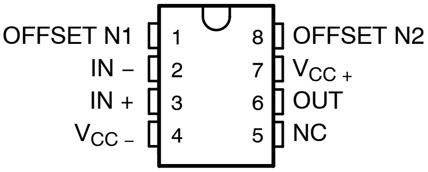
# TLE2027, TLE2037, TLE2027A, TLE2037A, TLE2027Y, TLE2037Y
# EXCALIBUR LOW-NOISE HIGH-SPEED PRECISION OPERATIONAL AMPLIFIERS

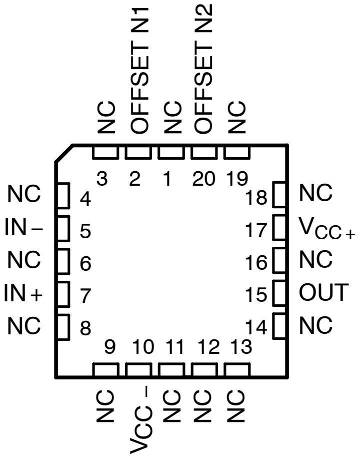
SLOS192C – FEBRUARY 1997 – REVISED APRIL 2010

- **Outstanding Combination of dc Precision and AC Performance:**
  **Unity-Gain Bandwidth . . . 15 MHz Typ**
  **$V_n$ ..... $3.3\ \text{nV}/\sqrt{\text{Hz}}$ at f = 10 Hz Typ,**
  **$2.5\ \text{nV}/\sqrt{\text{Hz}}$ at f = 1 kHz Typ**
  **$V_{IO}$ .... 25 μV Max**
  **$A_{VD}$ .... 45 V/μV Typ With $R_L$ = 2 kΩ,**
  **19 V/μV Typ With $R_L$ = 600 Ω**
- **Available in Standard-Pinout Small-Outline Package**
- **Output Features Saturation Recovery Circuitry**
- **Macromodels and Statistical information**

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



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



## description

The TLE20x7 and TLE20x7A contain innovative circuit design expertise and high-quality process control techniques to produce a level of ac performance and dc precision previously unavailable in single operational amplifiers. Manufactured using Texas Instruments state-of-the-art Excalibur process, these devices allow upgrades to systems that use lower-precision devices.

In the area of dc precision, the TLE20x7 and TLE20x7A offer maximum offset voltages of 100 μV and 25 μV, respectively, common-mode rejection ratio of 131 dB (typ), supply voltage rejection ratio of 144 dB (typ), and dc gain of 45 V/μV (typ).

**AVAILABLE OPTIONS**

| $T_A$ | $V_{IO}$max AT 25°C | PACKAGED DEVICES | | | | CHIP FORM‡ (Y) |
|---|---|---|---|---|---|---|
| | | SMALL OUTLINE† (D) | CHIP CARRIER (FK) | CERAMIC DIP (JG) | PLASTIC DIP (P) | |
| 0°C to 70°C | 25 μV | TLE2027ACD<br>TLE2037ACD | —<br>— | —<br>— | TLE2027ACP<br>TLE2037ACP | TLE2027Y<br>TLE2037Y |
| | 100 μV | TLE2027CD<br>TLE2037CD | —<br>— | —<br>— | TLE2027CP<br>TLE2037CP | TLE2027Y<br>TLE2037Y |
| –40°C to 105°C | 25 μV | TLE2027AID<br>TLE2037AID | —<br>— | —<br>— | TLE2027AIP<br>TLE2037AIP | — |
| | 100 μV | TLE2027ID<br>TLE2037ID | —<br>— | —<br>— | TLE2027IP<br>TLE2037IP | — |
| –55°C to 125°C | 25 μV | TLE2027AMD<br>TLE2037AMD | TLE2027AMFK<br>TLE2037AMFK | TLE2027AMJG<br>TLE2037AMJG | TLE2027AMP<br>TLE2037AMP | — |
| | 100 μV | TLE2027MD<br>TLE2037MD | TLE2027MFK<br>TLE2037MFK | TLE2027MJG<br>TLE2037MJG | TLE2027MP<br>TLE2037MP | — |

† The D packages are available taped and reeled. Add R suffix to device type (e.g., TLE2027ACDR).
‡ Chip forms are tested at 25°C only.

TEXAS INSTRUMENTS
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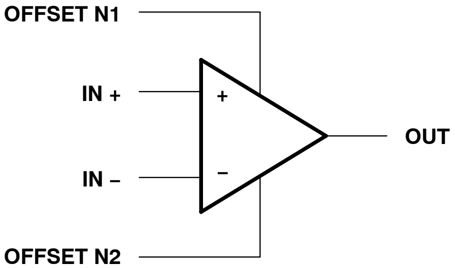
## description (continued)

The ac performance of the TLE2027 and TLE2037 is highlighted by a typical unity-gain bandwidth specification of 15 MHz, 55° of phase margin, and noise voltage specifications of 3.3 nV/$\sqrt{\text{Hz}}$ and 2.5 nV/$\sqrt{\text{Hz}}$ at frequencies of 10 Hz and 1 kHz respectively. The TLE2037 and TLE2037A have been decompensated for faster slew rate (–7.5 V/µs, typical) and wider bandwidth (50 MHz). To ensure stability, the TLE2037 and TLE2037A should be operated with a closed-loop gain of 5 or greater.

Both the TLE20x7 and TLE20x7A are available in a wide variety of packages, including the industry-standard 8-pin small-outline version 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 105°C. The M-suffix devices are characterized for operation over the full military temperature range of −55°C to 125°C.

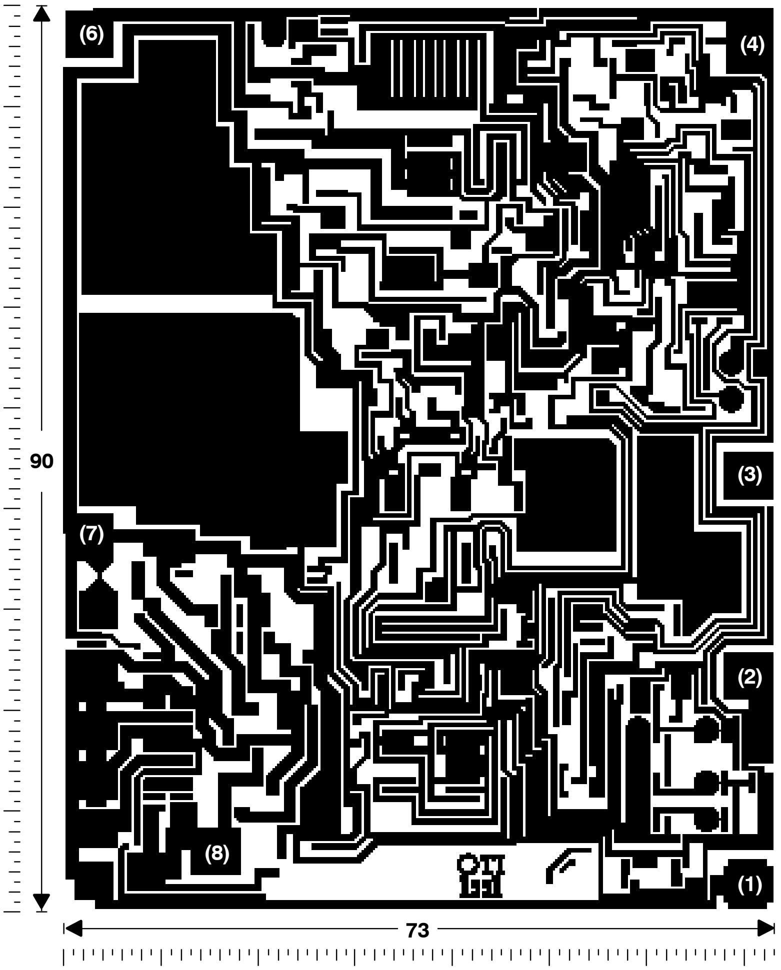
## symbol

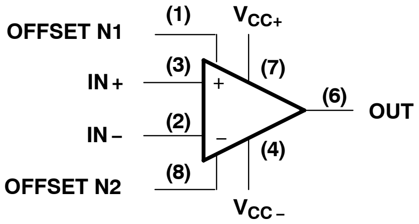


## TLE202xY chip information

This chip, when properly assembled, displays characteristics similar to the TLE202xC. Thermal compression or ultrasonic bonding may be used on the doped-aluminum bonding pads. The chip may be mounted with conductive epoxy or a gold-silicon preform.

**BONDING PAD ASSIGNMENTS**





CHIP THICKNESS: 15 MILS TYPICAL

BONDING PADS: 4 × 4 MILS MINIMUM

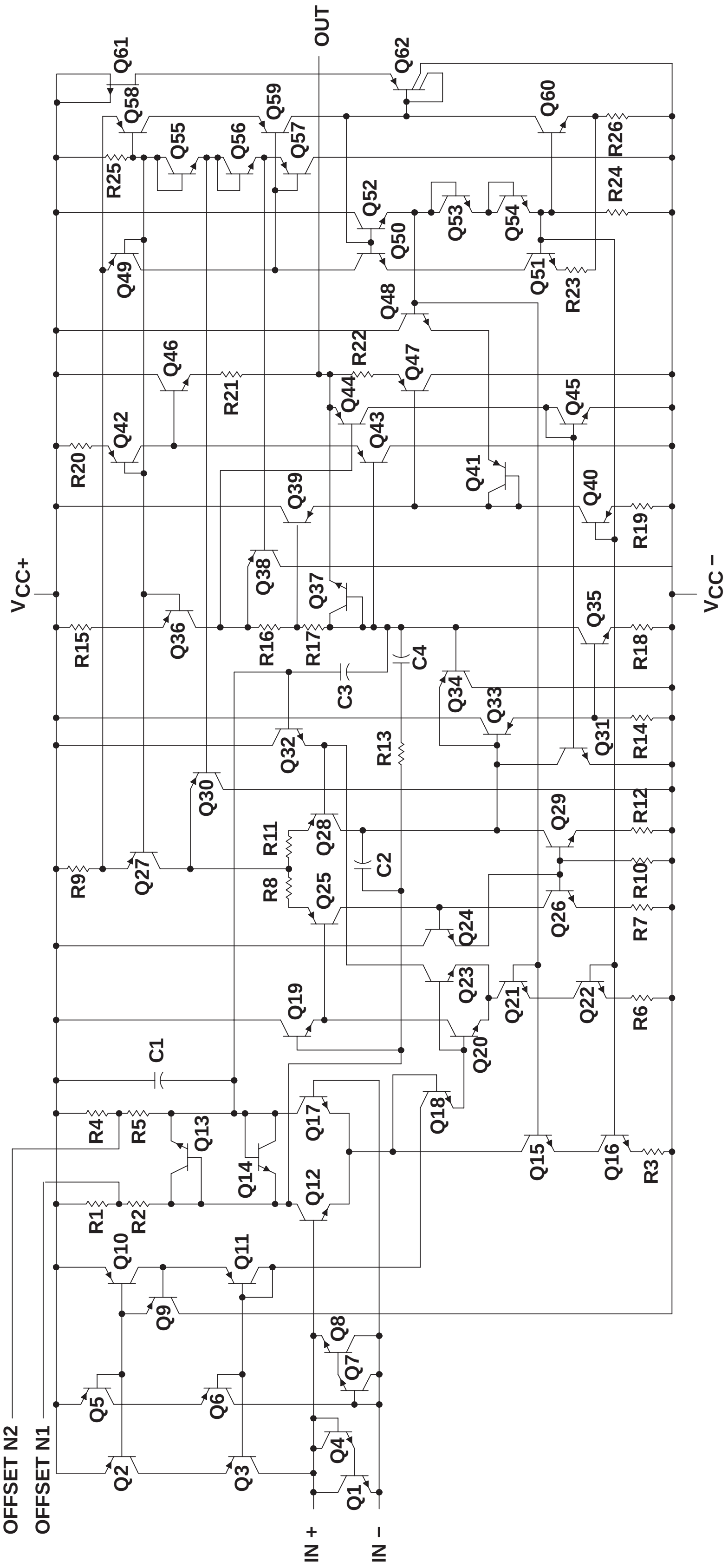
$T_J$max = 150°C

TOLERANCES ARE ±10%.

ALL DIMENSIONS ARE IN MILS.

PIN (4) IS INTERNALLY CONNECTED
TO BACKSIDE OF CHIP.

## equivalent schematic



ACTUAL DEVICE COMPONENT COUNT

| COMPONENT | TLE2027 | TLE2037 |
|---|---|---|
| Transistors | 61 | 61 |
| Resistors | 26 | 26 |
| epiFET | 1 | 1 |
| Capacitors | 4 | 4 |

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

| | |
|---|---|
| Supply voltage, $V_{CC+}$ (see Note 1) | 19 V |
| Supply voltage, $V_{CC-}$ | − 19 V |
| Differential input voltage, $V_{ID}$ (see Note 2) | ±1.2 V |
| Input voltage range, $V_I$ (any input) | $V_{CC\pm}$ |
| Input current, $I_I$ (each Input) | ±1 mA |
| Output current, $I_O$ | ± 50 mA |
| Total current into $V_{CC+}$ | 50 mA |
| Total current out of $V_{CC-}$ | 50 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 105°C |
| M suffix | − 55°C to 125°C |
| Storage temperature range, $T_{stg}$ | − 65°C to 150°C |
| Case temperature for 60 seconds, $T_C$: 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 60 seconds: JG package | 300°C |

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

NOTES: 1. All voltage values, except differential voltages, are with respect to the midpoint between $V_{CC+}$ and $V_{CC-}$.

2. Differential voltages are at IN+ with respect to IN−. Excessive current flows if a differential input voltage in excess of approximately ±1.2 V is applied between the inputs unless some limiting resistance is used.

3. The output may be shorted to either supply. Temperature and/or supply voltages must be limited to ensure that the maximum dissipation rating is not exceeded.

**DISSIPATION RATING TABLE**

| PACKAGE | $T_A \le 25°C$ POWER RATING | DERATING FACTOR ABOVE $T_A = 25°C$ | $T_A = 70°C$ POWER RATING | $T_A = 105°C$ POWER RATING | $T_A = 125°C$ POWER RATING |
|---|---|---|---|---|---|
| D | 725 mW | 5.8 mW/°C | 464 mW | 261 mW | 145 mW |
| FK | 1375 mW | 11.0 mW/°C | 880 mW | 495 mW | 275 mW |
| JG | 1050 mW | 8.4 mW/°C | 672 mW | 378 mW | 210 mW |
| P | 1000 mW | 8.0 mW/°C | 640 mW | 360 mW | 200 mW |

## recommended operating conditions

| | | C SUFFIX | | I SUFFIX | | M SUFFIX | | UNIT |
|---|---|---|---|---|---|---|---|---|
| | | MIN | MAX | MIN | MAX | MIN | MAX | |
| Supply voltage, $V_{CC\pm}$ | | ±4 | ± 19 | ±4 | ±19 | ±4 | ±19 | V |
| Common-mode input voltage, $V_{IC}$ | $T_A = 25°C$ | −11 | 11 | −11 | 11 | −11 | 11 | V |
| | $T_A$ = Full range[‡] | −10.5 | 10.5 | −10.4 | 10.4 | −10.2 | 10.2 | |
| Operating free-air temperature, $T_A$ | | 0 | 70 | −40 | 105 | −55 | 125 | °C |

[‡] Full range is 0°C to 70°C for C-suffix devices, −40°C to 105°C for I-suffix devices, and −55°C to 125°C for M-suffix devices.

### TLE20x7C electrical characteristics at specified free-air temperature, $V_{CC\pm}$ = ±15 V (unless otherwise noted)

| PARAMETER | TEST CONDITIONS | $T_A$† | TLE20x7C | | | TLE20x7AC | | | UNIT |
|---|---|---|---|---|---|---|---|---|---|
| | | | MIN | TYP | MAX | MIN | TYP | MAX | |
| $V_{IO}$ Input offset voltage | $V_{IC}$ = 0, $R_S$ = 50 Ω | 25°C | | 20 | 100 | | 10 | 25 | µV |
| | | Full range | | | 145 | | | 70 | |
| $\alpha_{VIO}$ Temperature coefficient of input offset voltage | | Full range | | 0.4 | 1 | | 0.2 | 1 | µV/°C |
| Input offset voltage long-term drift (see Note 4) | | 25°C | | 0.006 | 1 | | 0.006 | 1 | µV/mo |
| $I_{IO}$ Input offset current | | 25°C | | 6 | 90 | | 6 | 90 | nA |
| | | Full range | | | 150 | | | 150 | |
| $I_{IB}$ Input bias current | | 25°C | | 15 | 90 | | 15 | 90 | nA |
| | | Full range | | | 150 | | | 150 | |
| $V_{ICR}$ Common-mode input voltage range | $R_S$ = 50 Ω | 25°C | −11 to 11 | −13 to 13 | | −11 to 11 | −13 to 13 | | V |
| | | Full range | −10.5 to 10.5 | | | −10.5 to 10.5 | | | |
| $V_{OM+}$ Maximum positive peak output voltage swing | $R_L$ = 600 Ω | 25°C | 10.5 | 12.9 | | 10.5 | 12.9 | | V |
| | | Full range | 10 | | | 10 | | | |
| | $R_L$ = 2 kΩ | 25°C | 12 | 13.2 | | 12 | 13.2 | | |
| | | Full range | 11 | | | 11 | | | |
| $V_{OM-}$ Maximum negative peak output voltage swing | $R_L$ = 600 Ω | 25°C | −10.5 | −13 | | −10.5 | −13 | | V |
| | | Full range | −10 | | | −10 | | | |
| | $R_L$ = 2 kΩ | 25°C | −12 | −13.5 | | −12 | −13.5 | | |
| | | Full range | −11 | | | −11 | | | |
| $A_{VD}$ Large-signal differential voltage amplification | $V_O$ = ±11 V, $R_L$ = 2 kΩ | 25°C | 5 | 45 | | 10 | 45 | | V/µV |
| | $V_O$ = ±10 V, $R_L$ = 2 kΩ | Full range | 2 | | | 4 | | | |
| | $V_O$ = ±10 V, $R_L$ = 1 kΩ | 25°C | 3.5 | 38 | | 8 | 38 | | |
| | | Full range | 1 | | | 2.5 | | | |
| | $V_O$ = ±10 V, $R_L$ = 600 Ω | 25°C | 2 | 19 | | 5 | 19 | | |
| | | Full range | 0.5 | | | 2 | | | |
| $C_i$ Input capacitance | | 25°C | | 8 | | | 8 | | pF |
| $z_o$ Open-loop output impedance | $I_O$ = 0 | 25°C | | 50 | | | 50 | | Ω |
| CMRR Common-mode rejection ratio | $V_{IC}$ = $V_{ICR}$min, $R_S$ = 50 Ω | 25°C | 100 | 131 | | 117 | 131 | | dB |
| | | Full range | 98 | | | 114 | | | |
| $k_{SVR}$ Supply-voltage rejection ratio ($\Delta V_{CC\pm}$ /$\Delta V_{IO}$) | $V_{CC\pm}$ = ±4 V to ±18 V, $R_S$ = 50 Ω | 25°C | 94 | 144 | | 110 | 144 | | dB |
| | $V_{CC\pm}$ = ±4 V to ±18 V, $R_S$ = 50 Ω | Full range | 92 | | | 106 | | | |
| $I_{CC}$ Supply current | $V_O$ = 0, No load | 25°C | | 3.8 | 5.3 | | 3.8 | 5.3 | mA |
| | | Full range | | | 5.6 | | | 5.6 | |

† Full range is 0°C to 70°C.

