- **Supply Current . . . 300 μA Max**
- **High Unity-Gain Bandwidth . . . 2 MHz Typ**
- **High Slew Rate . . . 0.45 V/μs Min**
- **Supply-Current Change Over Military Temp Range . . . 10 μA Typ at $V_{CC\pm}$ = ± 15 V**
- **Specified for Both 5-V Single-Supply and ±15-V Operation**
- **Phase-Reversal Protection**
- **High Open-Loop Gain . . . 6.5 V/μV (136 dB) Typ**
- **Low Offset Voltage . . . 100 μV Max**
- **Offset Voltage Drift With Time 0.005 μV/mo Typ**
- **Low Input Bias Current . . . 50 nA Max**
- **Low Noise Voltage . . . 19 nV/√Hz Typ**

## description

The TLE202x, TLE202xA, and TLE202xB devices are precision, high-speed, low-power operational amplifiers using a new Texas Instruments Excalibur process. These devices combine the best features of the OP21 with highly improved slew rate and unity-gain bandwidth.

The complementary bipolar Excalibur process utilizes isolated vertical pnp transistors that yield dramatic improvement in unity-gain bandwidth and slew rate over similar devices.

The addition of a bias circuit in conjunction with this process results in extremely stable parameters with both time and temperature. This means that a precision device remains a precision device even with changes in temperature and over years of use.

This combination of excellent dc performance with a common-mode input voltage range that includes the negative rail makes these devices the ideal choice for low-level signal conditioning applications in either single-supply or split-supply configurations. In addition, these devices offer phase-reversal protection circuitry that eliminates an unexpected change in output states when one of the inputs goes below the negative supply rail.

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

**TLE2021 AVAILABLE OPTIONS**

| $T_A$ | $V_{IO}$max AT 25°C | PACKAGED DEVICES | | | | | | CHIP FORM§ (Y) |
|---|---|---|---|---|---|---|---|---|
| | | SMALL OUTLINE† (D) | SSOP‡ (DB) | CHIP CARRIER (FK) | CERAMIC DIP (JG) | PLASTIC DIP (P) | TSSOP‡ (PW) | |
| 0°C to 70°C | 200 µV<br>500 µV | TLE2021ACD<br>TLE2021CD | TLE2021CDBLE | — | — | TLE2021ACP<br>TLE2021CP | —<br>TLE2021CPWLE | —<br>TLE2021Y |
| –40°C to 85°C | 200 µV<br>500 µV | TLE2021AID<br>TLE2021ID | — | — | — | TLE2021AIP<br>TLE2021IP | — | — |
| –55°C to 125°C | 100 µV<br>500 µV | —<br>TLE2021MD | — | TLE2021BMFK<br>TLE2021MFK | TLE2021BMJG<br>TLE2021MJG | —<br>TLE2021MP | — | — |

† The D packages are available taped and reeled. To order a taped and reeled part, add the suffix R (e.g., TLE2021CDR).
‡ The DB and PW packages are only available left-end taped and reeled.
§ Chip forms are tested at 25°C only.

**TLE2022 AVAILABLE OPTIONS**

| $T_A$ | $V_{IO}$max AT 25°C | PACKAGED DEVICES | | | | | | CHIP FORM§ (Y) |
|---|---|---|---|---|---|---|---|---|
| | | SMALL OUTLINE† (D) | SSOP‡ (DB) | CHIP CARRIER (FK) | CERAMIC DIP (JG) | PLASTIC DIP (P) | TSSOP‡ (PW) | |
| 0°C to 70°C | 150 µV<br>300 µV<br>500 µV | TLE2022BCD<br>TLE2022ACD<br>TLE2022CD | —<br>—<br>TLE2022CDBLE | — | — | —<br>TLE2022ACP<br>TLE2022CP | —<br>—<br>TLE2022CPWLE | —<br>—<br>TLE2022Y |
| –40°C to 85°C | 150 µV<br>300 µV<br>500 µV | TLE2022BID<br>TLE2022AID<br>TLE2022ID | — | — | — | —<br>TLE2022AIP<br>TLE2022IP | — | — |
| –55°C to 125°C | 150 µV<br>300 µV<br>500 µV | —<br>TLE2022AMD<br>TLE2022MD | — | —<br>TLE2022AMFK<br>TLE2022MFK | TLE2022BMJG<br>TLE2022AMJG<br>TLE2022MJG | —<br>TLE2022AMP<br>TLE2022MP | — | — |

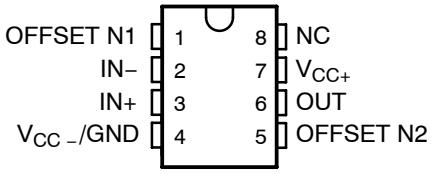
† The D packages are available taped and reeled. To order a taped and reeled part, add the suffix R (e.g., TLE2022CDR).
‡ The DB and PW packages are only available left-end taped and reeled.
§ Chip forms are tested at 25°C only.

**TLE2024 AVAILABLE OPTIONS**

| $T_A$ | $V_{IO}$max AT 25°C | PACKAGED DEVICES | | | | CHIP FORM§ (Y) |
|---|---|---|---|---|---|---|
| | | SMALL OUTLINE (DW) | CHIP CARRIER (FK) | CERAMIC DIP (J) | PLASTIC DIP (N) | |
| 0°C to 70°C | 500 µV<br>750 µV<br>1000 µV | TLE2024BCDW<br>TLE2024ACDW<br>TLE2024CDW | — | — | TLE2024BCN<br>TLE2024ACN<br>TLE2024CN | —<br>—<br>TLE2024Y |
| –40°C to 85°C | 500 µV<br>750 µV<br>1000 µV | TLE2024BIDW<br>TLE2024AIDW<br>TLE2024IDW | — | — | TLE2024BIN<br>TLE2024AIN<br>TLE2024IN | — |
| –55°C to 125°C | 500 µV<br>750 µV<br>1000 µV | TLE2024BMDW<br>TLE2024AMDW<br>TLE2024MDW | TLE2024BMFK<br>TLE2024AMFK<br>TLE2024MFK | TLE2024BMJ<br>TLE2024AMJ<br>TLE2024MJ | TLE2024BMN<br>TLE2024AMN<br>TLE2024MN | — |

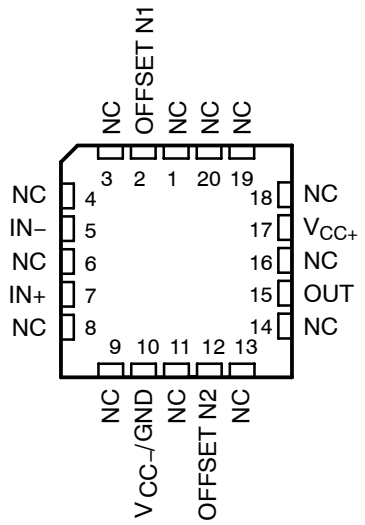
§ Chip forms are tested at 25°C only.

