 2161I                   |
| TLE2161IDR.A                    | Active        | Production           | SOIC (D)   8   | 2500   LARGE T&R      | Yes         | NIPDAU                               | Level-1-260C-UNLIM                | See TLE2161IDR | 2161I                   |
| <a href="#">TLE2161MJGB</a>     | Active        | Production           | CDIP (JG)   8  | 50   TUBE             | No          | SNPB                                 | N/A for Pkg Type                  | -55 to 125     | 9095801QPA<br>TLE2161M  |
| TLE2161MJGB.A                   | Active        | Production           | CDIP (JG)   8  | 50   TUBE             | No          | SNPB                                 | N/A for Pkg Type                  | -55 to 125     | 9095801QPA<br>TLE2161M  |

<sup>(1)</sup> **Status:** For more details on status, see our [product life cycle](#).

<sup>(2)</sup> **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

<sup>(3)</sup> **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

<sup>(4)</sup> **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

<sup>(5)</sup> **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

<sup>(6)</sup> **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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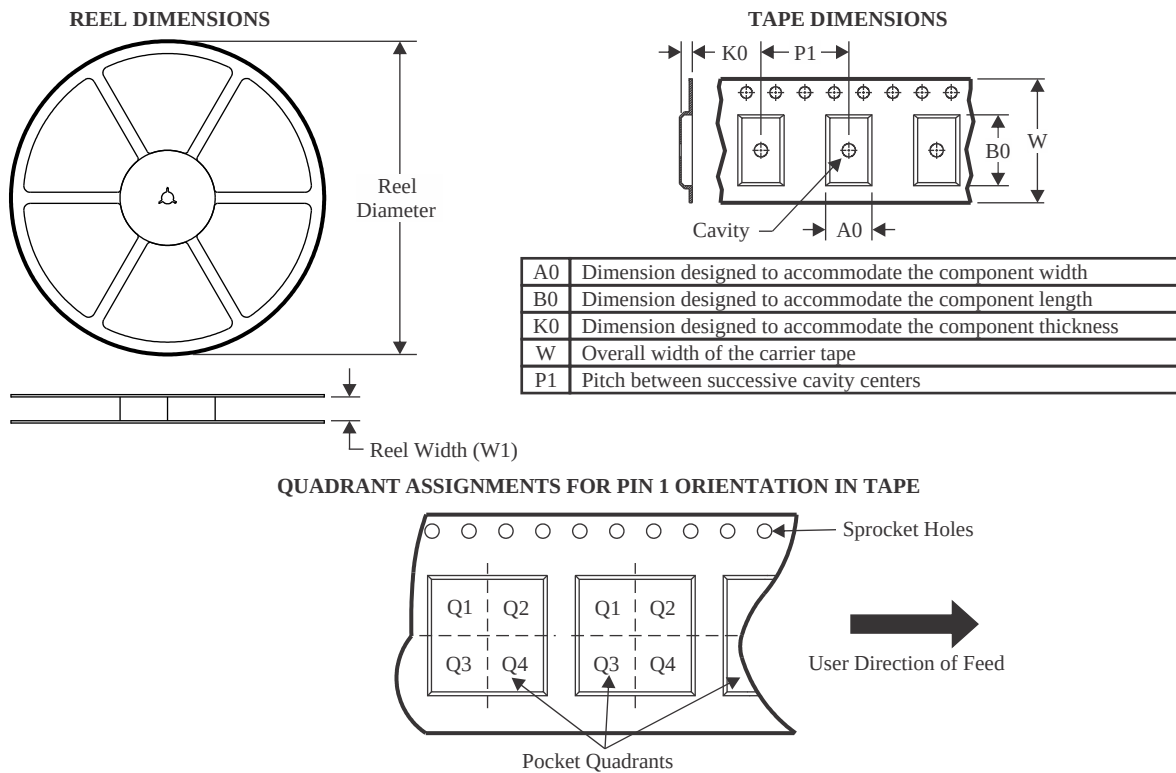
**OTHER QUALIFIED VERSIONS OF TLE2161, TLE2161A, TLE2161AM, TLE2161M :**

- Catalog : [TLE2161A](#), [TLE2161](#)
- Military : [TLE2161M](#), [TLE2161AM](#)

**NOTE: Qualified Version Definitions:**

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

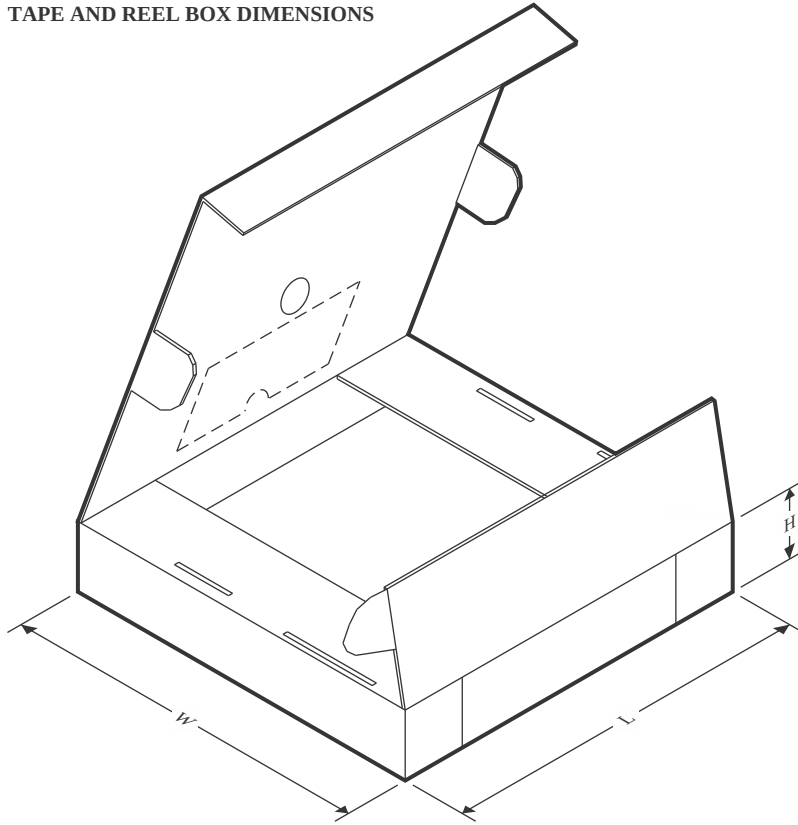
## TAPE AND REEL INFORMATION



\*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            |

## 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 | 353.0       | 353.0      | 32.0        |

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Last updated 10/2025