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

## TLE20x7C operating characteristics at specified free-air temperature, $V_{CC\pm} = \pm15$ V, $T_A = 25°C$ (unless otherwise specified)

| PARAMETER | | TEST CONDITIONS | | TLE20x7C | | | TLE20x7AC | | | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | MIN | TYP | MAX | MIN | TYP | MAX | |
| SR | Slew rate at unity gain | $R_L$ = 2 kΩ,<br>$C_L$ = 100 pF,<br>See Figure 1 | TLE2027 | 1.7 | 2.8 | | 1.7 | 2.8 | | V/μs |
| | | | TLE2037 | 6 | 7.5 | | 6 | 7.5 | | |
| | | $R_L$ = 2 kΩ,<br>$C_L$ = 100 pF,<br>$T_A$ = 0°C to 70°C,<br>See Figure 1 | TLE2027 | 1.2 | | | 1.2 | | | |
| | | | TLE2037 | 5 | | | 5 | | | |
| $V_n$ | Equivalent input noise voltage (see Figure 2) | $R_S$ = 20 Ω, | f = 10 Hz | | 3.3 | 8 | | 3.3 | 4.5 | nV/√Hz |
| | | $R_S$ = 20 Ω, | f = 1 kHz | | 2.5 | 4.5 | | 2.5 | 3.8 | |
| $V_{N(PP)}$ | Peak-to-peak equivalent input noise voltage | f = 0.1 Hz to 10 Hz | | | 50 | 250 | | 50 | 130 | nV |
| $I_n$ | Equivalent input noise current | f = 10 Hz | | | 10 | 25 | | 10 | 25 | pA/√Hz |
| | | f = 1 kHz | | | 0.8 | 1.8 | | 0.8 | 1.8 | |
| THD | Total harmonic distortion | $V_O$ = +10 V,<br>$A_{VD}$ = 1,<br>See Note 5 | TLE2027 | | <0.002% | | | <0.002% | | |
| | | $V_O$ = +10 V,<br>$A_{VD}$ = 5,<br>See Note 5 | TLE2037 | | <0.002% | | | <0.002% | | |
| $B_1$ | Unity-gain bandwidth (see Figure 3) | $R_L$ = 2 kΩ,<br>$C_L$ = 100 pF | TLE2027 | 9[6] | 13 | | 9[6] | 13 | | MHz |
| GBW | Gain bandwidth product | $R_L$ = 2 kΩ,<br>$C_L$ = 100 pF | TLE2037 | 35 | 50 | | 35 | 50 | | |
| $B_{OM}$ | Maximum output-swing bandwidth | $R_L$ = 2 kΩ | TLE2027 | | 30 | | | 30 | | kHz |
| | | | TLE2037 | | 80 | | | 80 | | |
| $\phi_m$ | Phase margin at unity gain (see Figure 3) | $R_L$ = 2 kΩ,<br>$C_L$ = 100 pF | TLE2027 | | 55° | | | 55° | | |
| | | | TLE2037 | | 50° | | | 50° | | |

NOTE 5: Measured distortion of the source used in the analysis was 0.002%.
NOTE 6: This parameter is not production tested

## TLE20x7I electrical characteristics at specified free-air temperature, $V_{CC\pm}$ = ±15 V (unless otherwise noted)

| PARAMETER | TEST CONDITIONS | $T_A$† | TLE20x7I | | | TLE20x7AI | | | UNIT |
|---|---|---|---|---|---|---|---|---|---|
| | | | MIN | TYP | MAX | MIN | TYP | MAX | |
| $V_{IO}$ Input offset voltage | $V_{IC}$ = 0, $R_S$ = 50 Ω | 25°C | | 20 | 100 | | 10 | 25 | µV |
| | | Full range | | | 180 | | | 105 | |
| $\alpha_{VIO}$ Temperature coefficient of input offset voltage | | Full range | | 0.4 | 1 | | 0.2 | 1 | µV/°C |
| Input offset voltage long-term drift (see Note 4) | | 25°C | | 0.006 | 1 | | 0.006 | 1 | µV/mo |
| $I_{IO}$ Input offset current | | 25°C | | 6 | 90 | | 6 | 90 | nA |
| | | Full range | | | 150 | | | 150 | |
| $I_{IB}$ Input bias current | | 25°C | | 15 | 90 | | 15 | 90 | nA |
| | | Full range | | | 150 | | | 150 | |
| $V_{ICR}$ Common-mode input voltage range | $R_S$ = 50 Ω | 25°C | −11 to 11 | −13 to 13 | | −11 to 11 | −13 to 13 | | V |
| | | Full range | −10.4 to 10.4 | | | −10.4 to 10.4 | | | |
| $V_{OM+}$ Maximum positive peak output voltage swing | $R_L$ = 600 Ω | 25°C | 10.5 | 12.9 | | 10.5 | 12.9 | | V |
| | | Full range | 10 | | | 10 | | | |
| | $R_L$ = 2 kΩ | 25°C | 12 | 13.2 | | 12 | 13.2 | | |
| | | Full range | 11 | | | 11 | | | |
| $V_{OM-}$ Maximum negative peak output voltage swing | $R_L$ = 600 Ω | 25°C | −10.5 | −13 | | −10.5 | −13 | | V |
| | | Full range | −10 | | | −10 | | | |
| | $R_L$ = 2 kΩ | 25°C | −12 | −13.5 | | −12 | −13.5 | | |
| | | Full range | −11 | | | −11 | | | |
| $A_{VD}$ Large-signal differential voltage amplification | $V_O$ = ±11 V, $R_L$ = 2 kΩ | 25°C | 5 | 45 | | 10 | 45 | | V/µV |
| | $V_O$ = ±10 V, $R_L$ = 2 kΩ | Full range | 2 | | | 3.5 | | | |
| | $V_O$ = ±10 V, $R_L$ = 1 kΩ | 25°C | 3.5 | 38 | | 8 | 38 | | |
| | | Full range | 1 | | | 2.2 | | | |
| | $V_O$ = ±10 V, $R_L$ = 600 Ω | 25°C | 2 | 19 | | 5 | 19 | | |
| | | Full range | 0.5 | | | 1.1 | | | |
| $C_i$ Input capacitance | | 25°C | | 8 | | | 8 | | pF |
| $z_o$ Open-loop output impedance | $I_O$ = 0 | 25°C | | 50 | | | 50 | | Ω |
| CMRR Common-mode rejection ratio | $V_{IC}$ = $V_{ICR}$min, $R_S$ = 50 Ω | 25°C | 100 | 131 | | 117 | 131 | | dB |
| | | Full range | 96 | | | 113 | | | |
| $k_{SVR}$ Supply-voltage rejection ratio ($\Delta V_{CC\pm}$ /$\Delta V_{IO}$) | $V_{CC\pm}$ = ±4 V to ±18 V, $R_S$ = 50 Ω | 25°C | 94 | 144 | | 110 | 144 | | dB |
| | $V_{CC\pm}$ = ±4 V to ±18 V, $R_S$ = 50 Ω | Full range | 90 | | | 105 | | | |
| $I_{CC}$ Supply current | $V_O$ = 0, No load | 25°C | | 3.8 | 5.3 | | 3.8 | 5.3 | mA |
| | | Full range | | | 5.6 | | | 5.6 | |

† Full range is – 40°C to 105°C.

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

## TLE20x7I operating characteristics at specified free-air temperature, $V_{CC\pm} = \pm15$ V, $T_A = 25°C$ (unless otherwise specified)

| PARAMETER | | TEST CONDITIONS | | TLE20x7I | | | TLE20x7AI | | | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | MIN | TYP | MAX | MIN | TYP | MAX | |
| SR | Slew rate at unity gain | $R_L$ = 2 kΩ,<br>$C_L$ = 100 pF,<br>See Figure 1 | TLE2027 | 1.7 | 2.8 | | 1.7 | 2.8 | | V/µs |
| | | | TLE2037 | 6 | 7.5 | | 6 | 7.5 | | |
| | | $R_L$ = 2 kΩ,<br>$C_L$ = 100 pF,<br>$T_A$ = −40°C to 85°C,<br>See Figure 1 | TLE2027 | 1.1 | | | 1.1 | | | |
| | | | TLE2037 | 4.7 | | | 4.7 | | | |
| $V_n$ | Equivalent input noise voltage (see Figure 2) | $R_S$ = 20 Ω, | f = 10 Hz | | 3.3 | 8 | | 3.3 | 4.5 | nV/√Hz |
| | | $R_S$ = 20 Ω, | f = 1 kHz | | 2.5 | 4.5 | | 2.5 | 3.8 | |
| $V_{N(PP)}$ | Peak-to-peak equivalent input noise voltage | f = 0.1 Hz to 10 Hz | | | 50 | 250 | | 50 | 130 | nV |
| $I_n$ | Equivalent input noise current | f = 10 Hz | | | 10 | 25 | | 10 | 25 | pA/√Hz |
| | | f = 1 kHz | | | 0.8 | 1,8 | | 0.8 | 1.8 | |
| THD | Total harmonic distortion | $V_O$ = +10 V,<br>$A_{VD}$ = 1,<br>See Note 5 | TLE2027 | | < 0.002% | | | < 0.002% | | |
| | | $V_O$ = +10 V,<br>$A_{VD}$ = 5,<br>See Note 5 | TLE2037 | | < 0.002% | | | < 0.002% | | |
| $B_1$ | Unity-gain bandwidth (see Figure 3) | $R_L$ = 2 kΩ,<br>$C_L$ = 100 pF | TLE2027 | 9(6) | 13 | | 9(6) | 13 | | MHz |
| GBW | Gain bandwidth product | $R_L$ = 2 kΩ,<br>$C_L$ = 100 pF | TLE2037 | 35 | 50 | | 35 | 50 | | |
| $B_{OM}$ | Maximum output-swing bandwidth | $R_L$ = 2 kΩ | TLE2027 | | 30 | | | 30 | | kHz |
| | | | TLE2037 | | 80 | | | 80 | | |
| $\phi_m$ | Phase margin at unity gain (see Figure 3) | $R_L$ = 2 kΩ,<br>$C_L$ = 100 pF | TLE2027 | | 55° | | | 55° | | |
| | | | TLE2037 | | 50° | | | 50° | | |

NOTE 5: Measured distortion of the source used in the analysis was 0.002%.
NOTE 6: This parameter is not production tested.

## TLE20x7M electrical characteristics at specified free-air temperature, $V_{CC\pm}$ = ±15 V (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | $T_A$† | TLE20x7M | | | TLE20x7AM | | | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | MIN | TYP | MAX | MIN | TYP | MAX | |
| $V_{IO}$ | Input offset voltage | $V_{IC}$ = 0, $R_S$ = 50 Ω | 25°C | | 20 | 100 | | 10 | 25 | μV |
| | | | Full range | | | 200 | | | 105 | |
| $\alpha_{VIO}$ | Temperature coefficient of input offset voltage | | Full range | | 0.4 | 1* | | 0.2 | 1* | μV/°C |
| | Input offset voltage long-term drift (see Note 4) | | 25°C | | 0.006 | 1* | | 0.006 | 1* | μV/mo |
| $I_{IO}$ | Input offset current | | 25°C | | 6 | 90 | | 6 | 90 | nA |
| | | | Full range | | | 150 | | | 150 | |
| $I_{IB}$ | Input bias current | | 25°C | | 15 | 90 | | 15 | 90 | nA |
| | | | Full range | | | 150 | | | 150 | |
| $V_{ICR}$ | Common-mode input voltage range | $R_S$ = 50 Ω | 25°C | −11 to 11 | −13 to 13 | | −11 to 11 | −13 to 13 | | V |
| | | | Full range | −10.3 to 10.3 | | | −10.4 to 10.4 | | | |
| $V_{OM+}$ | Maximum positive peak output voltage swing | $R_L$ = 600 Ω | 25°C | 10.5 | 12.9 | | 10.5 | 12.9 | | V |
| | | | Full range | 10 | | | 10 | | | |
| | | $R_L$ = 2 kΩ | 25°C | 12 | 13.2 | | 12 | 13.2 | | |
| | | | Full range | 11 | | | 11 | | | |
| $V_{OM-}$ | Maximum negative peak output voltage swing | $R_L$ = 600 Ω | 25°C | −10.5 | −13 | | −10.5 | −13 | | V |
| | | | Full range | −10 | | | −10 | | | |
| | | $R_L$ = 2 kΩ | 25°C | −12 | −13.5 | | −12 | −13.5 | | |
| | | | Full range | −11 | | | −11 | | | |
| $A_{VD}$ | Large-signal differential voltage amplification | $V_O$ = ±11 V, $R_L$ = 2 kΩ | 25°C | 5 | 45 | | 10 | 45 | | V/μV |
| | | $V_O$ = ±10 V, $R_L$ = 2 kΩ | Full range | 2.5 | | | 3.5 | | | |
| | | $V_O$ = ±10 V, $R_L$ = 1 kΩ | 25°C | 3.5 | 38 | | 8 | 38 | | |
| | | | Full range | 1.8 | | | 2.2 | | | |
| | | $V_O$ = ±10 V, $R_L$ = 600 Ω | 25°C | 2 | 19 | | 5 | 19 | | |
| $C_i$ | Input capacitance | | 25°C | | 8 | | | 8 | | pF |
| $z_o$ | Open-loop output impedance | $I_O$ = 0 | 25°C | | 50 | | | 50 | | Ω |
| CMRR | Common-mode rejection ratio | $V_{IC}$ = $V_{ICR}$min, $R_S$ = 50 Ω | 25°C | 100 | 131 | | 117 | 131 | | dB |
| | | | Full range | 96 | | | 113 | | | |
| $k_{SVR}$ | Supply-voltage rejection ratio ($\Delta V_{CC\pm}$ /$\Delta V_{IO}$) | $V_{CC\pm}$ = ±4 V to ±18 V, $R_S$ = 50 Ω | 25°C | 94 | 144 | | 110 | 144 | | dB |
| | | $V_{CC\pm}$ = ±4 V to ±18 V, $R_S$ = 50 Ω | Full range | 90 | | | 105 | | | |
| $I_{CC}$ | Supply current | $V_O$ = 0, No load | 25°C | | 3.8 | 5.3 | | 3.8 | 5.3 | mA |
| | | | Full range | | | 5.6 | | | 5.6 | |

* On products compliant to MIL-PRF-38535, this parameter is not production tested.

† Full range is − 55°C to 125°C.

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

## TLE20x7M operating characteristics at specified free-air temperature, $V_{CC\pm}$ = ±15 V, $T_A$ = 25°C (unless otherwise specified)

| PARAMETER | | TEST CONDITIONS | | TLE20x7M | | | TLE20x7AM | | | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | MIN | TYP | MAX | MIN | TYP | MAX | |
| SR | Slew rate at unity gain | $R_L$ = 2 kΩ,<br>$C_L$ = 100 pF,<br>See Figure 1 | TLE2027 | 1.7 | 2.8 | | 1.7 | 2.8 | | V/µs |
| | | | TLE2037 | 6* | 7.5 | | 6* | 7.5 | | |
| | | $R_L$ = 2 kΩ,<br>$C_L$ = 100 pF,<br>$T_A$ = −55°C to 125°C,<br>See Figure 1 | TLE2027 | 1 | | | 1 | | | |
| | | | TLE2037 | 4.4* | | | 4.4* | | | |
| $V_n$ | Equivalent input noise voltage (see Figure 2) | $R_S$ = 20 Ω, | f = 10 Hz | | 3.3 | 8* | | 3.3 | 8* | nV/√Hz |
| | | $R_S$ = 20 Ω, | f = 1 kHz | | 2.5 | 4* | | 2.5 | 4* | |
| $V_{N(PP)}$ | Peak-to-peak equivalent input noise voltage | f = 0.1 Hz to 10 Hz | | | 225 | 375* | | 225 | 375* | nV |
| $I_n$ | Equivalent input noise current | f = 10 Hz | | | 25 | | | 25 | | pA/√Hz |
| | | f = 1 kHz | | | 2.5 | | | 2.5 | | |
| THD | Total harmonic distortion | $V_O$ = +10 V,<br>$A_{VD}$ = 1,<br>See Note 5 | TLE2027 | | < 0.002% | | | < 0.002% | | |
| | | $V_O$ = +10 V,<br>$A_{VD}$ = 5,<br>See Note 5 | TLE2037 | | < 0.002% | | | < 0.002% | | |
| $B_1$ | Unity-gain bandwidth (see Figure 3) | $R_L$ = 2 kΩ,<br>$C_L$ = 100 pF | TLE2027 | 7* | 13 | | 9* | 13 | | MHz |
| | | | TLE2037 | 35 | 50 | | 35 | 50 | | |
| $B_{OM}$ | Maximum output-swing bandwidth | $R_L$ = 2 kΩ | TLE2027 | | 30 | | | 30 | | kHz |
| | | | TLE2037 | | 80 | | | 80 | | |
| $\phi_m$ | Phase margin at unity gain (see Figure 3) | $R_L$ = 2 kΩ,<br>$C_L$ = 100 pF | TLE2027 | | 55° | | | 55° | | |
| | | | TLE2037 | | 50° | | | 50° | | |

* On products compliant to MIL-PRF-38535, this parameter is not production tested.

NOTE 5: Measured distortion of the source used in the analysis was 0.002%.

## TLE20x7Y electrical characteristics, $V_{CC\pm}$ = ±15 V, $T_A$ = 25°C (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | TLE20x7Y | | | UNIT |
|---|---|---|---|---|---|---|
| | | | MIN | TYP | MAX | |
| $V_{IO}$ | Input offset voltage | $V_{IC}$ = 0, $R_S$ = 50 Ω | | 20 | | µV |
| | Input offset voltage long-term drift (see Note 4) | | | 0.006 | | µV/mo |
| $I_{IO}$ | Input offset current | | | 6 | | nA |
| $I_{IB}$ | Input bias current | | | 15 | | nA |
| $V_{ICR}$ | Common-mode input voltage range | $R_S$ = 50 Ω | | −13<br>to<br>13 | | V |
| $V_{OM+}$ | Maximum positive peak output voltage swing | $R_L$ = 600 Ω | | 12.9 | | V |
| | | $R_L$ = 2 kΩ | | 13.2 | | |
| $V_{OM-}$ | Maximum negative peak output voltage swing | $R_L$ = 600 Ω | | −13 | | V |
| | | $R_L$ = 2 kΩ | | −13.5 | | |
| $A_{VD}$ | Large-signal differential voltage amplification | $V_O$ = ±11 V, $R_L$ = 2 kΩ | | 45 | | V/µV |
| | | $V_O$ = ±10 V, $R_L$ = 1 kΩ | | 38 | | |
| | | $V_O$ = ±10 V, $R_L$ = 600 Ω | | 19 | | |
| $C_i$ | Input capacitance | | | 8 | | pF |
| $z_o$ | Open-loop output impedance | $I_O$ = 0 | | 50 | | Ω |
| CMRR | Common-mode rejection ratio | $V_{IC}$ = $V_{ICR}$min, $R_S$ = 50 Ω | | 131 | | dB |
| $k_{SVR}$ | Supply-voltage rejection ratio ($\Delta V_{CC\pm}$ /$\Delta V_{IO}$) | $V_{CC\pm}$ = ±4 V to ±18 V, $R_S$ = 50 Ω | | 144 | | dB |
| $I_{CC}$ | Supply current | $V_O$ = 0, No load | | 3.8 | | mA |

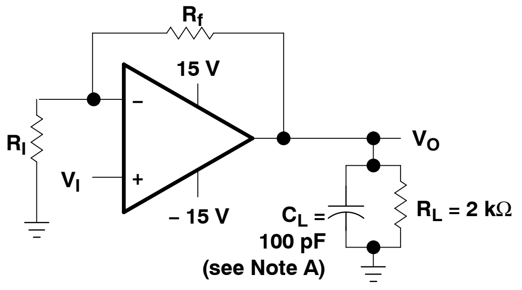
NOTE 4: Typical values are based on the input offset voltage shift observed through 168 hours of operating life test at $T_A$ = 150°C extrapolated to $T_A$ = 25°C using the Arrhenius equation and assuming an activation energy of 0.96 eV.