**TLE2021**
**D, DB, JG, P, OR PW PACKAGE**
**(TOP VIEW)**

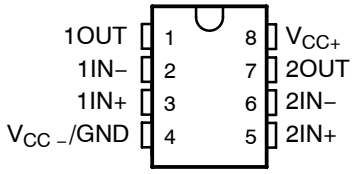



NC – No internal connection

**TLE2021**
**FK PACKAGE**
**(TOP VIEW)**

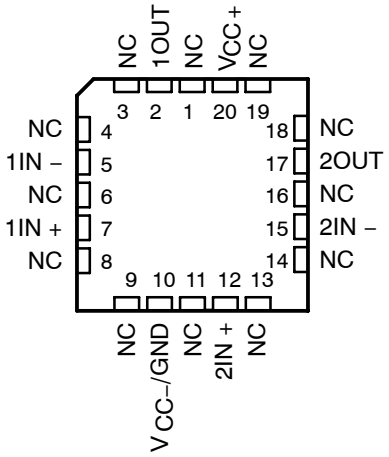



**D, DB, JG, P, OR PW PACKAGE**
**(TOP VIEW)**

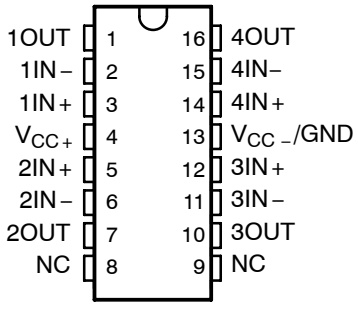



NC – No internal connection

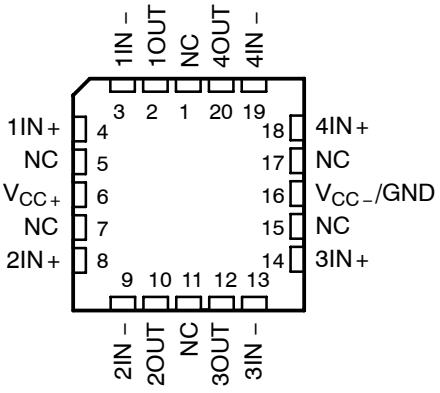
**FK PACKAGE**
**(TOP VIEW)**



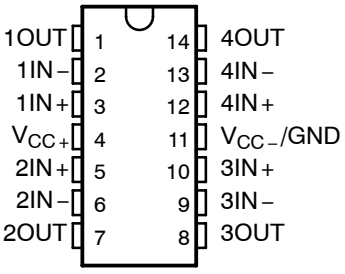

**DW PACKAGE**
**(TOP VIEW)**




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




**J OR N PACKAGE**
**(TOP VIEW)**

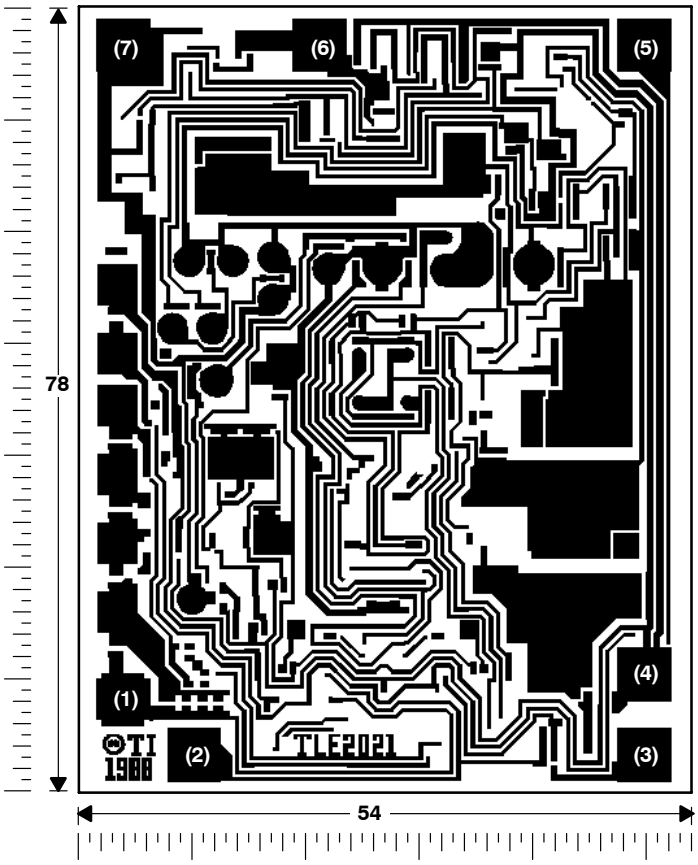


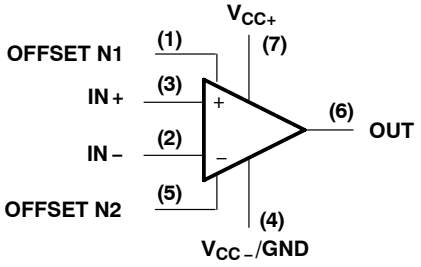

NC – No internal connection

## TLE2021Y chip information

This chip, when properly assembled, display characteristics similar to the TLE2021. Thermal compression or ultrasonic bonding may be used on the doped-aluminum bonding pads. This 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**

**$T_{Jmax}$= 150°C**

**TOLERANCES ARE ±10%.**

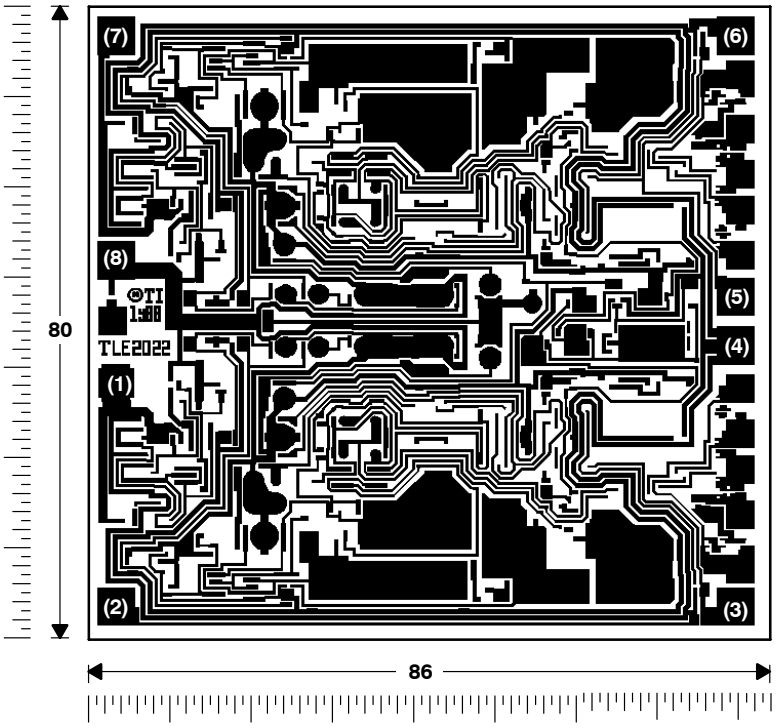
**ALL DIMENSIONS ARE IN MILS.**

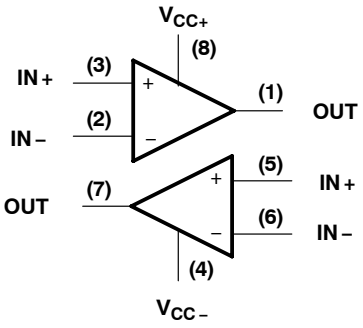
**PIN (4) IS INTERNALLY CONNECTED TO BACKSIDE OF CHIP.**

## TLE2022Y chip information

This chip, when properly assembled, displays characteristics similar to TLE2022. Thermal compression or ultrasonic bonding may be used on the doped-aluminum bonding pads. This 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%.**

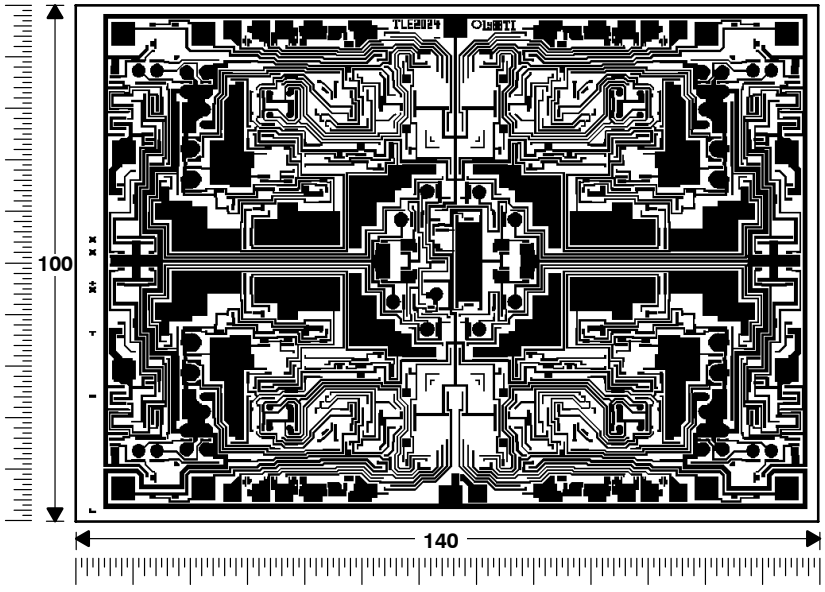
**ALL DIMENSIONS ARE IN MILS.**

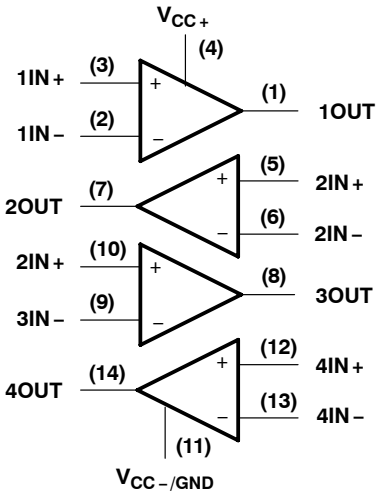
**PIN (4) IS INTERNALLY CONNECTED TO BACKSIDE OF CHIP.**

## TLE2024Y chip information

This chip, when properly assembled, displays characteristics similar to the TLE2024. Thermal compression or ultrasonic bonding may be used on the doped aluminum-bonding pads. This 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**

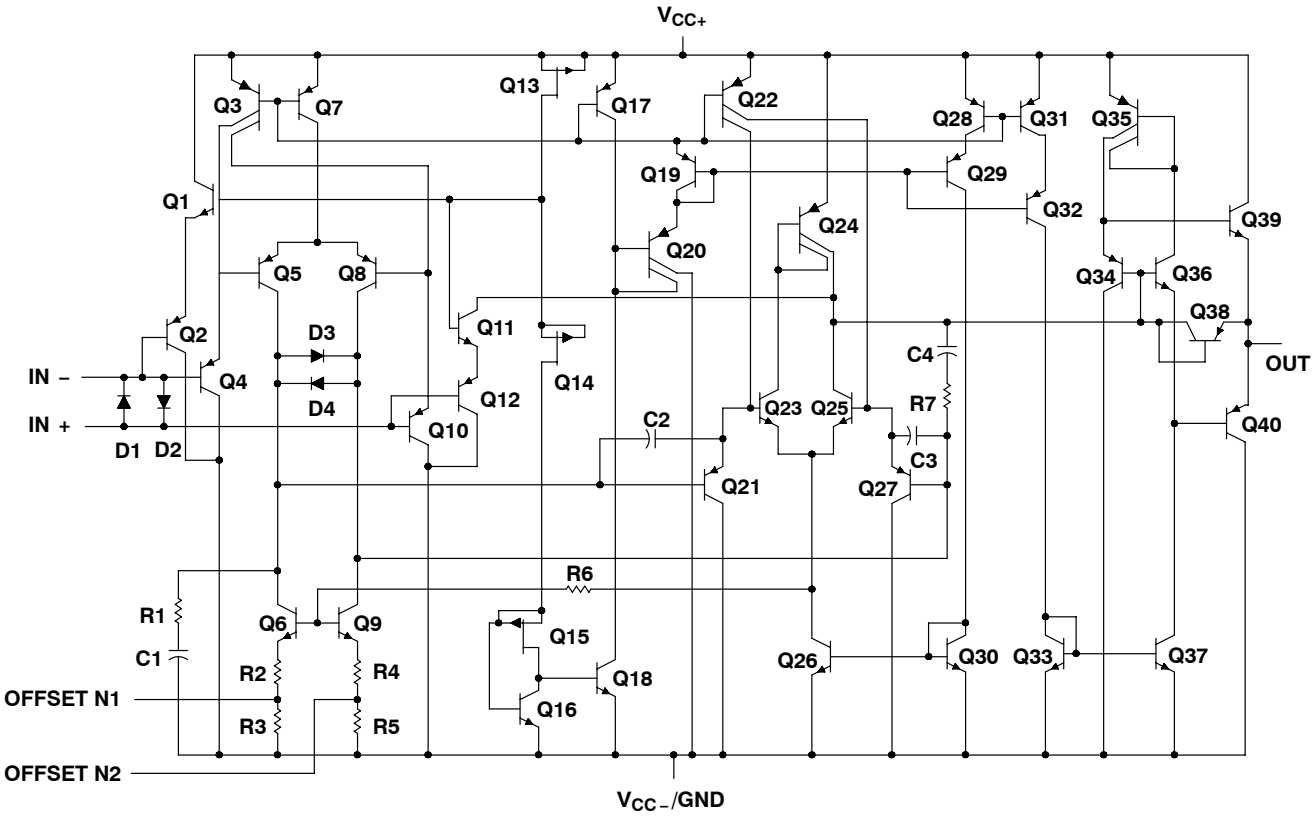
**$T_J$max = 150°C**

**TOLERANCES ARE ±10%.**

**ALL DIMENSIONS ARE IN MILS.**

**PIN (11) IS INTERNALLY CONNECTED TO BACKSIDE OF CHIP.**

### equivalent schematic (each amplifier)




| ACTUAL DEVICE COMPONENT COUNT | | | |
|---|---|---|---|
| COMPONENT | TLE2021 | TLE2022 | TLE2024 |
| Transistors | 40 | 80 | 160 |
| Resistors | 7 | 14 | 28 |
| Diodes | 4 | 8 | 16 |
| Capacitors | 4 | 8 | 16 |