## TLE20x7Y operating characteristics at specified free-air temperature, $V_{CC\pm}$ = ±15 V

| PARAMETER | | TEST CONDITIONS | | TLE20x7Y | | | UNIT |
|---|---|---|---|---|---|---|---|
| | | | | MIN | TYP | MAX | |
| SR | Slew rate at unity gain | $R_L$ = 2 kΩ, $C_L$ = 100 pF, See Figure 1 | TLE2027 | | 2.8 | | V/µs |
| | | | TLE2037 | | 7.5 | | |
| $V_n$ | Equivalent input noise voltage (see Figure 2) | $R_S$ = 20 Ω, f = 10 Hz | | | 3.3 | | nV/√Hz |
| | | $R_S$ = 20 Ω, f = 1 kHz | | | 2.5 | | |
| $V_{N(PP)}$ | Peak-to-peak equivalent input noise voltage | f = 0.1 Hz to 10 Hz | | | 50 | | nV |
| $I_n$ | Equivalent input noise current | f = 10 Hz | | | 10 | | pA/√Hz |
| | | f = 1 kHz | | | 0.8 | | |
| THD | Total harmonic distortion | $V_O$ = +10 V, $A_{VD}$ = 1, See Note 5 | TLE2027 | | < 0.002% | | |
| | | $V_O$ = +10 V, $A_{VD}$ = 5, See Note 5 | TLE2037 | | < 0.002% | | |
| $B_1$ | Unity-gain bandwidth (see Figure 3) | $R_L$ = 2 kΩ, $C_L$ = 100 pF | TLE2027 | | 13 | | MHz |
| | | | TLE2037 | | 50 | | |
| $B_{OM}$ | Maximum output-swing bandwidth | $R_L$ = 2 kΩ | TLE2027 | | 30 | | kHz |
| | | | TLE2037 | | 80 | | |
| $\phi_m$ | Phase margin at unity gain (see Figure 3) | $R_L$ = 2 kΩ, $C_L$ = 100 pF | TLE2027 | | 55° | | |
| | | | TLE2037 | | 50° | | |

NOTE 5: Measured distortion of the source used in the analysis was 0.002%.

## PARAMETER MEASUREMENT INFORMATION



NOTE A: $C_L$ includes fixture capacitance.

Figure 1. Slew-Rate Test Circuit

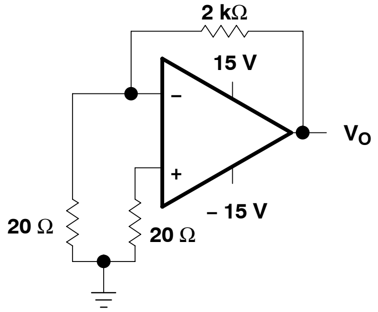
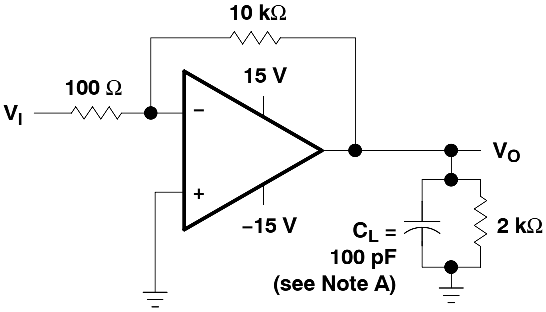
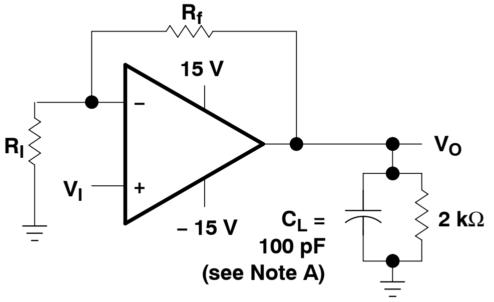


Figure 2. Noise-Voltage Test Circuit



NOTE A: $C_L$ includes fixture capacitance.



NOTES: A. $C_L$ includes fixture capacitance.
B. For the TLE2037 and TLE2037A, $A_{VD}$ must be ≥ 5.

Figure 3. Unity-Gain Bandwidth and Phase-Margin Test Circuit (TLE2027 Only)

Figure 4. Small-Signal Pulse-Response Test Circuit

## typical values

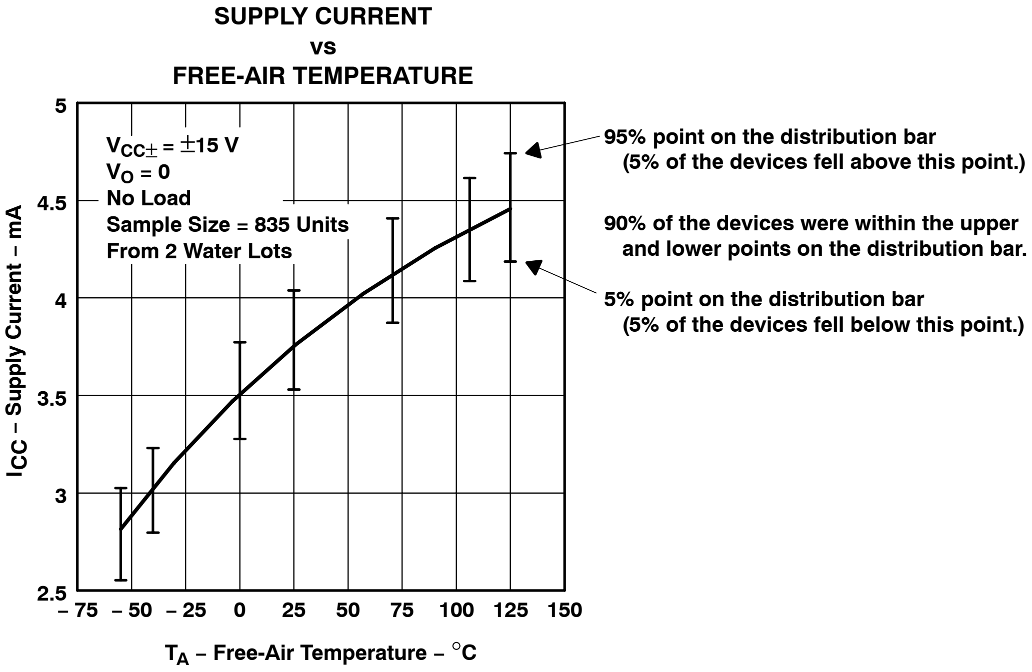
Typical values presented in this data sheet represent the median (50% point) of device parametric performance.

## initial estimates of parameter distributions

In the ongoing program of improving data sheets and supplying more information to our customers, Texas Instruments has added an estimate of not only the typical values but also the spread around these values. These are in the form of distribution bars that show the 95% (upper) points and the 5% (lower) points from the characterization of the initial wafer lots of this new device type (see Figure 5). The distribution bars are shown at the points where data was actually collected. The 95% and 5% points are used instead of ± 3 sigma since some of the distributions are not true Gaussian distributions.

The number of units tested and the number of different wafer lots used are on all of the graphs where distribution bars are shown. As noted in Figure 5, there were a total of 835 units from two wafer lots. In this case, there is a good estimate for the within-lot variability and a possibly poor estimate of the lot-to-lot variability. This is always the case on newly released products since there can only be data available from a few wafer lots.

The distribution bars are not intended to replace the minimum and maximum limits in the electrical tables. Each distribution bar represents 90% of the total units tested at a specific temperature. While 10% of the units tested fell outside any given distribution bar, this should not be interpreted to mean that the same individual devices fell outside every distribution bar.



SUPPLY CURRENT
vs
FREE-AIR TEMPERATURE

95% point on the distribution bar
(5% of the devices fell above this point.)

90% of the devices were within the upper
and lower points on the distribution bar.

5% point on the distribution bar
(5% of the devices fell below this point.)

Figure 5. Sample Graph With Distribution Bars

## TYPICAL CHARACTERISTICS

### Table of Graphs

| | | | FIGURE |
|---|---|---|---|
| $V_{IO}$ | Input offset voltage | Distribution | 6, 7 |
| $\Delta V_{IO}$ | Input offset voltage change | vs Time after power on | 8, 9 |
| $I_{IO}$ | Input offset current | vs Free-air temperature | 10 |
| $I_{IB}$ | Input bias current | vs Free-air temperature | 11 |
| | | vs Common-mode input voltage | 12 |
| $I_I$ | Input current | vs Differential input voltage | 13 |
| $V_{O(PP)}$ | Maximum peak-to-peak output voltage | vs Frequency | 14, 15 |
| $V_{OM}$ | Maximum (positive/negative) peak output voltage | vs Load resistance | 16, 17 |
| | | vs Free-air temperature | 18, 19 |
| $A_{VD}$ | Large-signal differential voltage amplification | vs Supply voltage | 20 |
| | | vs Load resistance | 21 |
| | | vs Frequency | 22 – 25 |
| | | vs Free-air temperature | 26 |
| $z_o$ | Output impedance | vs Frequency | 27 |
| CMRR | Common-mode rejection ratio | vs Frequency | 28 |
| $k_{SVR}$ | Supply-voltage rejection ratio | vs Frequency | 29 |
| $I_{OS}$ | Short-circut output current | vs Supply voltage | 30, 31 |
| | | vs Elapsed time | 32, 33 |
| | | vs Free-air temperature | 34, 35 |
| $I_{CC}$ | Supply current | vs Supply voltage | 36 |
| | | vs Free-air temperature | 37 |
| | Voltage-follower pulse response | Small signal | 38, 40 |
| | | Large signal | 39, 41 |
| $V_n$ | Equivalent input noise voltage | vs Frequency | 42 |
| | Noise voltage (referred to input) | Over 10-second interval | 43 |
| $B_1$ | Unity-gain bandwidth | vs Supply voltage | 44 |
| | | vs Load capacitance | 45 |
| | Gain bandwidth product | vs Supply voltage | 46 |
| | | vs Load capacitance | 47 |
| SR | Slew rate | vs Free-air temperature | 48, 49 |
| $\phi_m$ | Phase margin | vs Supply voltage | 50, 51 |
| | | vs Load capacitance | 52, 53 |
| | | vs Free-air temperature | 54, 55 |
| | Phase shift | vs Frequency | 22 – 25 |