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

Supply voltage, $V_{CC+}$ (see Note 1) . . . . . 20 V
Supply voltage, $V_{CC-}$ (see Note 1) . . . . . −20 V
Differential input voltage, $V_{ID}$ (see Note 2) . . . . . ±0.6 V
Input voltage range, $V_I$ (any input, see Note 1) . . . . . $\pm V_{CC}$
Input current, $I_I$ (each input) . . . . . ±1 mA
Output current, $I_O$ (each output): TLE2021 . . . . . ±20 mA
TLE2022 . . . . . ±30 mA
TLE2024 . . . . . ±40 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, $T_C$: FK package . . . . . 260°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds: D, DP, P, or PW 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 ±600 mV 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 | $T_A = 85°C$ POWER RATING | $T_A = 125°C$ POWER RATING |
|---|---|---|---|---|---|
| D–8 | 725 mW | 5.8 mW/°C | 464 mW | 377 mW | 145 mW |
| DB–8 | 525 mW | 4.2 mW/°C | 336 mW | — | — |
| DW–16 | 1025 mW | 8.2 mW/°C | 656 mW | 533 mW | 205 mW |
| FK | 1375 mW | 11.0 mW/°C | 880 mW | 715 mW | 275 mW |
| J–14 | 1375 mW | 11.0 mW/°C | 880 mW | 715 mW | 275 mW |
| JG–8 | 1050 mW | 8.4 mW/°C | 672 mW | 546 mW | 210 mW |
| N–14 | 1150 mW | 9.2 mW/°C | 736 mW | 598 mW | 230 mW |
| P–8 | 1000 mW | 8.0 mW/°C | 640 mW | 520 mW | 200 mW |
| PW–8 | 525 mW | 4.2 mW/°C | 336 mW | — | — |

## recommended operating conditions

| | | C SUFFIX | | I SUFFIX | | M SUFFIX | | UNIT |
|---|---|---|---|---|---|---|---|---|
| | | MIN | MAX | MIN | MAX | MIN | MAX | |
| Supply voltage, $V_{CC}$ | | ±2 | ±20 | ±2 | ±20 | ±2 | ±20 | V |
| Common-mode input voltage, $V_{IC}$ | $V_{CC} = \pm$ 5 V | 0 | 3.5 | 0 | 3.2 | 0 | 3.2 | V |
| | $V_{CC\pm} = \pm$15 V | −15 | 13.5 | −15 | 13.2 | −15 | 13.2 | |
| Operating free-air temperature, $T_A$ | | 0 | 70 | −40 | 85 | −55 | 125 | °C |

## TLE2021 electrical characteristics at specified free-air temperature, $V_{CC}$ = 5 V (unless otherwise noted

| PARAMETER | | TEST CONDITIONS | $T_A$† | TLE2021C | | | TLE2021AC | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | MIN | TYP | MAX | MIN | TYP | MAX | MIN |
| $V_{IO}$ | Input offset voltage | $V_{IC}$ = 0, $R_S$ = 50 Ω | 25°C | | 120 | 600 | | 100 | 300 | |
| | | | Full range | | | 850 | | | 600 | |
| $\alpha_{VIO}$ | Temperature coefficient of input offset voltage | | Full range | | 2 | | | 2 | | |
| | Input offset voltage long-term drift (see Note 4) | | 25°C | | 0.005 | | | 0.005 | | |
| $I_{IO}$ | Input offset current | | 25°C | | 0.2 | 6 | | 0.2 | 6 | |
| | | | Full range | | | 10 | | | 10 | |
| $I_{IB}$ | Input bias current | | 25°C | | 25 | 70 | | 25 | 70 | |
| | | | Full range | | | 90 | | | 90 | |
| $V_{ICR}$ | Common-mode input voltage range | $R_S$ = 50 Ω | 25°C | 0 to 3.5 | – 0.3 to 4 | | 0 to 3.5 | – 0.3 to 4 | | 0 to 3.5 |
| | | | Full range | 0 to 3.5 | | | 0 to 3.5 | | | 0 to 3.5 |
| $V_{OH}$ | High-level output voltage | $R_L$= 10 kΩ | 25°C | 4 | 4.3 | | 4 | 4.3 | | 4 |
| | | | Full range | 3.9 | | | 3.9 | | | 3.9 |
| $V_{OL}$ | Low-level output voltage | | 25°C | | 0.7 | 0.8 | | 0.7 | 0.8 | |
| | | | Full range | | | 0.85 | | | 0.85 | |
| $A_{VD}$ | Large-signal differential voltage amplification | $V_O$ = 1.4 V to 4 V, $R_L$ = 10 kΩ | 25°C | 0.3 | 1.5 | | 0.3 | 1.5 | | 0.3 |
| | | | Full range | 0.3 | | | 0.3 | | | 0.3 |
| CMRR | Common-mode rejection ratio | $V_{IC}$ = $V_{ICR}$min, $R_S$ = 50 Ω | 25°C | 85 | 110 | | 85 | 110 | | 85 |
| | | | Full range | 80 | | | 80 | | | 80 |
| $k_{SVR}$ | Supply-voltage rejection ratio ($\Delta V_{CC}/\Delta V_{IO}$) | $V_{CC}$ = 5 V to 30 V | 25°C | 105 | 120 | | 105 | 120 | | 105 |
| | | | Full range | 100 | | | 100 | | | 100 |
| $I_{CC}$ | Supply current | $V_O$ = 2.5 V, No load | 25°C | | 200 | 300 | | 200 | 300 | |
| | | | Full range | | | 300 | | | 300 | |
| $\Delta I_{CC}$ | Supply-current change over operating temperature range | | Full range | | 5 | | | 5 | | |

† 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 and assuming an activation energy of 0.96 eV.

## TLE2021 electrical characteristics at specified free-air temperature, $V_{CC}$ = ±15 V (unless otherwise no

| PARAMETER | | TEST CONDITIONS | $T_A$† | TLE2021C | | | TLE2021AC | | | T |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | MIN | TYP | MAX | MIN | TYP | MAX | MIN |
| $V_{IO}$ | Input offset voltage | $V_{IC}$ = 0, $R_S$ = 50 Ω | 25°C | | 120 | 500 | | 80 | 200 | |
| | | | Full range | | | 750 | | | 500 | |
| $\alpha_{VIO}$ | Temperature coefficient of input offset voltage | | Full range | | 2 | | | 2 | | |
| | Input offset voltage long-term drift (see Note 4) | | 25°C | | 0.006 | | | 0.006 | | |
| $I_{IO}$ | Input offset current | | 25°C | | 0.2 | 6 | | 0.2 | 6 | |
| | | | Full range | | | 10 | | | 10 | |
| $I_{IB}$ | Input bias current | | 25°C | | 25 | 70 | | 25 | 70 | |
| | | | Full range | | | 90 | | | 90 | |
| $V_{ICR}$ | Common-mode input voltage range | $R_S$ = 50 Ω | 25°C | −15 to 13.5 | −15.3 to 14 | | −15 to 13.5 | −15.3 to 14 | | −15 to 13.5 |
| | | | Full range | −15 to 13.5 | | | −15 to 13.5 | | | −15 to 13.5 |
| $V_{OM+}$ | Maximum positive peak output voltage swing | $R_L$ = 10 kΩ | 25°C | 14 | 14.3 | | 14 | 14.3 | | 14 |
| | | | Full range | 13.9 | | | 13.9 | | | 13.9 |
| $V_{OM-}$ | Maximum negative peak output voltage swing | | 25°C | −13.7 | −14.1 | | −13.7 | −14.1 | | −13.7 |
| | | | Full range | −13.7 | | | −13.7 | | | −13.7 |
| $A_{VD}$ | Large-signal differential voltage amplification | $V_O$ = ± 10 V, $R_L$ = 10 kΩ | 25°C | 1 | 6.5 | | 1 | 6.5 | | 1 |
| | | | Full range | 1 | | | 1 | | | 1 |
| CMRR | Common-mode rejection ratio | $V_{IC}$ = $V_{ICR}$ min, $R_S$ = 50 Ω | 25°C | 100 | 115 | | 100 | 115 | | 100 |
| | | | Full range | 96 | | | 96 | | | 96 |
| $k_{SVR}$ | Supply-voltage rejection ratio ($\Delta V_{CC}/\Delta V_{IO}$) | $V_{CC\pm}$ = ± 2.5 V to ± 15 V | 25°C | 105 | 120 | | 105 | 120 | | 105 |
| | | | Full range | 100 | | | 100 | | | 100 |
| $I_{CC}$ | Supply current | $V_O$ = 0, No load | 25°C | | 240 | 350 | | 240 | 350 | |
| | | | Full range | | | 350 | | | 350 | |
| $\Delta I_{CC}$ | Supply-current change over operating temperature range | | Full range | | 6 | | | 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 and assuming an activation energy of 0.96 eV.

## TLE2022 electrical characteristics at specified free-air temperature, $V_{CC}$ = 5 V (unless otherwise noted

| PARAMETER | | TEST CONDITIONS | $T_A$† | TLE2022C | | | TLE2022AC | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | MIN | TYP | MAX | MIN | TYP | MAX | MIN |
| $V_{IO}$ | Input offset voltage | $V_{IC}$ = 0, $R_S$ = 50 Ω | 25°C | | | 600 | | | 400 | |
| | | | Full range | | | 800 | | | 550 | |
| $\alpha_{VIO}$ | Temperature coefficient of input offset voltage | | Full range | | 2 | | | 2 | | |
| | Input offset voltage long-term drift (see Note 4) | | 25°C | | 0.005 | | | 0.005 | | |
| $I_{IO}$ | Input offset current | | 25°C | | 0.5 | 6 | | 0.4 | 6 | |
| | | | Full range | | | 10 | | | 10 | |
| $I_{IB}$ | Input bias current | | 25°C | | 35 | 70 | | 33 | 70 | |
| | | | Full range | | | 90 | | | 90 | |
| $V_{ICR}$ | Common-mode input voltage range | $R_S$ = 50 Ω | 25°C | 0 to 3.5 | −0.3 to 4 | | 0 to 3.5 | −0.3 to 4 | | 0 to 3.5 |
| | | | Full range | 0 to 3.5 | | | 0 to 3.5 | | | 0 to 3.5 |
| $V_{OH}$ | High-level output voltage | $R_L$ = 10 kΩ | 25°C | 4 | 4.3 | | 4 | 4.3 | | |
| | | | Full range | 3.9 | | | 3.9 | | | 3.9 |
| $V_{OL}$ | Low-level output voltage | | 25°C | | 0.7 | 0.8 | | 0.7 | 0.8 | |
| | | | Full range | | | 0.85 | | | 0.85 | |
| $A_{VD}$ | Large-signal differential voltage amplification | $V_O$ = 1.4 V to 4 V, $R_L$ = 10 kΩ | 25°C | 0.3 | 1.5 | | 0.4 | 1.5 | | 0.5 |
| | | | Full range | 0.3 | | | 0.4 | | | 0.5 |
| CMRR | Common-mode rejection ratio | $V_{IC}$ = $V_{ICR}$min, $R_S$ = 50 Ω | 25°C | 85 | 100 | | 87 | 102 | | 90 |
| | | | Full range | 80 | | | 82 | | | 85 |
| $k_{SVR}$ | Supply-voltage rejection ratio ($\Delta V_{CC\pm}/\Delta V_{IO}$) | $V_{CC}$ = 5 V to 30 V | 25°C | 100 | 115 | | 103 | 118 | | 105 |
| | | | Full range | 95 | | | 98 | | | 100 |
| $I_{CC}$ | Supply current | $V_O$ = 2.5 V, No load | 25°C | | 450 | 600 | | 450 | 600 | |
| | | | Full range | | | 600 | | | 600 | |
| $\Delta I_{CC}$ | Supply current change over operating temperature range | | Full range | | 7 | | | 7 | | |

† 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 $T_A$ equation and assuming an activation energy of 0.96 eV.