## TYPICAL CHARACTERISTICS

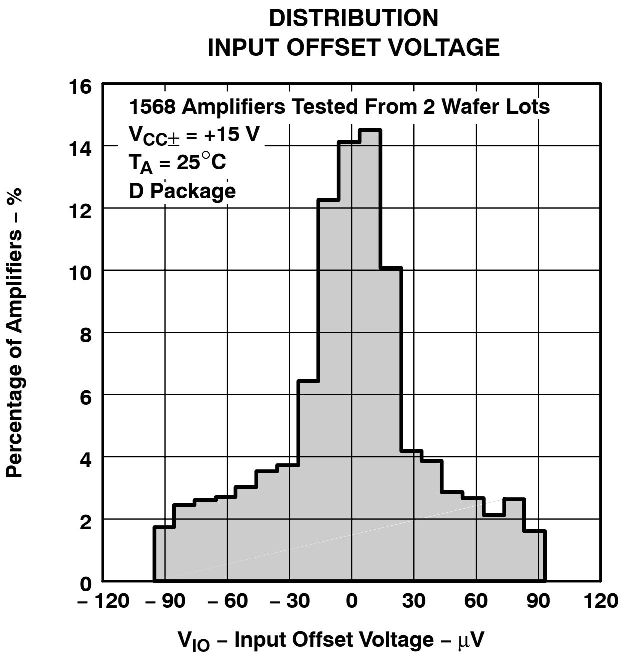

DISTRIBUTION
INPUT OFFSET VOLTAGE

Figure 6

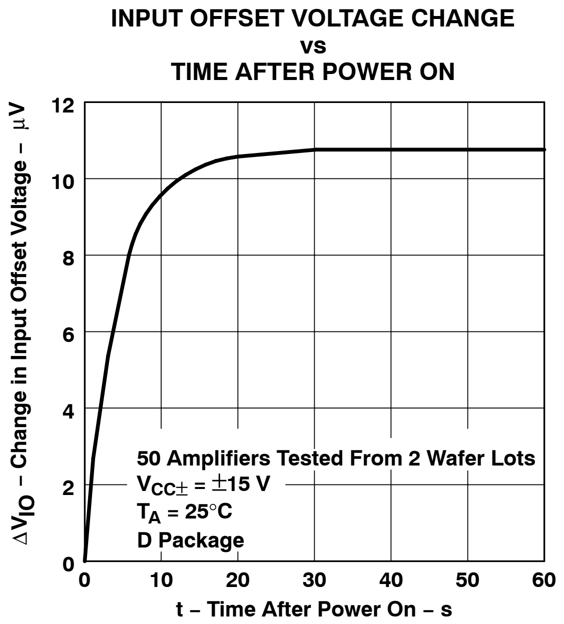

INPUT OFFSET VOLTAGE CHANGE
vs
TIME AFTER POWER ON

Figure 7

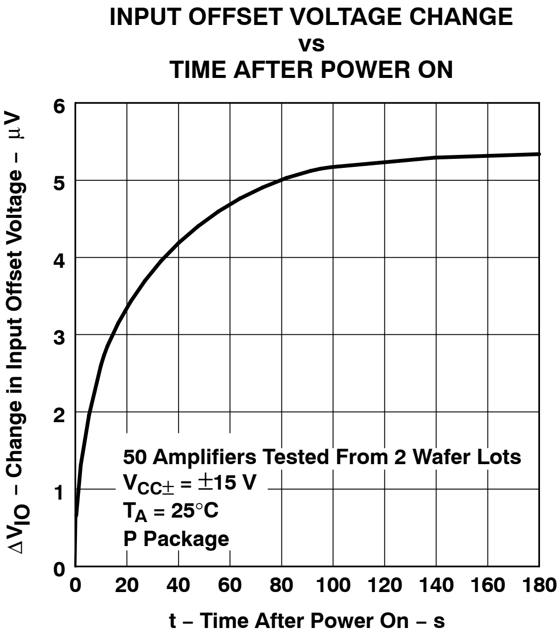

INPUT OFFSET VOLTAGE CHANGE
vs
TIME AFTER POWER ON

Figure 8

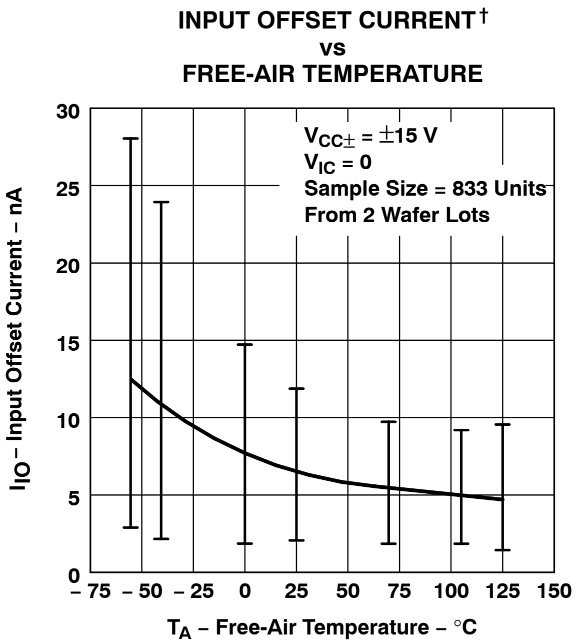

INPUT OFFSET CURRENT†
vs
FREE-AIR TEMPERATURE

Figure 9

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

## TYPICAL CHARACTERISTICS

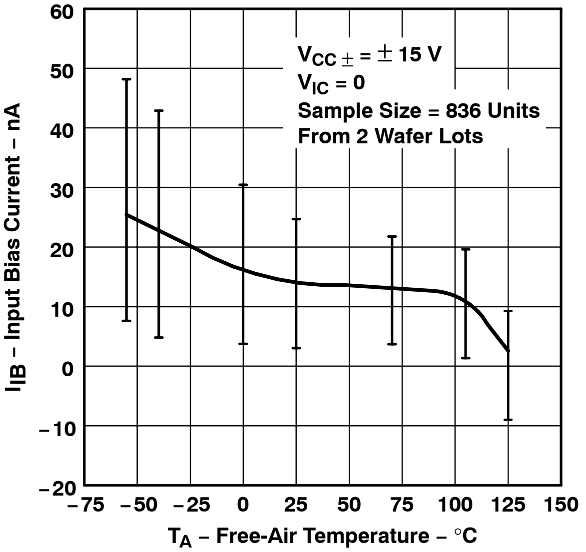

**INPUT BIAS CURRENT †
vs
FREE-AIR TEMPERATURE**

**Figure 10**

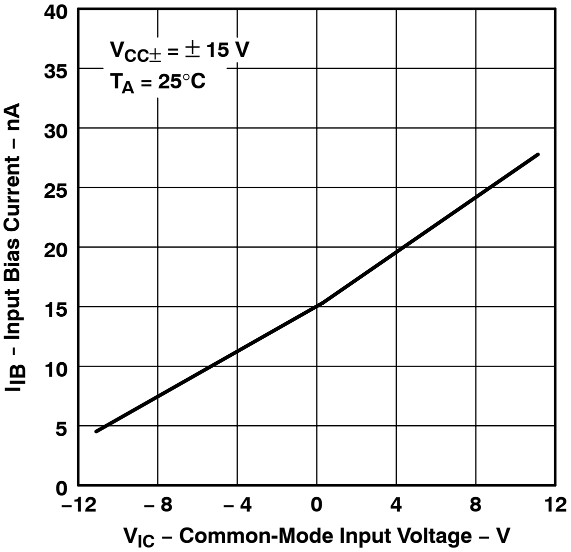

**INPUT BIAS CURRENT
vs
COMMON-MODE INPUT VOLTAGE**

**Figure 11**

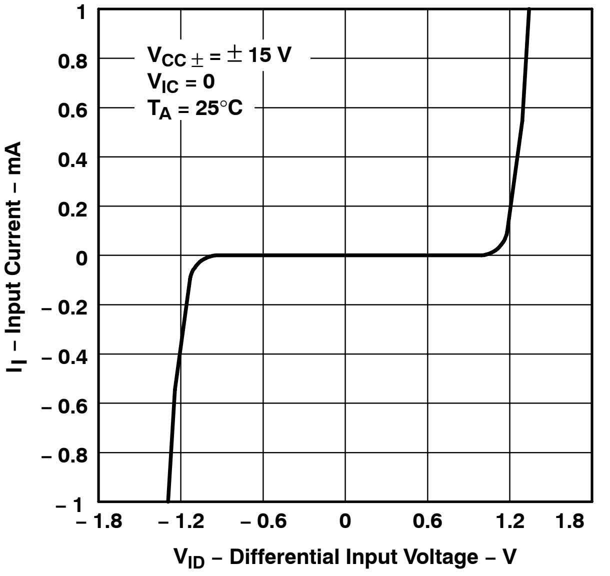

**INPUT CURRENT
vs
DIFFERENTIAL INPUT VOLTAGE**

**Figure 12**

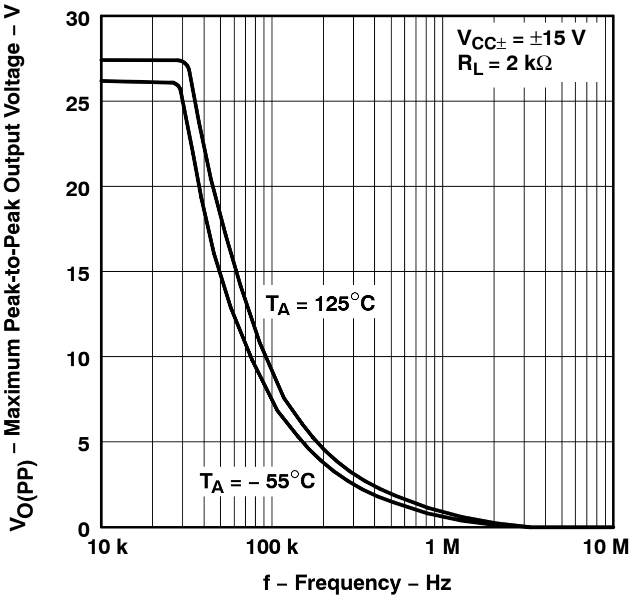

**TLE2027
MAXIMUM PEAK-TO-PEAK
OUTPUT VOLTAGE †
vs
FREQUENCY**

**Figure 13**

---

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

## TYPICAL CHARACTERISTICS

**TLE2037**
**MAXIMUM PEAK-TO-PEAK**
**OUTPUT VOLTAGE†**
**vs**
**FREQUENCY**

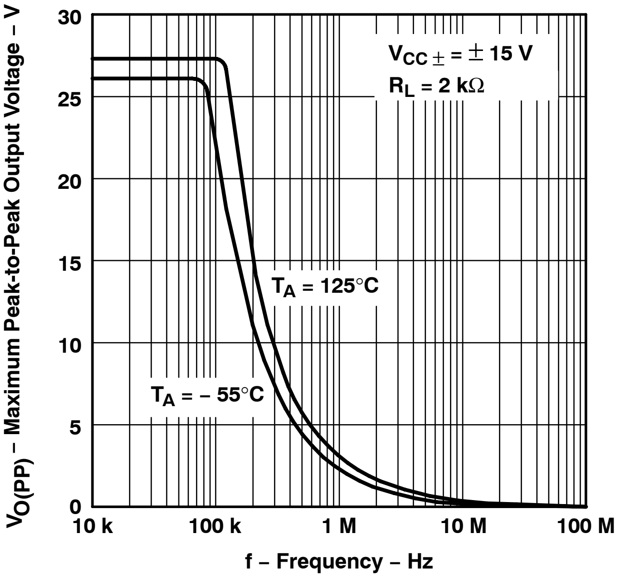


**Figure 14**

**MAXIMUM POSITIVE PEAK**
**OUTPUT VOLTAGE**
**vs**
**LOAD RESISTANCE**

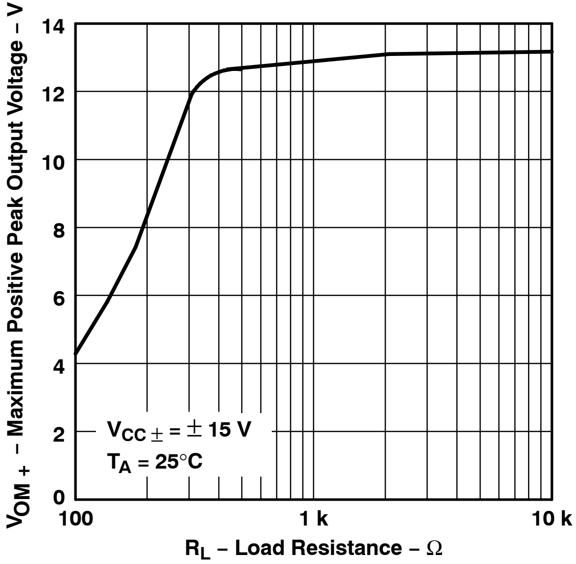


**Figure 15**

**MAXIMUM NEGATIVE PEAK**
**OUTPUT VOLTAGE**
**vs**
**LOAD RESISTANCE**

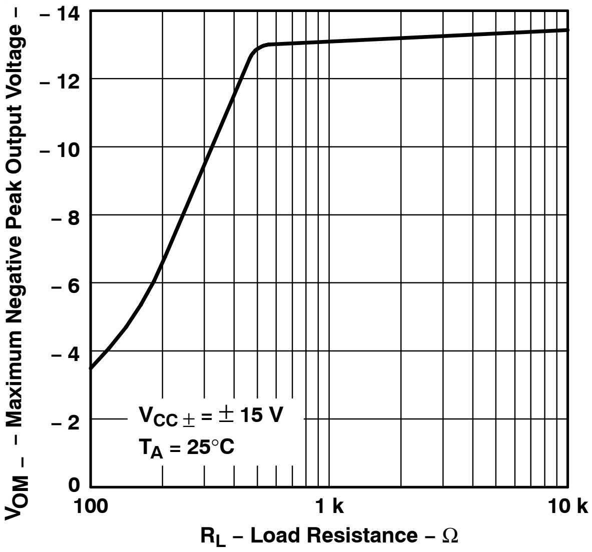


**Figure 16**

**MAXIMUM POSITIVE PEAK**
**OUTPUT VOLTAGE†**
**vs**
**FREE-AIR TEMPERATURE**

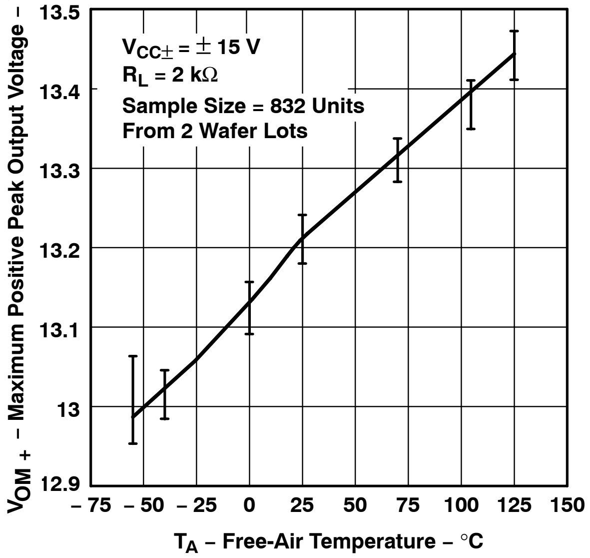


**Figure 17**

---

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

## TYPICAL CHARACTERISTICS

MAXIMUM NEGATIVE PEAK OUTPUT VOLTAGE†
vs
FREE-AIR TEMPERATURE

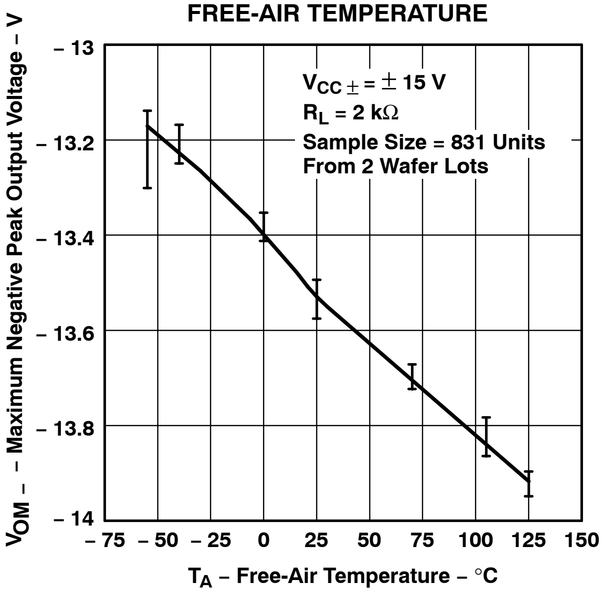


Figure 18

LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION
vs
SUPPLY VOLTAGE

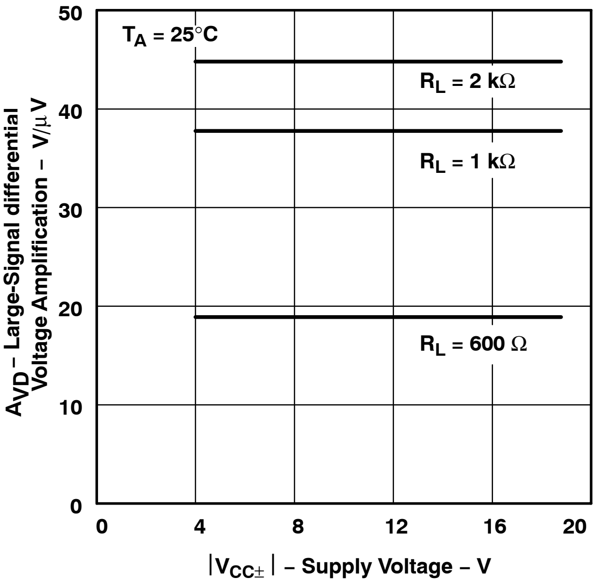


Figure 19

LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION
vs
LOAD RESISTANCE

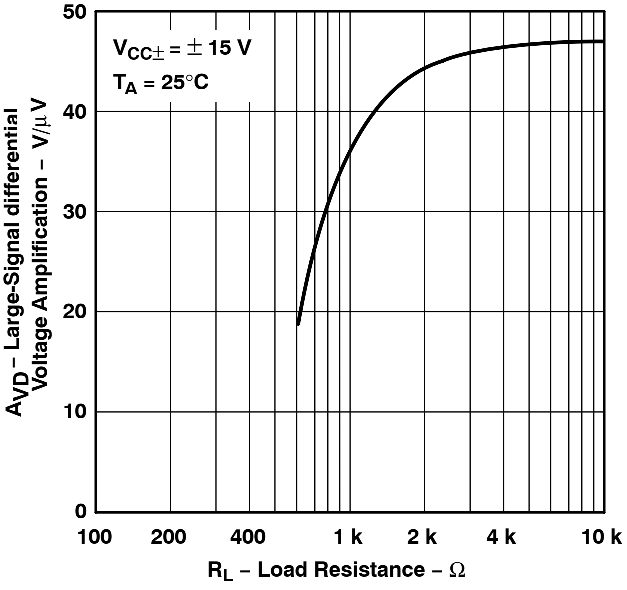


Figure 20

---

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

## TYPICAL CHARACTERISTICS

### TLE2027
### LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION AND PHASE SHIFT vs FREQUENCY

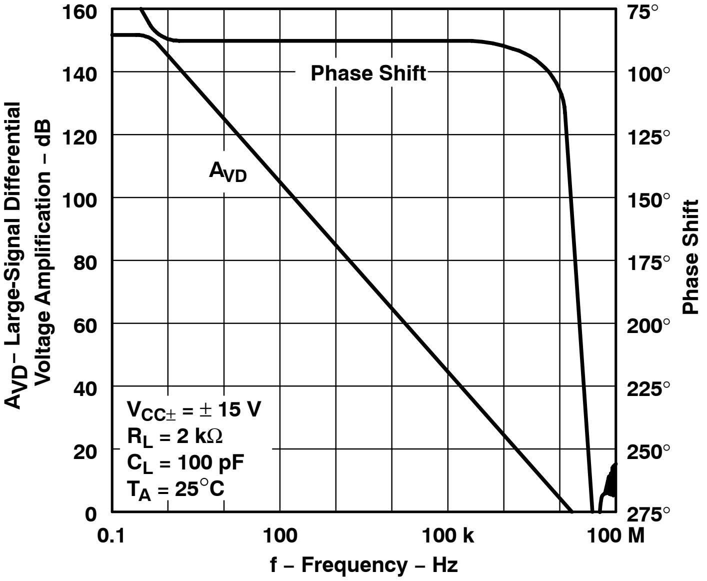


Figure 21

### TLE2037
### LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION AND PHASE SHIFT vs FREQUENCY

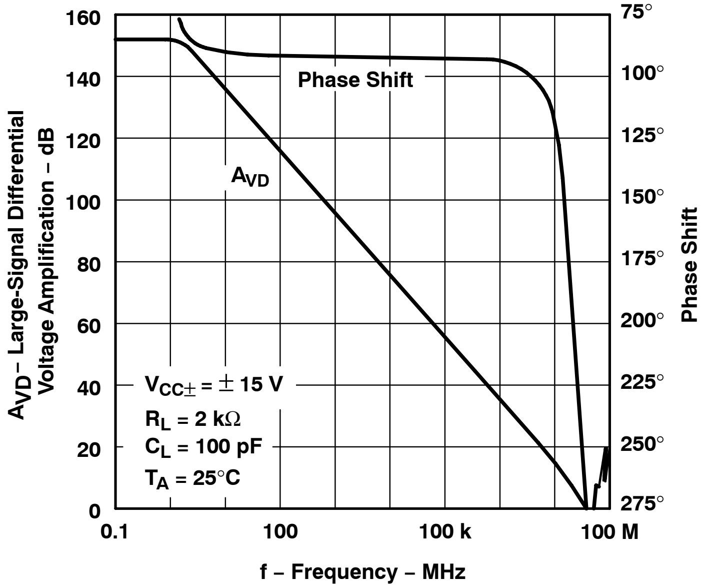


Figure 22

## TYPICAL CHARACTERISTICS

### TLE2027
### LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION AND PHASE SHIFT
### vs
### FREQUENCY

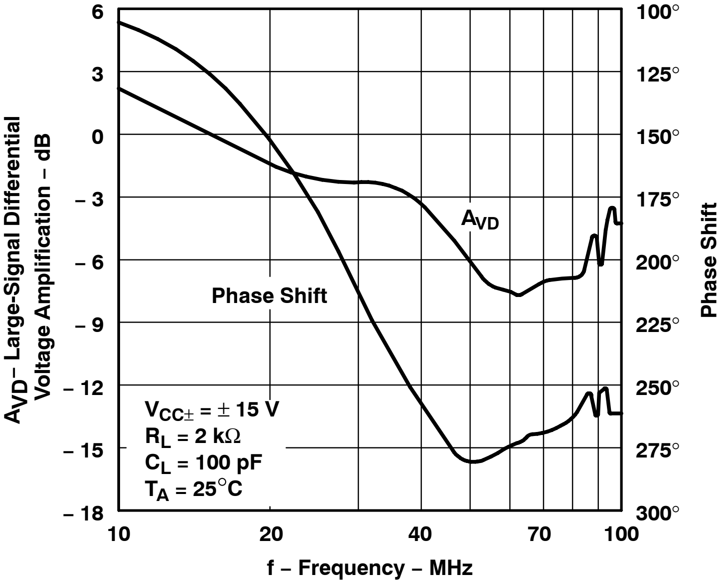


Figure 23

### TLE2037
### LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION AND PHASE SHIFT
### vs
### FREQUENCY

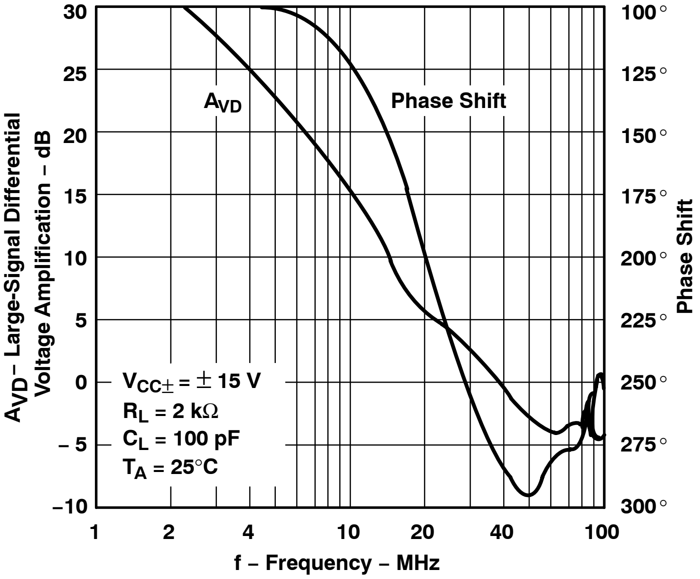


Figure 24

## TYPICAL CHARACTERISTICS

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

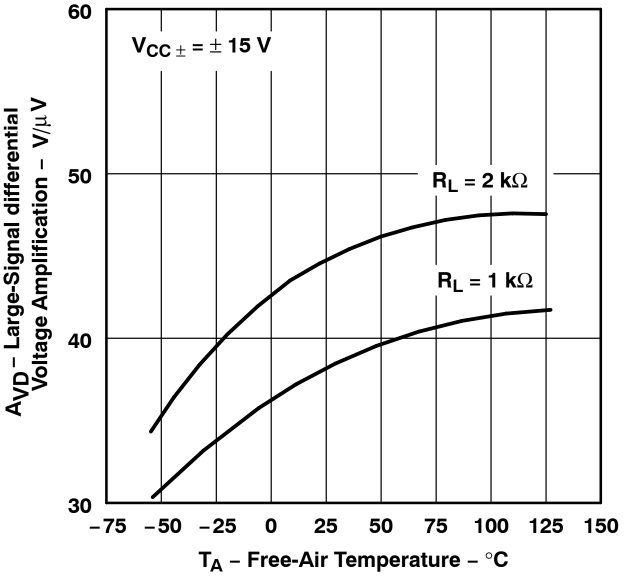
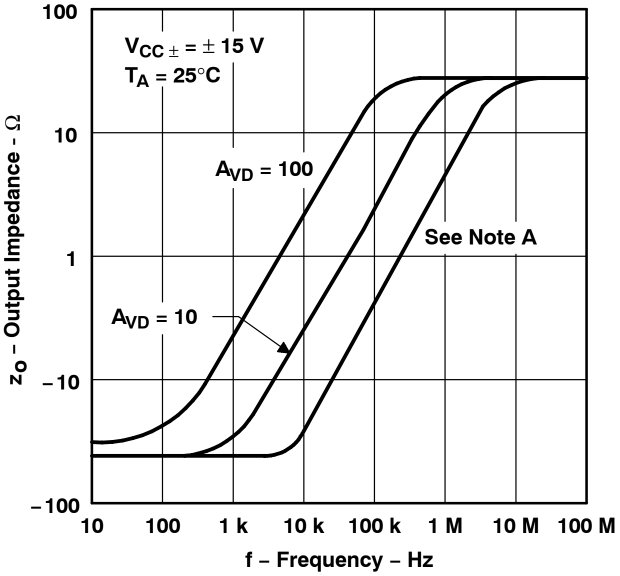


Figure 25

OUTPUT IMPEDANCE vs FREQUENCY



NOTE A: For this curve, the TLE2027 is $A_{VD}$ = 1 and the TLE2037 is $A_{VD}$ = 5.

Figure 26

COMMON-MODE REJECTION RATIO vs FREQUENCY

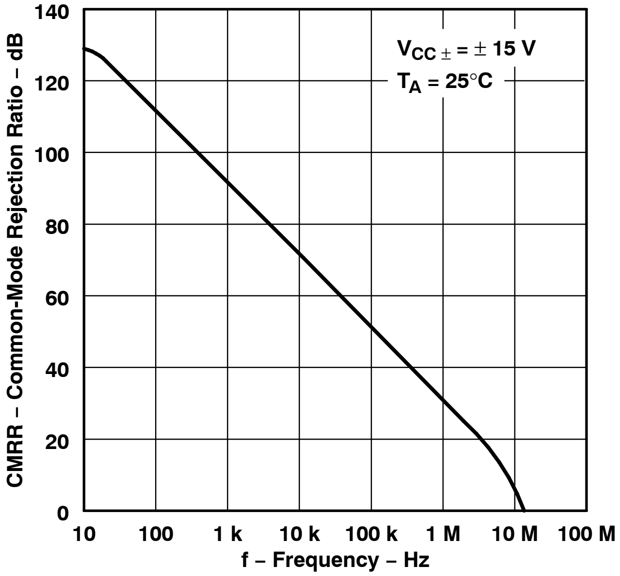


Figure 27

SUPPLY-VOLTAGE REJECTION RATIO vs FREQUENCY

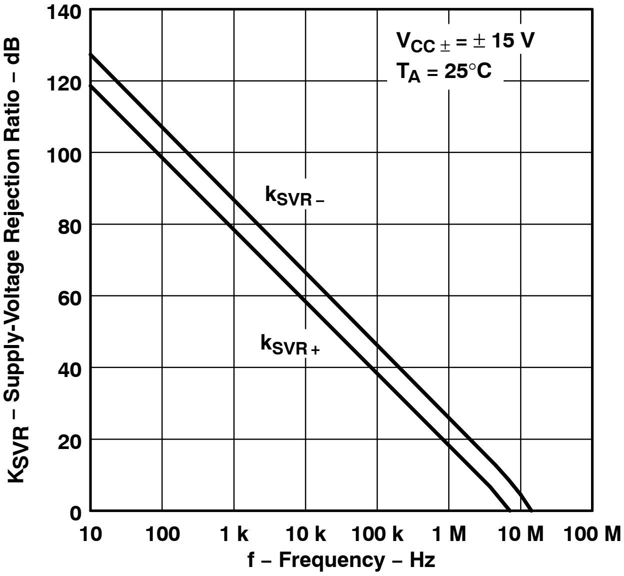


Figure 28

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

## TYPICAL CHARACTERISTICS

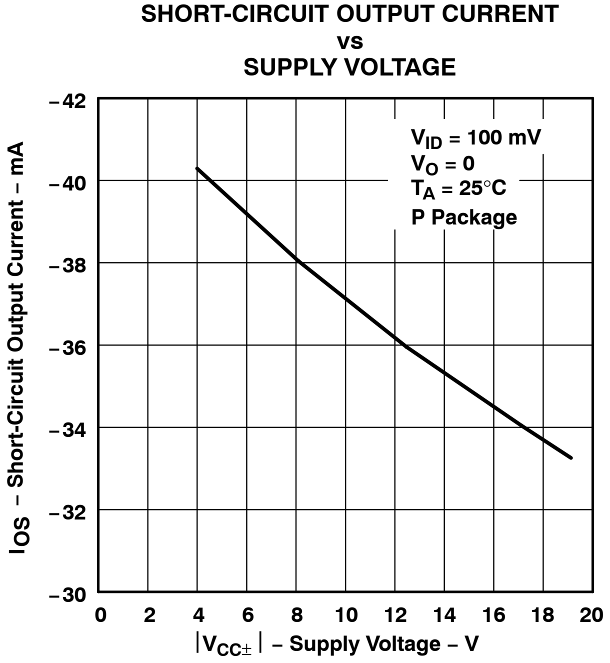

Figure 29

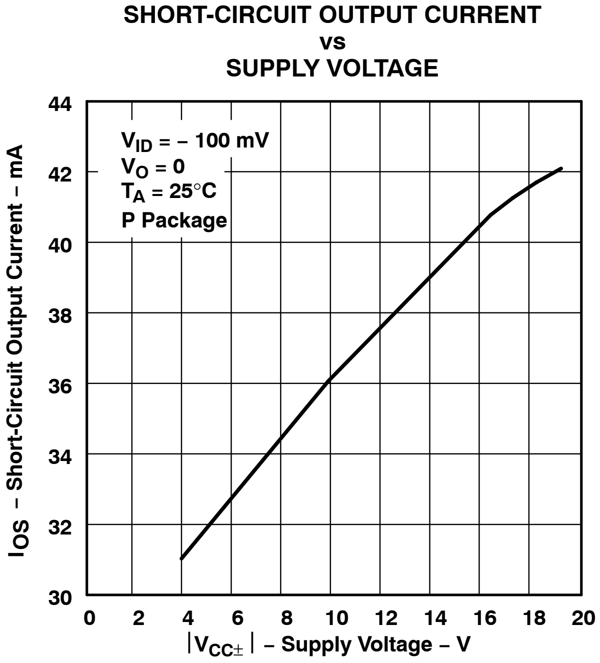

Figure 30

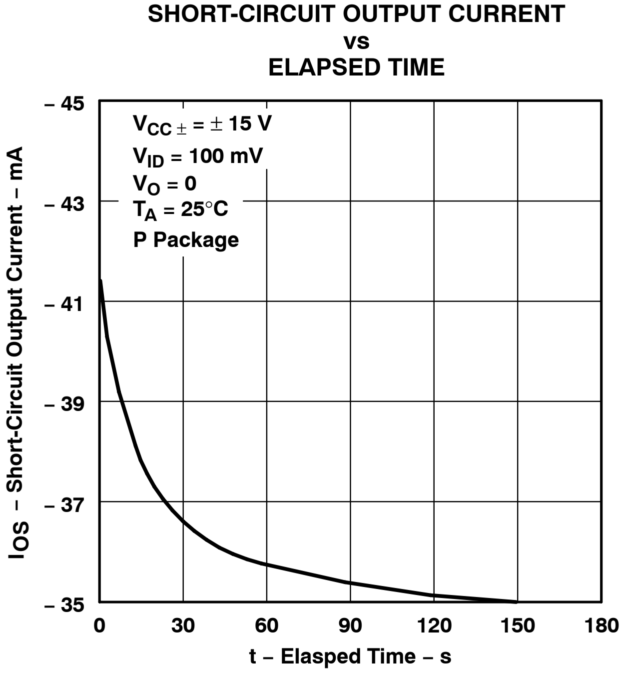

Figure 31

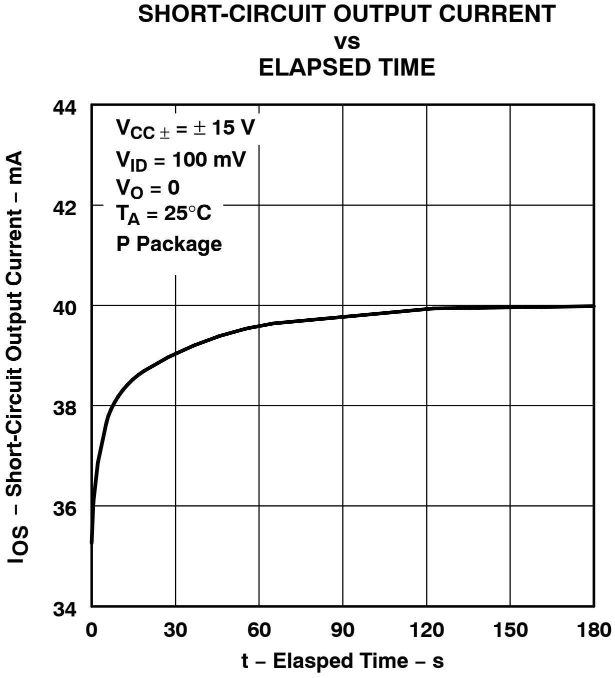

Figure 32

## TYPICAL CHARACTERISTICS

**SHORT-CIRCUIT OUTPUT CURRENT †**
**vs**
**FREE-AIR TEMPERATURE**

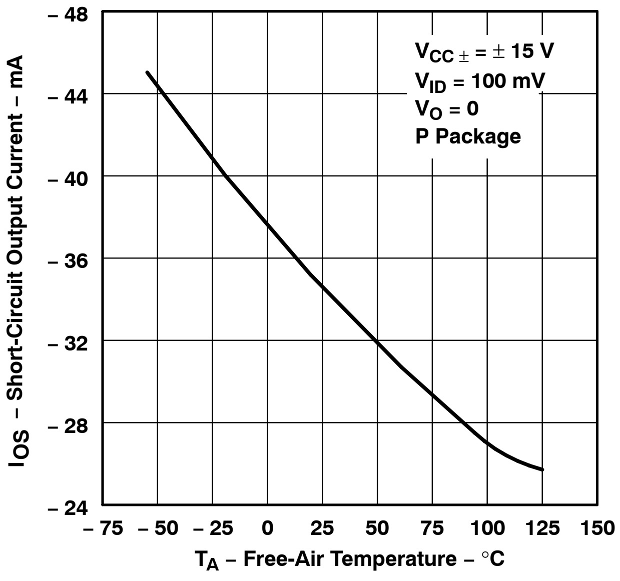

**Figure 33**

**SHORT-CIRCUIT OUTPUT CURRENT †**
**vs**
**FREE-AIR TEMPERATURE**

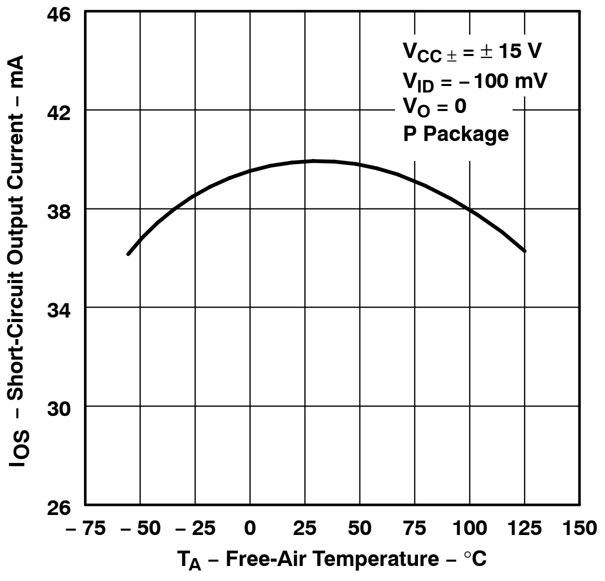

**Figure 34**

**SUPPLY CURRENT †**
**vs**
**SUPPLY VOLTAGE**

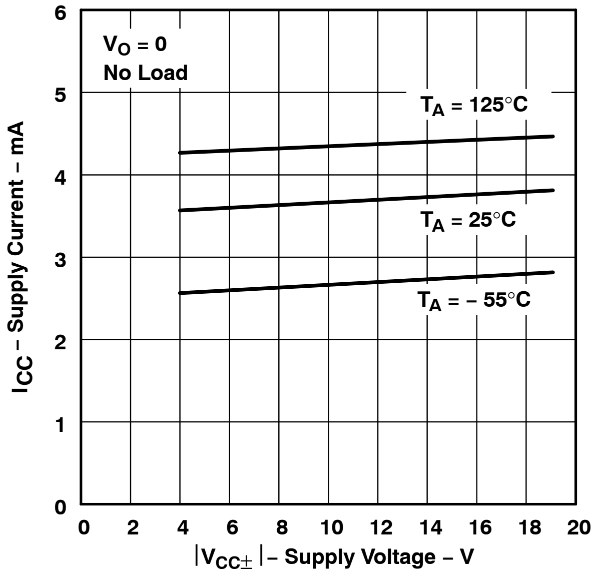

**Figure 35**

**SUPPLY CURRENT †**
**vs**
**FREE-AIR TEMPERATURE**

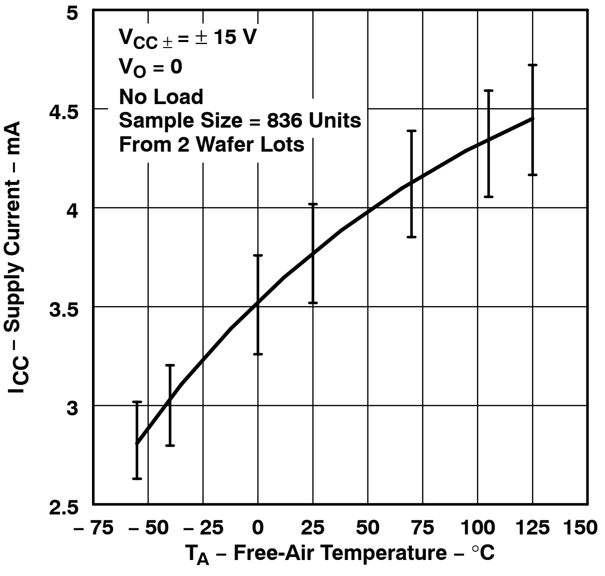

**Figure 36**

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

## TYPICAL CHARACTERISTICS

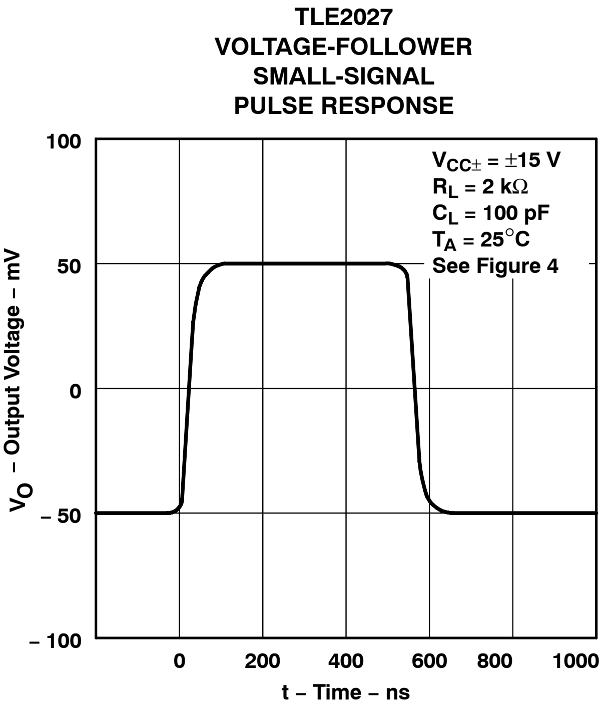

Figure 37

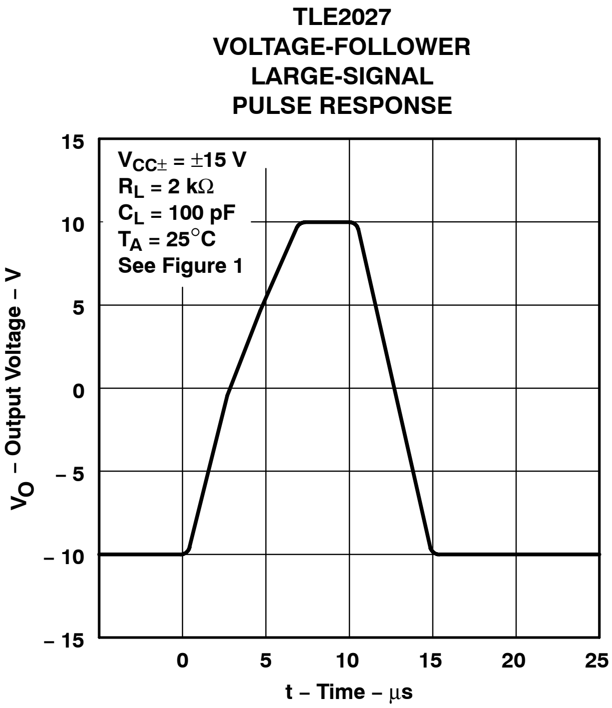

Figure 38

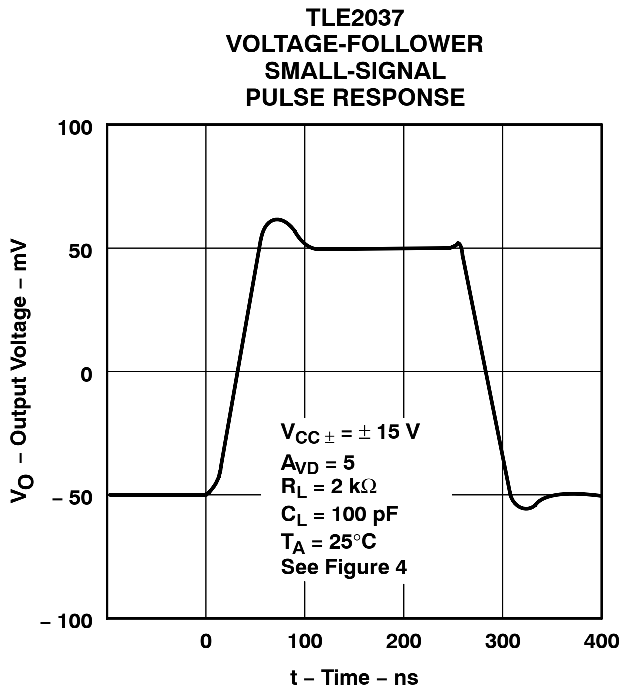

Figure 39

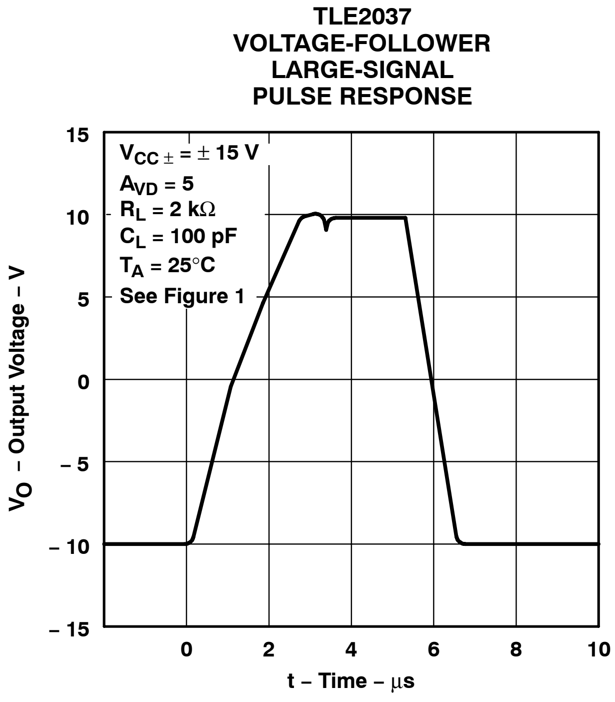

Figure 40

## TYPICAL CHARACTERISTICS

EQUIVALENT INPUT NOISE VOLTAGE
vs
FREQUENCY

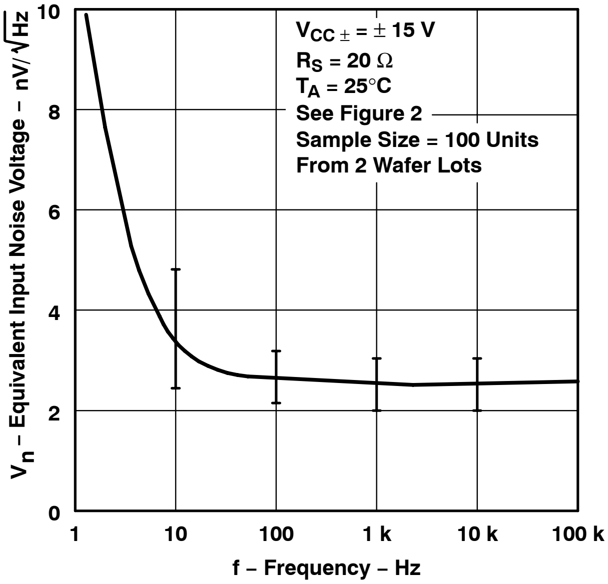

Figure 41

NOISE VOLTAGE
(REFERRED TO INPUT)
OVER A 10-SECOND INTERVAL

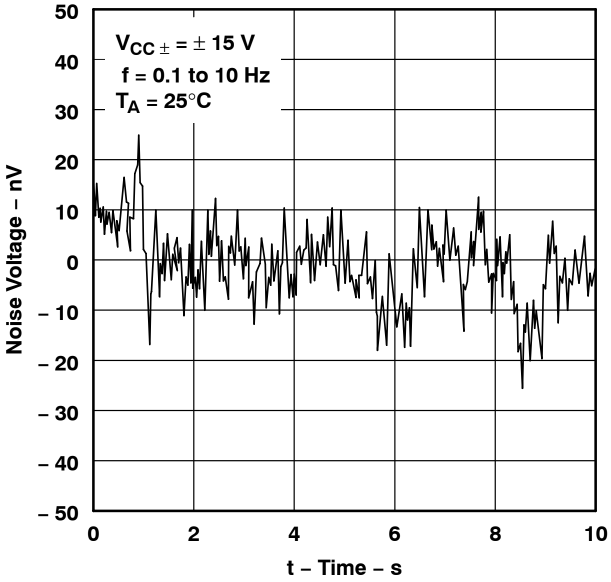

Figure 42

TLE2027