## TLE2022 electrical characteristics at specified free-air temperature, $V_{CC}$ = ±15 V (unless otherwise no

| PARAMETER | | TEST CONDITIONS | $T_A$† | TLE2022C | | | TLE2022AC | | | TL |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | MIN | TYP | MAX | MIN | TYP | MAX | MIN |
| $V_{IO}$ | Input offset voltage | $V_{IC}$ = 0, $R_S$ = 50 Ω | 25°C | | 150 | 500 | | 120 | 300 | |
| | | | Full range | | | 700 | | | 450 | |
| $\alpha_{VIO}$ | Temperature coefficient of input offset voltage | | Full range | | 2 | | | 2 | | |
| | Input offset voltage long-term drift (see Note 4) | | 25°C | | 0.006 | | | 0.006 | | |
| $I_{IO}$ | Input offset current | | 25°C | | 0.5 | 6 | | 0.4 | 6 | |
| | | | Full range | | | 10 | | | 10 | |
| $I_{IB}$ | Input bias current | | 25°C | | 35 | 70 | | 33 | 70 | |
| | | | Full range | | | 90 | | | 90 | |
| $V_{ICR}$ | Common-mode input voltage range | $R_S$ = 50 Ω | 25°C | −15 to 13.5 | −15.3 to 14 | | −15 to 13.5 | −15.3 to 14 | | −15 to 13.5 |
| | | | Full range | −15 to 13.5 | | | −15 to 13.5 | | | −15 to 13.5 |
| $V_{OM+}$ | Maximum positive peak output voltage swing | $R_L$ = 10 kΩ | 25°C | 14 | 14.3 | | 14 | 14.3 | | 14 |
| | | | Full range | 13.9 | | | 13.9 | | | 13.9 |
| $V_{OM-}$ | Maximum negative peak output voltage swing | | 25°C | −13.7 | −14.1 | | −13.7 | −14.1 | | −13.7 |
| | | | Full range | −13.7 | | | −13.7 | | | −13.7 |
| $A_{VD}$ | Large-signal differential voltage amplification | $V_O$ = ±10 V, $R_L$ = 10 kΩ | 25°C | 0.8 | 4 | | 1 | 7 | | 1.5 |
| | | | Full range | 0.8 | | | 1 | | | 1.5 |
| CMRR | Common-mode rejection ratio | $V_{IC}$ = $V_{ICR}$min, $R_S$ = 50 Ω | 25°C | 95 | 106 | | 97 | 109 | | 100 |
| | | | Full range | 91 | | | 93 | | | 96 |
| $k_{SVR}$ | Supply-voltage rejection ratio ($\Delta V_{CC\pm}/\Delta V_{IO}$) | $V_{CC\pm}$ = ±2.5 V to ±15 V | 25°C | 100 | 115 | | 103 | 118 | | 105 |
| | | | Full range | 95 | | | 98 | | | 100 |
| $I_{CC}$ | Supply current | $V_O$ = 0, No load | 25°C | | 550 | 700 | | 550 | 700 | |
| | | | Full range | | | 700 | | | 700 | |
| $\Delta I_{CC}$ | Supply current change over operating temperature range | | Full range | | 9 | | | 9 | | |

† 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 $T_A$ equation and assuming an activation energy of 0.96 eV.

## TLE2024 electrical characteristics at specified free-air temperature, $V_{CC}$ = 5 V (unless otherwise noted

| PARAMETER | | TEST CONDITIONS | | $T_A$† | TLE2024C | | | TLE2024AC | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | MIN | TYP | MAX | MIN | TYP | MAX | MIN |
| $V_{IO}$ | Input offset voltage | $V_{IC}$ = 0, | $R_S$ = 50 Ω | 25°C | | | 1100 | | | 850 | |
| | | | | Full range | | | 1300 | | | 1050 | |
| $\alpha_{VIO}$ | Temperature coefficient of input offset voltage | | | Full range | | 2 | | | 2 | | |
| | Input offset voltage long-term drift (see Note 4) | | | 25°C | | 0.005 | | | 0.005 | | |
| $I_{IO}$ | Input offset current | | | 25°C | | 0.6 | 6 | | 0.5 | 6 | |
| | | | | Full range | | | 10 | | | 10 | |
| $I_{IB}$ | Input bias current | | | 25°C | | 45 | 70 | | 40 | 70 | |
| | | | | Full range | | | 90 | | | 90 | |
| $V_{ICR}$ | Common-mode input voltage range | $R_S$ = 50 Ω | | 25°C | 0 to 3.5 | −0.3 to 4 | | 0 to 3.5 | −0.3 to 4 | | 0 to 3.5 |
| | | | | Full range | 0 to 3.5 | | | 0 to 3.5 | | | 0 to 3.5 |
| $V_{OH}$ | High-level output voltage | $R_L$ = 10 kΩ | | 25°C | 3.9 | 4.2 | | 3.9 | 4.2 | | 4 |
| | | | | Full range | 3.7 | | | 3.7 | | | 3.8 |
| $V_{OL}$ | Low-level output voltage | | | 25°C | | 0.7 | 0.8 | | 0.7 | 0.8 | |
| | | | | Full range | | | 0.95 | | | 0.95 | |
| $A_{VD}$ | Large-signal differential voltage amplification | $V_O$ = 1.4 V to 4 V, | $R_L$ = 10 kΩ | 25°C | 0.2 | 1.5 | | 0.3 | 1.5 | | 0.4 |
| | | | | Full range | 0.1 | | | 0.1 | | | 0.1 |
| CMRR | Common-mode rejection ratio | $V_{IC}$ = $V_{ICR}$min, | $R_S$ = 50 Ω | 25°C | 80 | 90 | | 82 | 92 | | 85 |
| | | | | Full range | 80 | | | 82 | | | 85 |
| $k_{SVR}$ | Supply-voltage rejection ratio ($\Delta V_{CC}/\Delta V_{IO}$) | $V_{CC}$ = 5 V to 30 V | | 25°C | 98 | 112 | | 100 | 115 | | 103 |
| | | | | Full range | 93 | | | 95 | | | 98 |
| $I_{CC}$ | Supply current | $V_O$ = 2.5 V, | No load | 25°C | | 800 | 1200 | | 800 | 1200 | |
| | | | | Full range | | | 1200 | | | 1200 | |
| $\Delta I_{CC}$ | Supply current change over operating temperature range | | | Full range | | 15 | | | 15 | | |

† 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 and assuming an activation energy of 0.96 eV.

## TLE2024 electrical characteristics at specified free-air temperature, $V_{CC}$ = ±15 V (unless otherwise no

| PARAMETER | | TEST CONDITIONS | $T_A$† | TLE2024C | | | TLE2024AC | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | MIN | TYP | MAX | MIN | TYP | MAX | MIN |
| $V_{IO}$ | Input offset voltage | $V_{IC}$ = 0, $R_S$ = 50 Ω | 25°C | | | 1000 | | | 750 | |
| | | | Full range | | | 1200 | | | 950 | |
| $\alpha_{VIO}$ | Temperature coefficient of input offset voltage | | Full range | | 2 | | | 2 | | |
| | Input offset voltage long-term drift (see Note 4) | | 25°C | | 0.006 | | | 0.006 | | |
| $I_{IO}$ | Input offset current | | 25°C | | 0.6 | 6 | | 0.5 | 6 | |
| | | | Full range | | | 10 | | | 10 | |
| $I_{IB}$ | Input bias current | | 25°C | | 50 | 70 | | 45 | 70 | |
| | | | Full range | | | 90 | | | 90 | |
| $V_{ICR}$ | Common-mode input voltage range | $R_S$ = 50 Ω | 25°C | −15 to 13.5 | −15.3 to 14 | | −15 to 13.5 | −15.3 to 14 | | −1 to 13.5 |
| | | | Full range | −15 to 13.5 | | | −15 to 13.5 | | | −1 to 13.5 |
| $V_{OM+}$ | Maximum positive peak output voltage swing | $R_L$ = 10 kΩ | 25°C | 13.8 | 14.1 | | 13.9 | 14.2 | | 14 |
| | | | Full range | 13.7 | | | 13.8 | | | 13.9 |
| $V_{OM-}$ | Maximum negative peak output voltage swing | | 25°C | −13.7 | −14.1 | | −13.7 | −14.1 | | −13.7 |
| | | | Full range | −13.6 | | | −13.6 | | | −13.6 |
| $A_{VD}$ | Large-signal differential voltage amplification | $V_O$ = ±10 V, $R_L$ = 10 kΩ | 25°C | 0.4 | 2 | | 0.8 | 4 | | 1 |
| | | | Full range | 0.4 | | | 0.8 | | | 1 |
| CMRR | Common-mode rejection ratio | $V_{IC}$ = $V_{ICR}$min, $R_S$ = 50 Ω | 25°C | 92 | 102 | | 94 | 105 | | 97 |
| | | | Full range | 88 | | | 90 | | | 93 |
| $k_{SVR}$ | Supply-voltage rejection ratio ($\Delta V_{CC\pm}/\Delta V_{IO}$) | $V_{CC\pm}$ = ±2.5 V to ±15 V | 25°C | 98 | 112 | | 100 | 115 | | 103 |
| | | | Full range | 93 | | | 95 | | | 98 |
| $I_{CC}$ | Supply current | $V_O$ = 0, No load | 25°C | | 1050 | 1400 | | 1050 | 1400 | |
| | | | Full range | | | 1400 | | | 1400 | |
| $\Delta I_{CC}$ | Supply current change over operating temperature range | | Full range | | 20 | | | 20 | | |

† 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 and assuming an activation energy of 0.96 eV.