UNITY-GAIN BANDWIDTH
vs
SUPPLY VOLTAGE

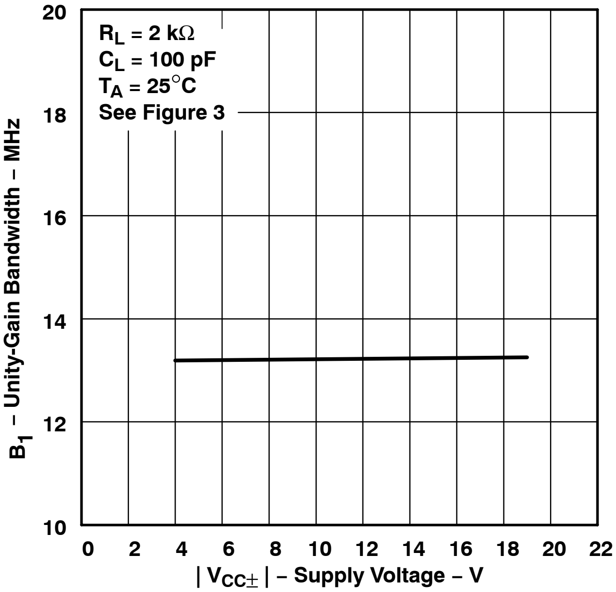

Figure 43

TLE2037
GAIN-BANDWIDTH PRODUCT
vs
SUPPLY VOLTAGE

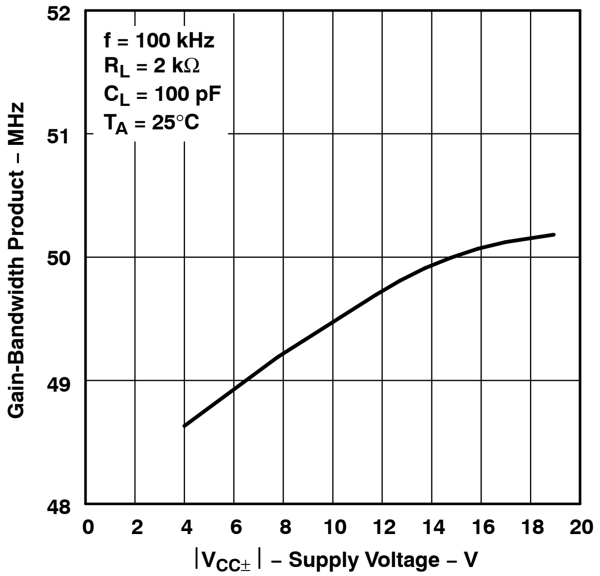

Figure 44

## TYPICAL CHARACTERISTICS

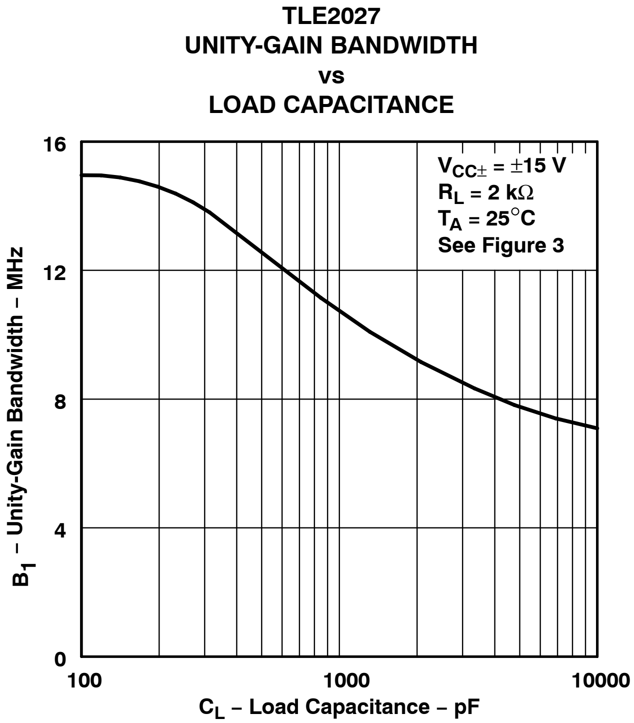
TLE2027
UNITY-GAIN BANDWIDTH
vs
LOAD CAPACITANCE

Figure 45

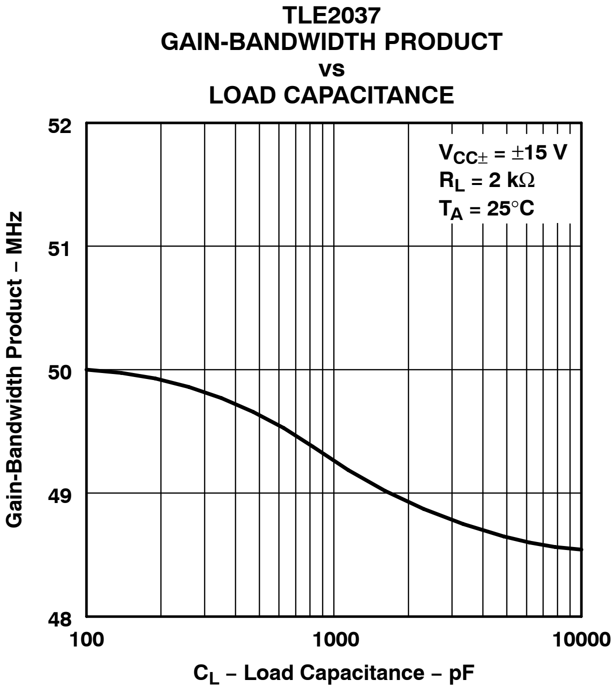
TLE2037
GAIN-BANDWIDTH PRODUCT
vs
LOAD CAPACITANCE

Figure 46

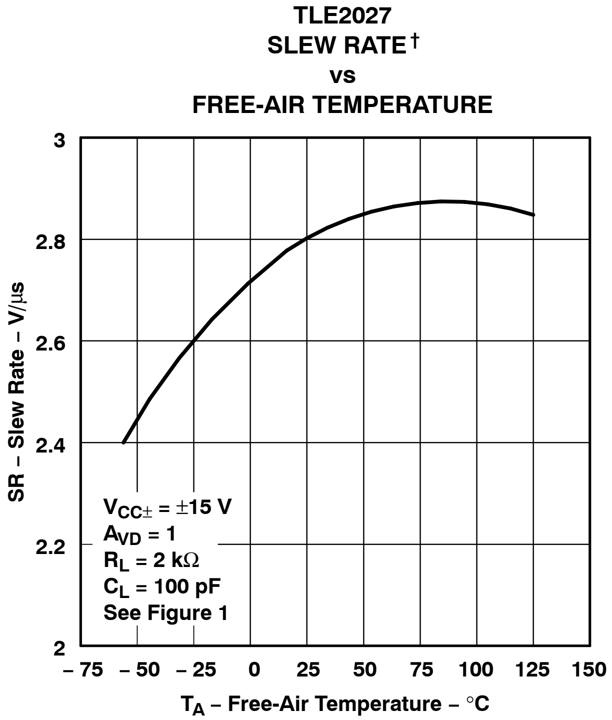
TLE2027
SLEW RATE†
vs
FREE-AIR TEMPERATURE

Figure 47

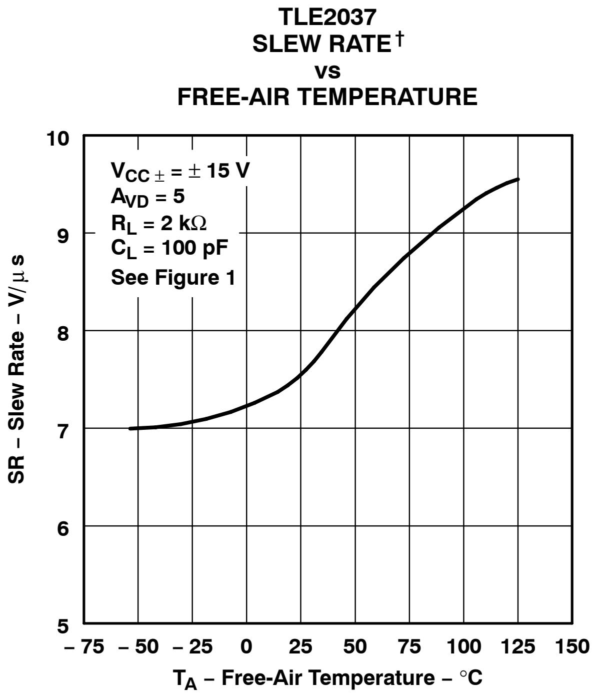
TLE2037
SLEW RATE†
vs
FREE-AIR TEMPERATURE

Figure 48

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

## TYPICAL CHARACTERISTICS

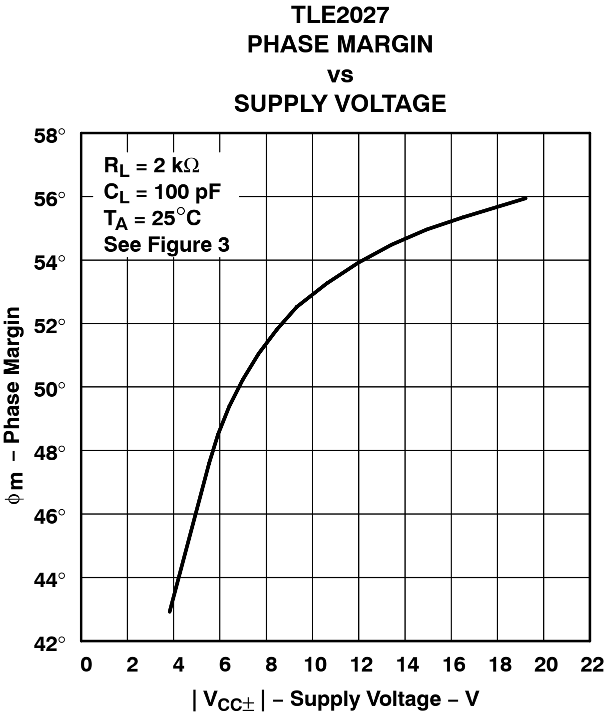

Figure 49

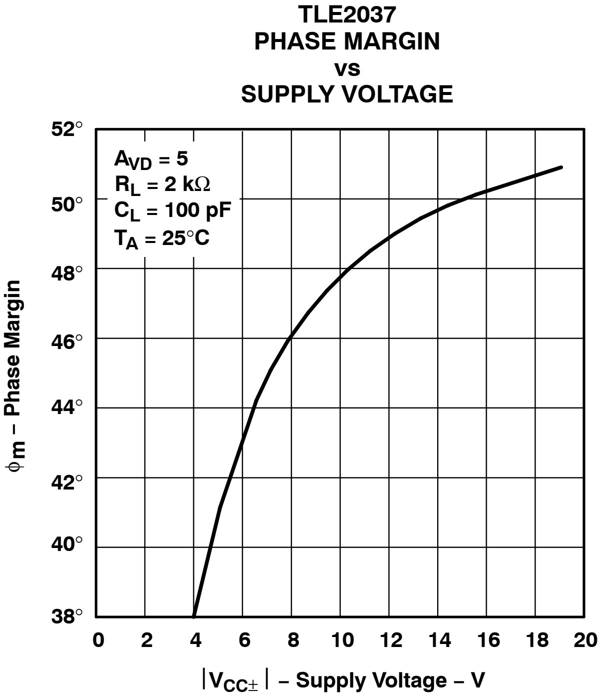

Figure 50

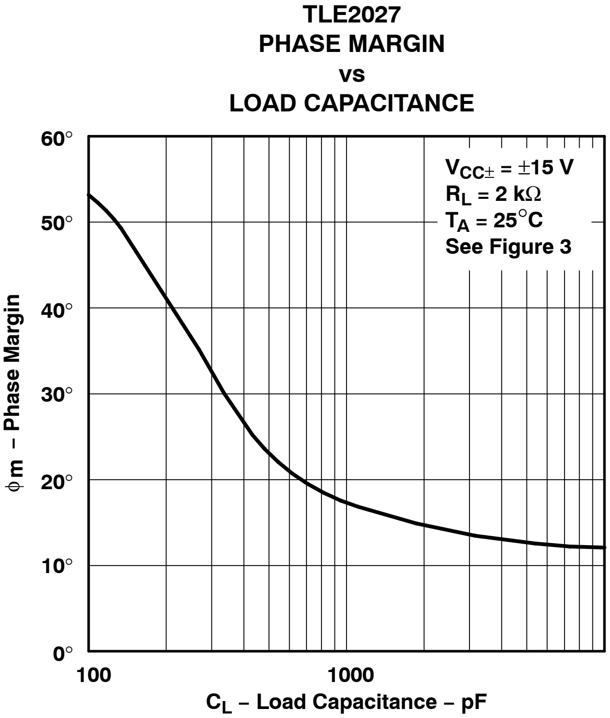

Figure 51

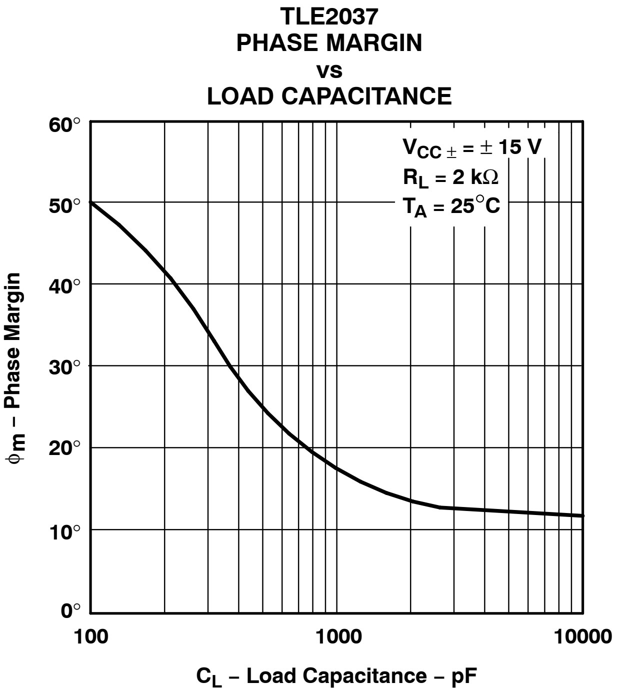

Figure 52

## TYPICAL CHARACTERISTICS

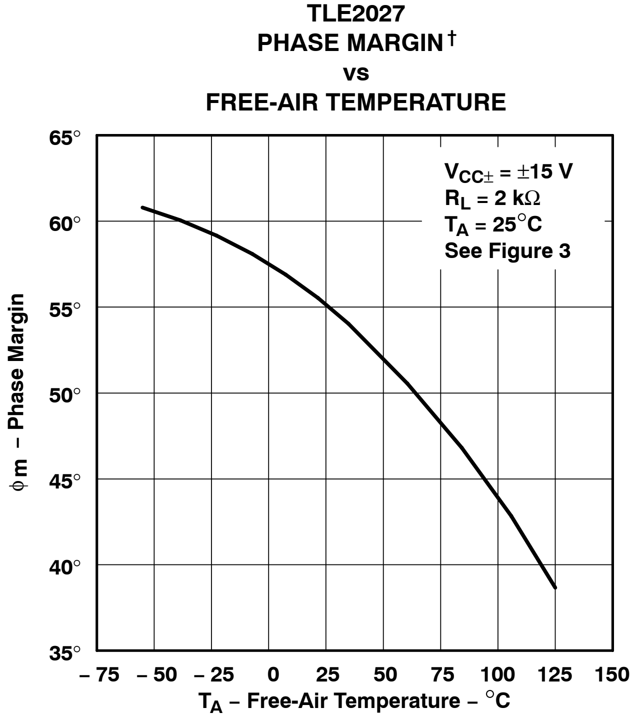

Figure 53

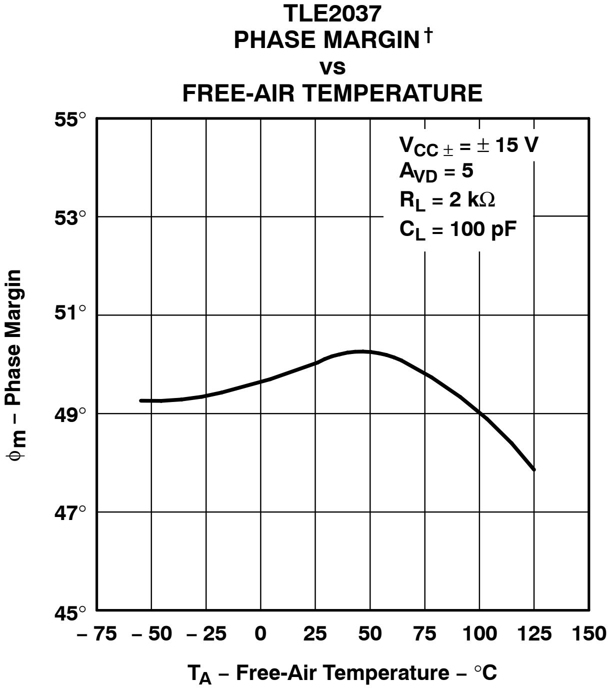

Figure 54

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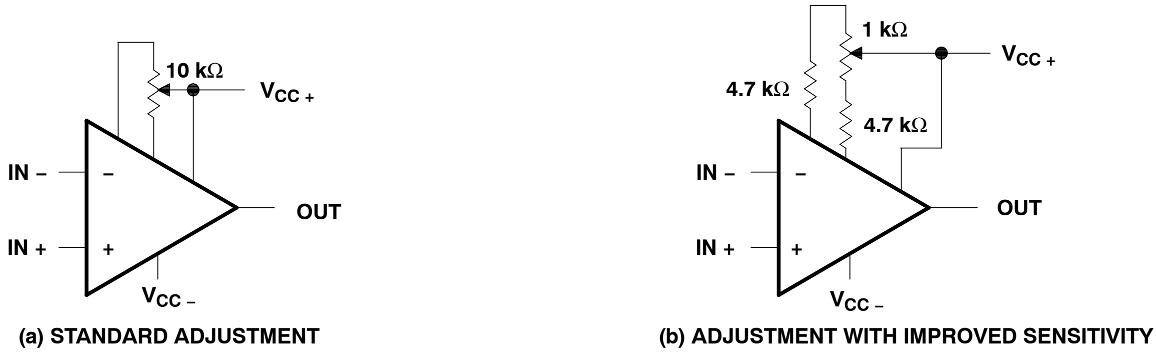
† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

## APPLICATION INFORMATION

### input offset voltage nulling

The TLE2027 and TLE2037 series offers external null pins that can be used to further reduce the input offset voltage. The circuits of Figure 55 can be connected as shown if the feature is desired. If external nulling is not needed, the null pins may be left disconnected.



(a) STANDARD ADJUSTMENT (b) ADJUSTMENT WITH IMPROVED SENSITIVITY

Figure 55. Input Offset Voltage Nulling Circuits

### voltage-follower applications

The TLE2027 circuitry includes input-protection diodes to limit the voltage across the input transistors; however, no provision is made in the circuit to limit the current if these diodes are forward biased. This condition can occur when the device is operated in the voltage-follower configuration and driven with a fast, large-signal pulse. It is recommended that a feedback resistor be used to limit the current to a maximum of 1 mA to prevent degradation of the device. Also, this feedback resistor forms a pole with the input capacitance of the device. For feedback resistor values greater than 10 kΩ, this pole degrades the amplifier phase margin. This problem can be alleviated by adding a capacitor (20 pF to 50 pF) in parallel with the feedback resistor (see Figure 56).

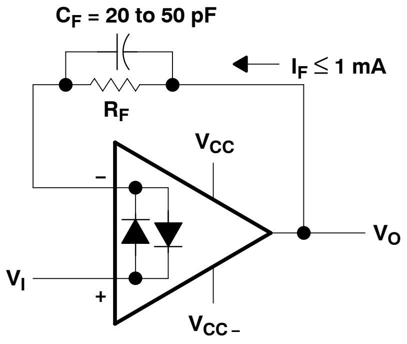


Figure 56. Voltage Follower

## 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 6) and subcircuit in Figure 57, Figure 58, and Figure 59 were generated using the TLE20x7 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

NOTE 6: 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).

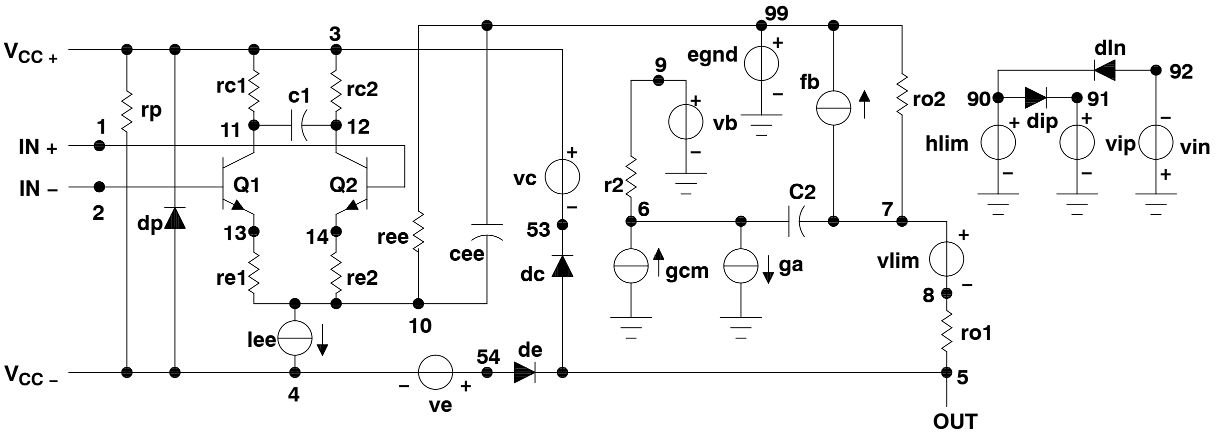


Figure 57. Boyle Macromodel

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

## APPLICATION INFORMATION

### macromodel information (continued)

```
.subckt TLE2027 1 2 3 4 5
*
  c1       11   12   4.003E-12
  c2        6    7   20.00E-12
  dc        5   53   dz
  de       54    5   dz
  dlp      90   91   dz
  dln      92   90   dx
  dp        4    3   dz
  egnd     99    0   poly(2) (3,0)
(4,0) 0 5 .5
  fb        7   99   poly(5) vb vc
ve vlp vln 0 954.8E6 -1E9 1E9 1E9
-1E9
  ga        6    0   11  12
2.062E-3
  gcm       0    6   10  99
531.3E-12
  iee      10    4   dc  56.01E-6
  hlim     90    0   vlim 1K
  q1       11    2   13 qx
```

```
  q2       12    1   14 qx
  r2        6    9   100.0E3
  rc1       3   11   530.5
  rc2       3   12   530.5
  re1      13   10   -393.2
  re2      14   10   -393.2
  ree      10   99   3.571E6
  ro1       8    5   25
  ro2       7   99   25
  rp        3    4   8.013E3
  vb        9    0   dc  0
  vc        3   53   dc  2.400
  ve       54    4   dc  2.100
  vlim      7    8   dc  0
  vlp      91    0   dc  40
  vln       0   92   dc  40
.modeldx D(Is=800.0E-18)
.modelqx NPN(Is=800.0E-18
Bf=7.000E3)
.ends
```

Figure 58. TLE2027 Macromodel Subcircuit

```
.subckt TLE2037 1 2 3 4 5
*
  c1       11   12   4.003E-12
  c2        6    7   7.500E-12
  dc        5   53   dz
  de       54    5   dz
  dlp      90   91   dz
  dln      92   90   dx
  dp        4    3   dz
  egnd     99    0   poly(2)  (3,0)
     (4,0)  0   .5   .5
  fb        7   99   poly(5)  vb vc
     ve vip vln 0 923.4E6 A800E6
     800E6 800E6 A800E6
  ga        6    0   11 12 2.121E-3
  gcm       0    6   10 99 597.7E-12
  iee      10    4   dc 56.26E-6
  hlim     90    0   vlim 1K
  q1       11    2   13 qx
```

```
  q2       12    1   14 qz
  r2        6    9   100.0E3
  rc1       3   11   471.5
  rc2       3   12   471.5
  re1      13   10   A448
  re2      14   10   A448
  ree      10   99   3.555E6
  ro1       8    5   25
  ro2       7   99   25
  rp        3    4   8.013E3
  vb        9    0   dc 0
  vc        3   53   dc  2.400
  ve       54    4   dc  2.100
  vlim      7    8   dc  0
  vlp      91    0   dc  40
  vln       0   92   dc  40
.model     dxD(Is=800.0E-18)
.model     qxNPN(Is=800.0E-18
   Bf=7.031E3)
.ends
```

Figure 59. TLE2037 Macromodel Subcircuit

## REVISION HISTORY

### Changes from Revision B (October 2006) to Revision C

- Changed values of $V_n$, $V_{N(PP)}$, and $I_n$ . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .. . . 11

## PACKAGING INFORMATION

| Orderable Device | Status [1] | Package Type | Package Drawing | Pins | Package Qty | Eco Plan [2] | Lead/Ball Finish | MSL Peak Temp [3] |
|---|---|---|---|---|---|---|---|---|
| 5962-9089601M2A | ACTIVE | LCCC | FK | 20 | 1 | TBD | POST-PLATE | N / A for Pkg Type |
| 5962-9089601MPA | ACTIVE | CDIP | JG | 8 | 1 | TBD | A42 | N / A for Pkg Type |
| 5962-9089602MPA | OBSOLETE | CDIP | JG | 8 |  | TBD | Call TI | Call TI |
| 5962-9089603Q2A | ACTIVE | LCCC | FK | 20 | 1 | TBD | POST-PLATE | N / A for Pkg Type |
| 5962-9089603QPA | ACTIVE | CDIP | JG | 8 | 1 | TBD | A42 | N / A for Pkg Type |
| TLE2027ACD | OBSOLETE | SOIC | D | 8 |  | TBD | Call TI | Call TI |
| TLE2027ACP | OBSOLETE | PDIP | P | 8 |  | TBD | Call TI | Call TI |
| TLE2027AID | OBSOLETE | SOIC | D | 8 |  | TBD | Call TI | Call TI |
| TLE2027AIP | OBSOLETE | PDIP | P | 8 |  | TBD | Call TI | Call TI |
| TLE2027AMD | ACTIVE | SOIC | D | 8 | 75 | TBD | CU NIPDAU | Level-1-220C-UNLIM |
| TLE2027AMDG4 | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLE2027AMFKB | ACTIVE | LCCC | FK | 20 | 1 | TBD | POST-PLATE | N / A for Pkg Type |
| TLE2027AMJG | ACTIVE | CDIP | JG | 8 | 1 | TBD | A42 | N / A for Pkg Type |
| TLE2027AMJGB | ACTIVE | CDIP | JG | 8 | 1 | TBD | A42 | N / A for Pkg Type |
| TLE2027CD | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLE2027CDG4 | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLE2027CDR | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLE2027CDRG4 | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLE2027CP | OBSOLETE | PDIP | P | 8 |  | TBD | Call TI | Call TI |
| TLE2027ID | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLE2027IDG4 | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLE2027IDR | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLE2027IDRG4 | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLE2027IP | OBSOLETE | PDIP | P | 8 |  | TBD | Call TI | Call TI |
| TLE2027MD | ACTIVE | SOIC | D | 8 | 75 | TBD | CU NIPDAU | Level-1-220C-UNLIM |
| TLE2027MDG4 | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLE2027MFKB | ACTIVE | LCCC | FK | 20 | 1 | TBD | POST-PLATE | N / A for Pkg Type |
| TLE2027MJG | ACTIVE | CDIP | JG | 8 | 1 | TBD | A42 | N / A for Pkg Type |
| TLE2027MJGB | ACTIVE | CDIP | JG | 8 | 1 | TBD | A42 | N / A for Pkg Type |
| TLE2037ACD | OBSOLETE | SOIC | D | 8 |  | TBD | Call TI | Call TI |
| TLE2037ACP | OBSOLETE | PDIP | P | 8 |  | TBD | Call TI | Call TI |
| TLE2037AID | OBSOLETE | SOIC | D | 8 |  | TBD | Call TI | Call TI |
| TLE2037AIP | OBSOLETE | PDIP | P | 8 |  | TBD | Call TI | Call TI |
| TLE2037AMD | ACTIVE | SOIC | D | 8 | 75 | TBD | CU NIPDAU | Level-1-220C-UNLIM |
| TLE2037AMDG4 | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & | CU NIPDAU | Level-1-260C-UNLIM |

| Orderable Device | Status [1] | Package Type | Package Drawing | Pins | Package Qty | Eco Plan [2] | Lead/Ball Finish | MSL Peak Temp [3] |
|---|---|---|---|---|---|---|---|---|
| | | | | | | no Sb/Br) | | |
| TLE2037AMJGB | OBSOLETE | CDIP | JG | 8 | | TBD | Call TI | Call TI |
| TLE2037CD | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLE2037CDG4 | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLE2037CDR | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLE2037CDRG4 | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLE2037CP | OBSOLETE | PDIP | P | 8 | | TBD | Call TI | Call TI |
| TLE2037ID | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLE2037IDG4 | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLE2037IDR | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLE2037IDRG4 | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLE2037IP | OBSOLETE | PDIP | P | 8 | | TBD | Call TI | Call TI |
| TLE2037MD | ACTIVE | SOIC | D | 8 | 75 | TBD | CU NIPDAU | Level-1-220C-UNLIM |
| TLE2037MDG4 | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLE2037MFKB | OBSOLETE | LCCC | FK | 20 | | TBD | Call TI | Call TI |
| TLE2037MJGB | OBSOLETE | CDIP | JG | 8 | | TBD | Call TI | Call TI |

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

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

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

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**OTHER QUALIFIED VERSIONS OF TLE2027, TLE2027A, TLE2027AM, TLE2027M, TLE2037, TLE2037A :**

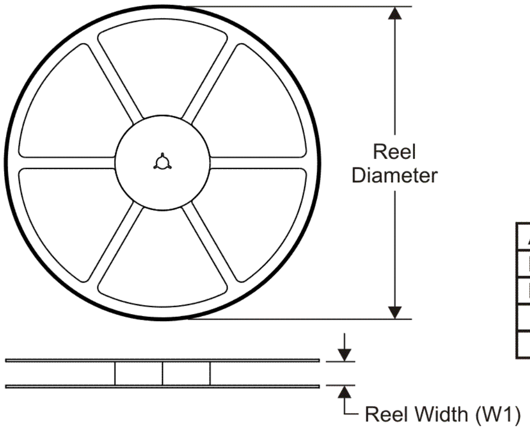
- Automotive: TLE2037-Q1, TLE2037A-Q1
- Enhanced Product: TLE2027-EP

NOTE: Qualified Version Definitions:

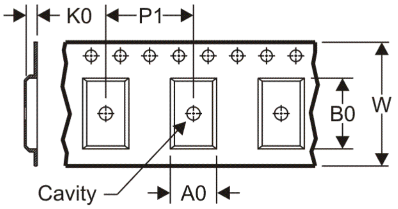
- Automotive - Q100 devices qualified for high-reliability automotive applications targeting zero defects
- Enhanced Product - Supports Defense, Aerospace and Medical Applications

## TAPE AND REEL INFORMATION

### REEL DIMENSIONS

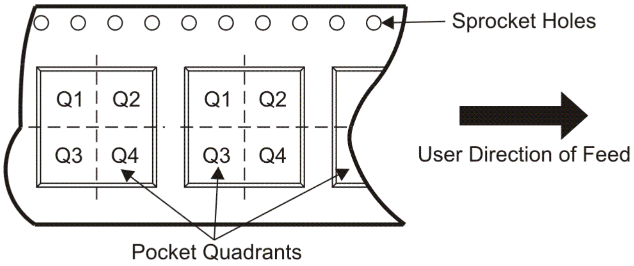


### TAPE DIMENSIONS



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

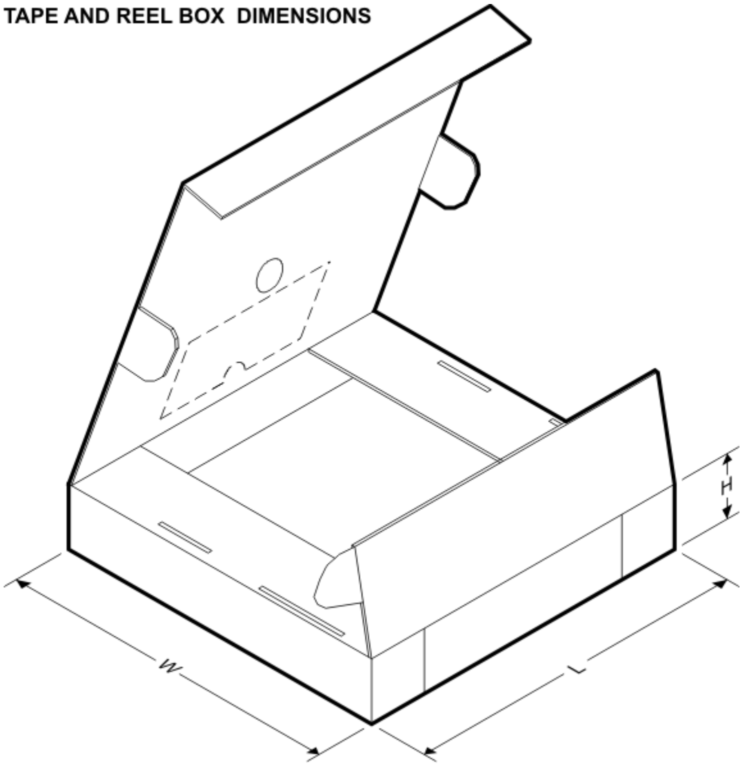
### QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TLE2027CDR | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.4 | 5.2 | 2.1 | 8.0 | 12.0 | Q1 |
| TLE2027IDR | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.4 | 5.2 | 2.1 | 8.0 | 12.0 | Q1 |
| TLE2037CDR | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.4 | 5.2 | 2.1 | 8.0 | 12.0 | Q1 |
| TLE2037IDR | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.4 | 5.2 | 2.1 | 8.0 | 12.0 | Q1 |

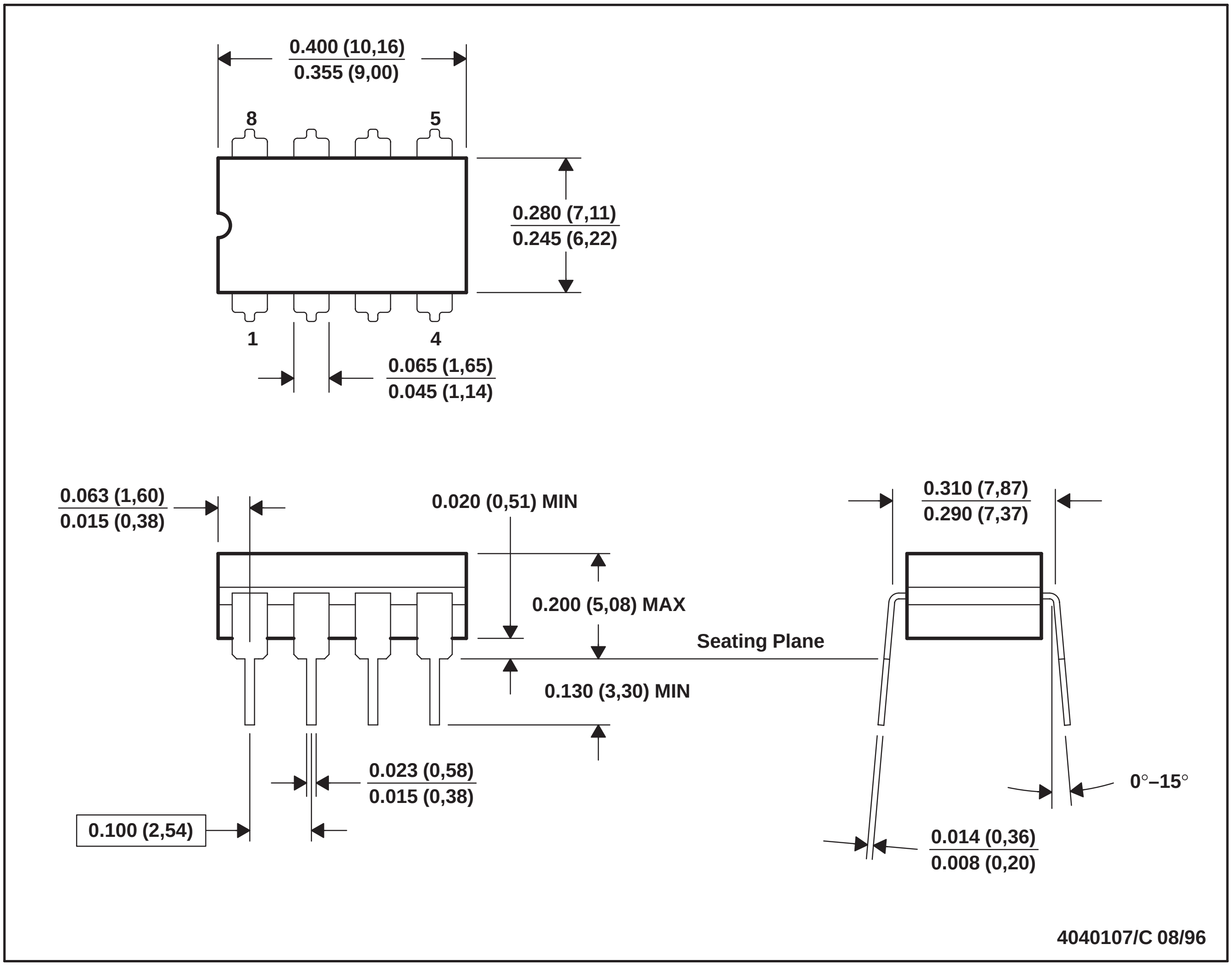
**TAPE AND REEL BOX DIMENSIONS**



*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|---|---|---|---|---|---|---|---|
| TLE2027CDR | SOIC | D | 8 | 2500 | 340.5 | 338.1 | 20.6 |
| TLE2027IDR | SOIC | D | 8 | 2500 | 340.5 | 338.1 | 20.6 |
| TLE2037CDR | SOIC | D | 8 | 2500 | 340.5 | 338.1 | 20.6 |
| TLE2037IDR | SOIC | D | 8 | 2500 | 340.5 | 338.1 | 20.6 |