## TLE2021 electrical characteristics at specified free-air temperature, $V_{CC}$ = 5 V (unless otherwise noted

| PARAMETER | | TEST CONDITIONS | $T_A$† | TLE2021I | | | TLE2021AI | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | MIN | TYP | MAX | MIN | TYP | MAX | MIN |
| $V_{IO}$ | Input offset voltage | $V_{IC}$ = 0, $R_S$ = 50 Ω | 25°C | | 120 | 600 | | 100 | 300 | |
| | | | Full range | | | 950 | | | 600 | |
| $\alpha_{VIO}$ | Temperature coefficient of input offset voltage | | Full range | | 2 | | | 2 | | |
| | Input offset voltage long-term drift (see Note 4) | | 25°C | | 0.005 | | | 0.005 | | |
| $I_{IO}$ | Input offset current | | 25°C | | 0.2 | 6 | | 0.2 | 6 | |
| | | | Full range | | | 10 | | | 10 | |
| $I_{IB}$ | Input bias current | | 25°C | | 25 | 70 | | 25 | 70 | |
| | | | Full range | | | 90 | | | 90 | |
| $V_{ICR}$ | Common-mode input voltage range | $R_S$ = 50 Ω | 25°C | 0 to 3.5 | −0.3 to 4 | | 0 to 3.5 | −0.3 to 4 | | 0 to 3.5 |
| | | | Full range | 0 to 3.2 | | | 0 to 3.2 | | | 0 to 3.2 |
| $V_{OH}$ | High-level output voltage | $R_L$ = 10 kΩ | 25°C | 4 | 4.3 | | 4 | 4.3 | | 4 |
| | | | Full range | 3.9 | | | 3.9 | | | 3.9 |
| $V_{OL}$ | Low-level output voltage | | 25°C | | 0.7 | 0.8 | | 0.7 | 0.8 | |
| | | | Full range | | | 0.9 | | | 0.9 | |
| $A_{VD}$ | Large-signal differential voltage amplification | $V_O$ = 1.4 V to 4 V, $R_L$ = 10 kΩ | 25°C | 0.3 | 1.5 | | 0.3 | 1.5 | | 0.3 |
| | | | Full range | 0.25 | | | 0.25 | | | 0.25 |
| CMRR | Common-mode rejection ratio | $V_{IC}$ = $V_{ICR}$ min, $R_S$ = 50 Ω | 25°C | 85 | 110 | | 85 | 110 | | 85 |
| | | | Full range | 80 | | | 80 | | | 80 |
| $k_{SVR}$ | Supply-voltage rejection ratio ($\Delta V_{CC}/\Delta V_{IO}$) | $V_{CC}$ = 5 V to 30 V | 25°C | 105 | 120 | | 105 | 120 | | 105 |
| | | | Full range | 100 | | | 100 | | | 100 |
| $I_{CC}$ | Supply current | $V_O$ = 2.5 V, No load | 25°C | | 200 | 300 | | 200 | 300 | |
| | | | Full range | | | 300 | | | 300 | |
| $\Delta I_{CC}$ | Supply-current change over operating temperature range | | Full range | | 6 | | | 6 | | |

† Full range is − 40°C to 85°C.

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

## TLE2021 electrical characteristics at specified free-air temperature, $V_{CC}$ = ± 15 V (unless otherwise no

| PARAMETER | | TEST CONDITIONS | $T_A$† | TLE2021I | | | TLE2021AI | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | MIN | TYP | MAX | MIN | TYP | MAX | MIN |
| $V_{IO}$ | Input offset voltage | $V_{IC}$ = 0, $R_S$ = 50 Ω | 25°C | | 120 | 500 | | 80 | 200 | |
| | | | Full range | | | 850 | | | 500 | |
| $\alpha_{VIO}$ | Temperature coefficient of input offset voltage | | Full range | | 2 | | | 2 | | |
| | Input offset voltage long-term drift (see Note 4) | | 25°C | | 0.006 | | | 0.006 | | |
| $I_{IO}$ | Input offset current | | 25°C | | 0.2 | 6 | | 0.2 | 6 | |
| | | | Full range | | | 10 | | | 10 | |
| $I_{IB}$ | Input bias current | | 25°C | | 25 | 70 | | 25 | 70 | |
| | | | Full range | | | 90 | | | 90 | |
| $V_{ICR}$ | Common-mode input voltage range | $R_S$ = 50 Ω | 25°C | −15 to 13.5 | −15.3 to 14 | | −15 to 13.5 | −15.3 to 14 | | −15 to 13.5 |
| | | | Full range | −15 to 13.2 | | | −15 to 13.2 | | | −15 to 13.2 |
| $V_{OM+}$ | Maximum positive peak output voltage swing | $R_L$ = 10 kΩ | 25°C | 14 | 14.3 | | 14 | 14.3 | | 14 |
| | | | Full range | 13.9 | | | 13.9 | | | 13.9 |
| $V_{OM-}$ | Maximum negative peak output voltage swing | | 25°C | −13.7 | −14.1 | | −13.7 | −14.1 | | −13.7 |
| | | | Full range | −13.6 | | | −13.6 | | | −13.6 |
| $A_{VD}$ | Large-signal differential voltage amplification | $V_O$ = 10 V, $R_L$ = 10 kΩ | 25°C | 1 | 6.5 | | 1 | 6.5 | | 1 |
| | | | Full range | 0.75 | | | 0.75 | | | 0.75 |
| CMRR | Common-mode rejection ratio | $V_{IC}$ = $V_{ICR}$ min, $R_S$ = 50 Ω | 25°C | 100 | 115 | | 100 | 115 | | 100 |
| | | | Full range | 96 | | | 96 | | | 96 |
| $k_{SVR}$ | Supply-voltage rejection ratio ($\Delta V_{CC}/\Delta V_{IO}$) | $V_{CC\pm}$ = ± 2. 5 V to ± 15 V | 25°C | 105 | 120 | | 105 | 120 | | 105 |
| | | | Full range | 100 | | | 100 | | | 100 |
| $I_{CC}$ | Supply current | $V_O$ = 0 V, No load | 25°C | | 240 | 350 | | 240 | 350 | |
| | | | Full range | | | 350 | | | 350 | |
| $\Delta I_{CC}$ | Supply-current change over operating temperature range | | Full range | | 7 | | | 7 | | |

† Full range is − 40°C to 85°C.