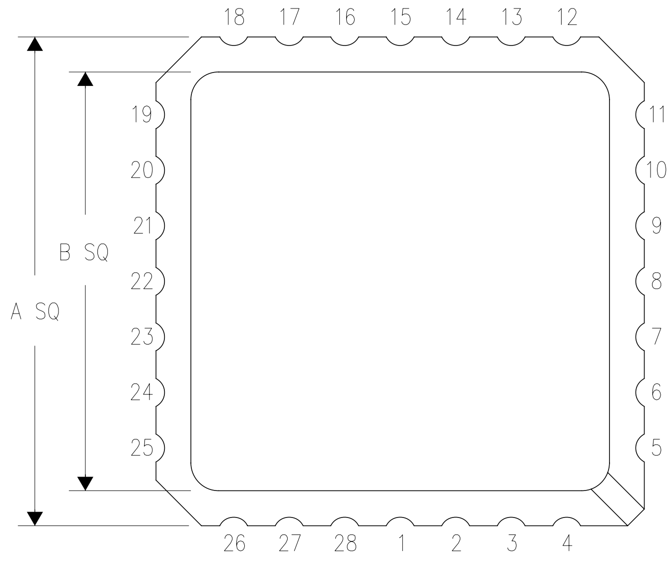
**JG (R-GDIP-T8)** **CERAMIC DUAL-IN-LINE**



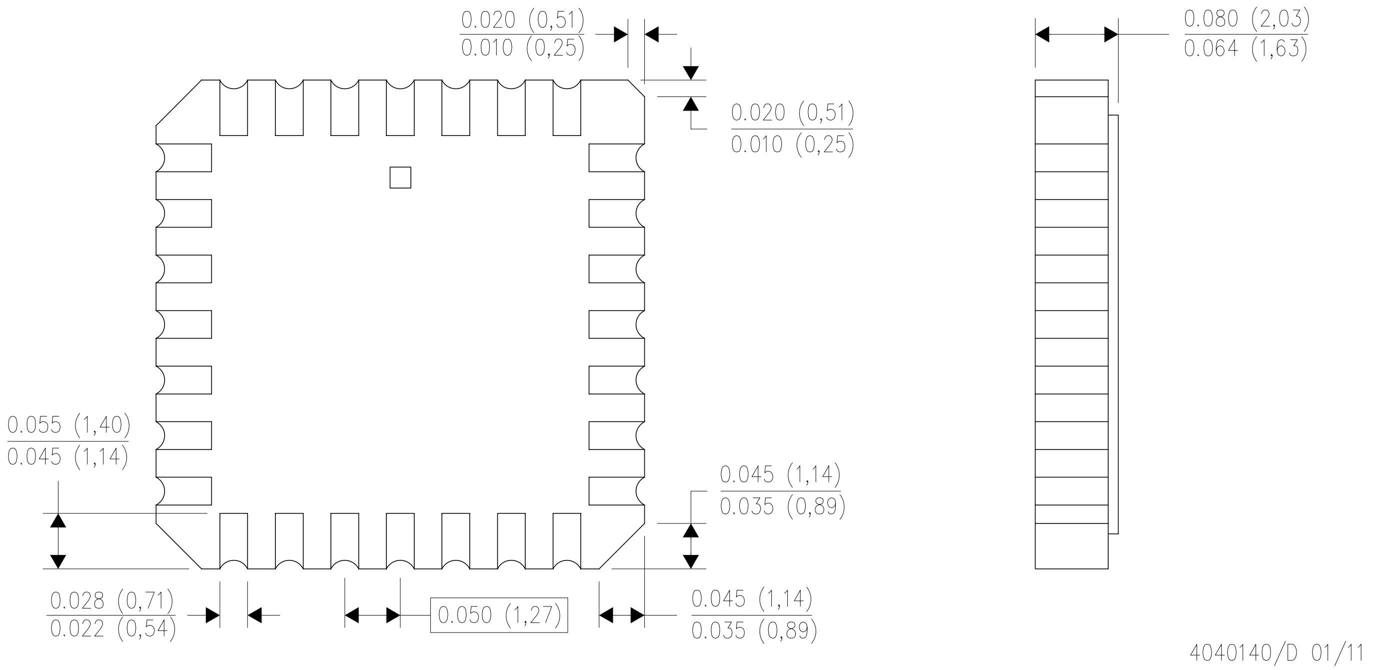
NOTES:
- A. All linear dimensions are in inches (millimeters).
- B. This drawing is subject to change without notice.
- C. This package can be hermetically sealed with a ceramic lid using glass frit.
- D. Index point is provided on cap for terminal identification.
- E. Falls within MIL STD 1835 GDIP1-T8

## FK (S-CQCC-N**) LEADLESS CERAMIC CHIP CARRIER

28 TERMINAL SHOWN



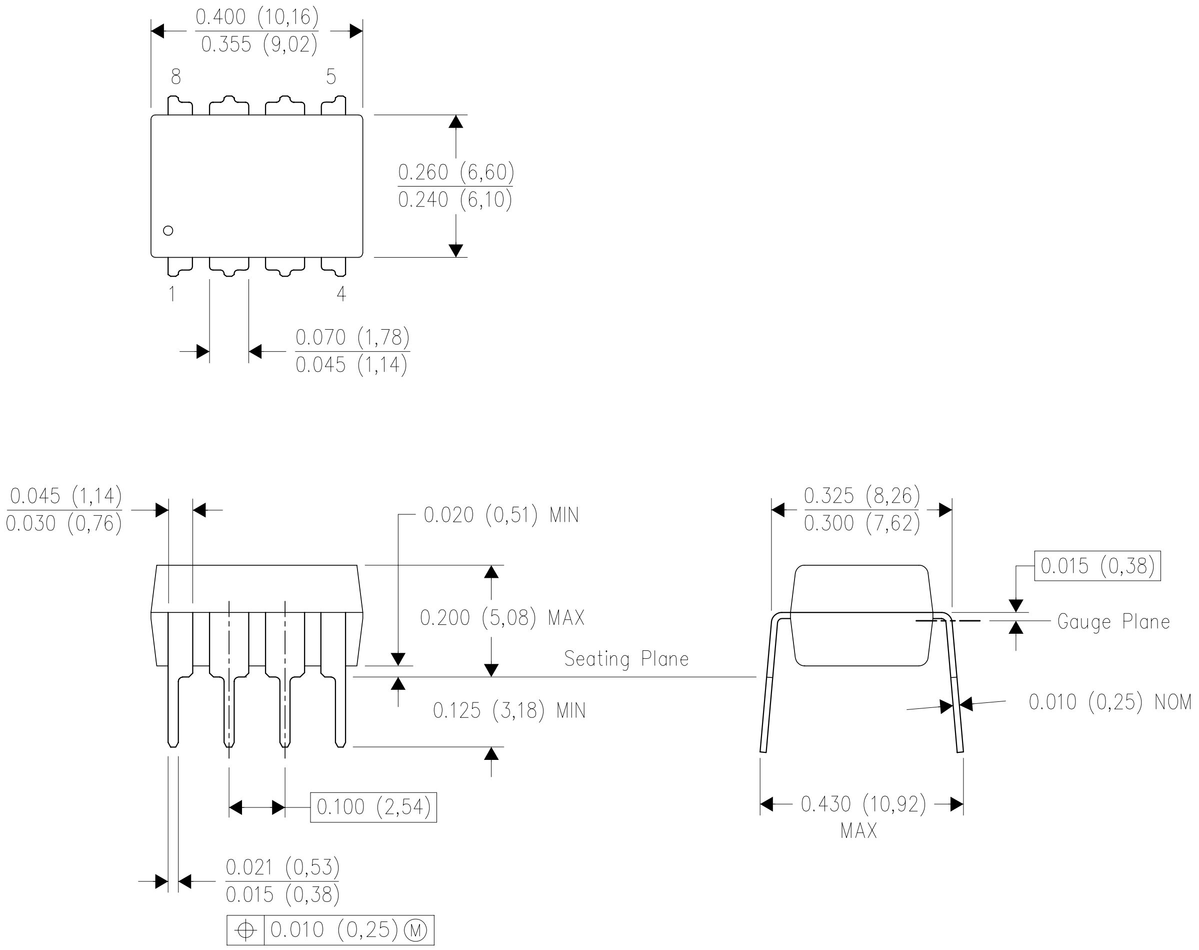
| NO. OF TERMINALS ** | A | | B | |
|---|---|---|---|---|
| | MIN | MAX | MIN | MAX |
| 20 | 0.342<br>(8,69) | 0.358<br>(9,09) | 0.307<br>(7,80) | 0.358<br>(9,09) |
| 28 | 0.442<br>(11,23) | 0.458<br>(11,63) | 0.406<br>(10,31) | 0.458<br>(11,63) |
| 44 | 0.640<br>(16,26) | 0.660<br>(16,76) | 0.495<br>(12,58) | 0.560<br>(14,22) |
| 52 | 0.740<br>(18,78) | 0.761<br>(19,32) | 0.495<br>(12,58) | 0.560<br>(14,22) |
| 68 | 0.938<br>(23,83) | 0.962<br>(24,43) | 0.850<br>(21,6) | 0.858<br>(21,8) |
| 84 | 1.141<br>(28,99) | 1.165<br>(29,59) | 1.047<br>(26,6) | 1.063<br>(27,0) |



4040140/D 01/11

NOTES:
- A. All linear dimensions are in inches (millimeters).
- B. This drawing is subject to change without notice.
- C. This package can be hermetically sealed with a metal lid.
- D. Falls within JEDEC MS-004

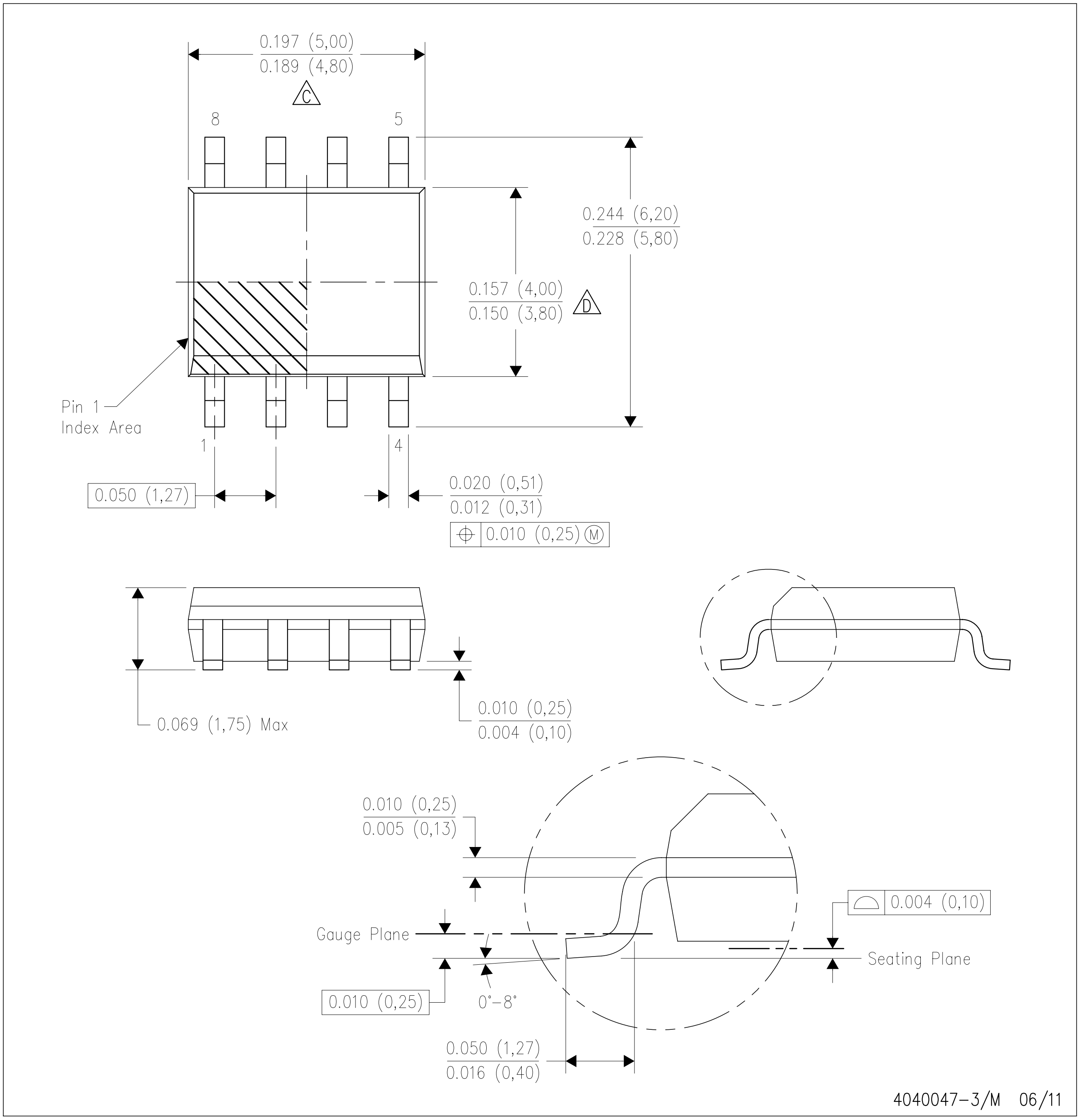
## P (R–PDIP–T8) PLASTIC DUAL–IN–LINE PACKAGE



4040082/E 04/2010

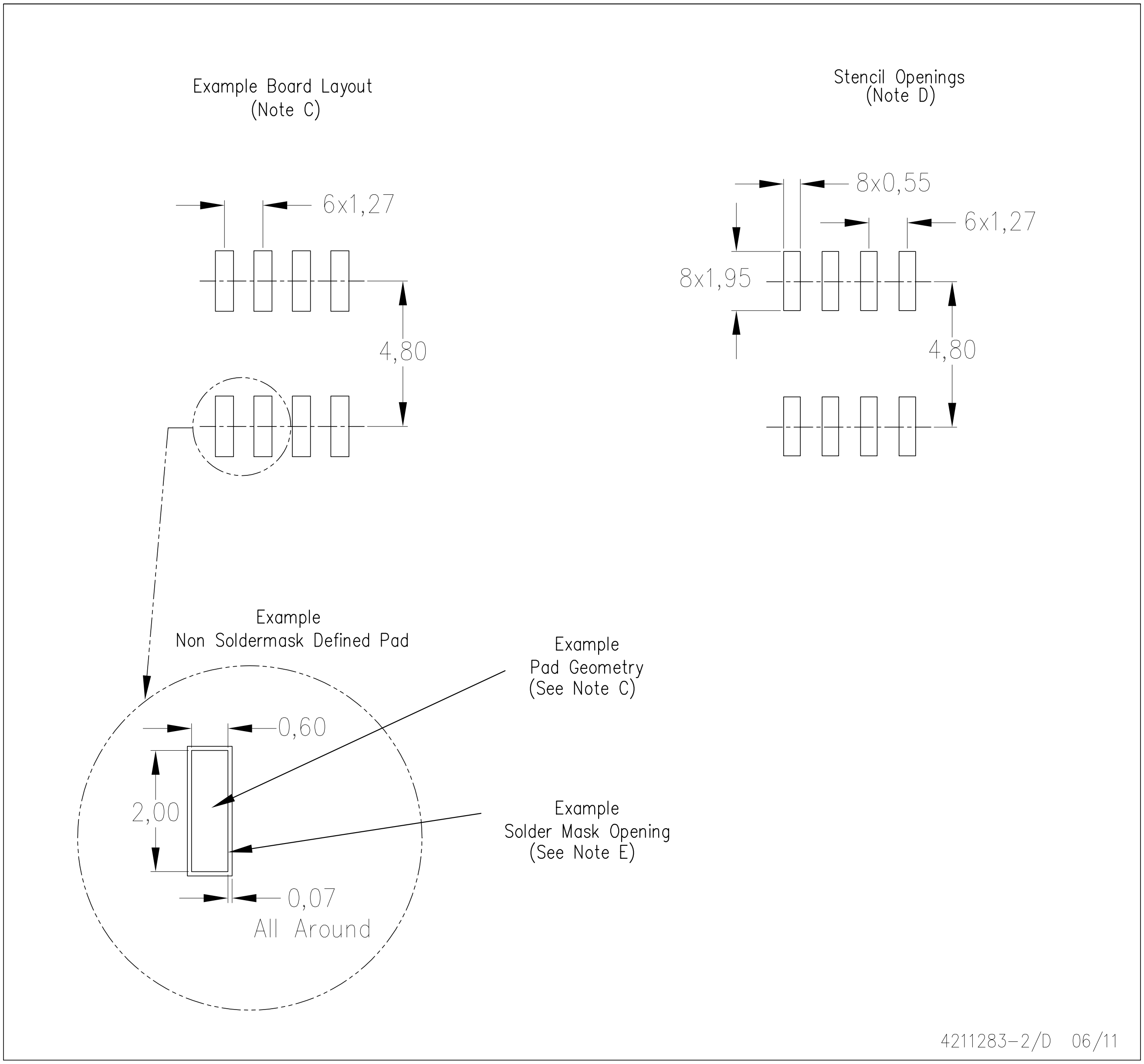
NOTES:
- A. All linear dimensions are in inches (millimeters).
- B. This drawing is subject to change without notice.
- C. Falls within JEDEC MS–001 variation BA.

## D (R–PDSO–G8) PLASTIC SMALL OUTLINE



NOTES:
- A. All linear dimensions are in inches (millimeters).
- B. This drawing is subject to change without notice.
- C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.006 (0,15) each side.
- D. Body width does not include interlead flash. Interlead flash shall not exceed 0.017 (0,43) each side.
- E. Reference JEDEC MS–012 variation AA.

D (R-PDSO-G8) PLASTIC SMALL OUTLINE



NOTES:
- A. All linear dimensions are in millimeters.
- B. This drawing is subject to change without notice.
- C. Publication IPC-7351 is recommended for alternate designs.
- D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC-7525 for other stencil recommendations.
- E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

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