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

## TLE2022 electrical characteristics at specified free-air temperature, $V_{CC}$ = 5 V (unless otherwise noted

| PARAMETER | | TEST CONDITIONS | | $T_A$† | TLE2022I | | | TLE2022AI | | | T |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | MIN | TYP | MAX | MIN | TYP | MAX | MIN |
| $V_{IO}$ | Input offset voltage | $V_{IC}$ = 0, | $R_S$ = 50 Ω | 25°C | | | 600 | | | 400 | |
| | | | | Full range | | | 800 | | | 550 | |
| $\alpha_{VIO}$ | Temperature coefficient of input offset voltage | | | Full range | | 2 | | | 2 | | |
| | Input offset voltage long-term drift (see Note 4) | | | 25°C | | 0.005 | | | 0.005 | | |
| $I_{IO}$ | Input offset current | | | 25°C | | 0.5 | 6 | | 0.4 | 6 | |
| | | | | Full range | | | 10 | | | 10 | |
| $I_{IB}$ | Input bias current | | | 25°C | | 35 | 70 | | 33 | 70 | |
| | | | | Full range | | | 90 | | | 90 | |
| $V_{ICR}$ | Common-mode input voltage range | $R_S$ = 50 Ω | | 25°C | 0 to 3.5 | −0.3 to 4 | | 0 to 3.5 | −0.3 to 4 | | 0 to 3.5 |
| | | | | Full range | 0 to 3.2 | | | 0 to 3.2 | | | 0 to 3.2 |
| $V_{OH}$ | High-level output voltage | $R_L$ = 10 kΩ | | 25°C | 4 | 4.3 | | 4 | 4.3 | | 4 |
| | | | | Full range | 3.9 | | | 3.9 | | | 3.9 |
| $V_{OL}$ | Low-level output voltage | | | 25°C | | 0.7 | 0.8 | | 0.7 | 0.8 | |
| | | | | Full range | | | 0.9 | | | 0.9 | |
| $A_{VD}$ | Large-signal differential voltage amplification | $V_O$ = 1.4 V to 4 V, | $R_L$ = 10 kΩ | 25°C | 0.3 | 1.5 | | 0.4 | 1.5 | | 0.5 |
| | | | | Full range | 0.2 | | | 0.2 | | | 0.2 |
| CMRR | Common-mode rejection ratio | $V_{IC}$ = $V_{ICR}$min, | $R_S$ = 50 Ω | 25°C | 85 | 100 | | 87 | 102 | | 90 |
| | | | | Full range | 80 | | | 82 | | | 85 |
| $k_{SVR}$ | Supply-voltage rejection ratio ($\Delta V_{CC\pm}/\Delta V_{IO}$) | $V_{CC}$ = 5 V to 30 V | | 25°C | 100 | 115 | | 103 | 118 | | 105 |
| | | | | Full range | 95 | | | 98 | | | 100 |
| $I_{CC}$ | Supply current | $V_O$ = 2.5 V, | No load | 25°C | | 450 | 600 | | 450 | 600 | |
| | | | | Full range | | | 600 | | | 600 | |
| $\Delta I_{CC}$ | Supply current change over operating temperature range | | | Full range | | 15 | | | 15 | | |

† Full range is −40°C to 85°C.

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

## TLE2022 electrical characteristics at specified free-air temperature, $V_{CC}$ = ± 15 V (unless otherwise no

| PARAMETER | | TEST CONDITIONS | $T_A$† | TLE2022I | | | TLE2022AI | | | TL |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | MIN | TYP | MAX | MIN | TYP | MAX | MIN |
| $V_{IO}$ | Input offset voltage | $V_{IC}$ = 0, $R_S$ = 50 Ω | 25°C | | 150 | 500 | | 120 | 300 | |
| | | | Full range | | | 700 | | | 450 | |
| $\alpha_{VIO}$ | Temperature coefficient of input offset voltage | | Full range | | 2 | | | 2 | | |
| | Input offset voltage long-term drift (see Note 4) | | 25°C | | 0.006 | | | 0.006 | | |
| $I_{IO}$ | Input offset current | | 25°C | | 0.5 | 6 | | 0.4 | 6 | |
| | | | Full range | | | 10 | | | 10 | |
| $I_{IB}$ | Input bias current | | 25°C | | 35 | 70 | | 33 | 70 | |
| | | | Full range | | | 90 | | | 90 | |
| $V_{ICR}$ | Common-mode input voltage range | $R_S$ = 50 Ω | 25°C | – 15 to 13.5 | – 15.3 to 14 | | – 15 to 13.5 | – 15.3 to 14 | | – 15 to 13.5 |
| | | | Full range | – 15 to 13.2 | | | – 15 to 13.2 | | | – 15 to 13.2 |
| $V_{OM+}$ | Maximum positive peak output voltage swing | $R_L$ = 10 kΩ | 25°C | 14 | 14.3 | | 14 | 14.3 | | 14 |
| | | | Full range | 13.9 | | | 13.9 | | | 13.9 |
| $V_{OM-}$ | Maximum negative peak output voltage swing | | 25°C | – 13.7 | – 14.1 | | – 13.7 | – 14.1 | | – 13.7 |
| | | | Full range | – 13.6 | | | – 13.6 | | | – 13.6 |
| $A_{VD}$ | Large-signal differential voltage amplification | $V_O$ = ± 10 V, $R_L$ = 10 kΩ | 25°C | 0.8 | 4 | | 1 | 7 | | 1.5 |
| | | | Full range | 0.8 | | | 1 | | | 1.5 |
| CMRR | Common-mode rejection ratio | $V_{IC}$ = $V_{ICR}$min, $R_S$ = 50 Ω | 25°C | 95 | 106 | | 97 | 109 | | 100 |
| | | | Full range | 91 | | | 93 | | | 96 |
| $k_{SVR}$ | Supply-voltage rejection ratio ($\Delta V_{CC\pm}/\Delta V_{IO}$) | $V_{CC}$ = ±2.5 V to ±15 V | 25°C | 100 | 115 | | 103 | 118 | | 105 |
| | | | Full range | 95 | | | 98 | | | 100 |
| $I_{CC}$ | Supply current | $V_O$ = 0, No load | 25°C | | 550 | 700 | | 550 | 700 | |
| | | | Full range | | | 700 | | | 700 | |
| $\Delta I_{CC}$ | Supply current change over operating temperature range | | Full range | | 30 | | | 30 | | |

† Full range is –40°C to 85°C.

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

## TLE2024 electrical characteristics at specified free-air temperature, $V_{CC}$ = 5 V (unless otherwise noted

| PARAMETER | | TEST CONDITIONS | $T_A$† | TLE2024I | | | TLE2024AI | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | MIN | TYP | MAX | MIN | TYP | MAX | MIN |
| $V_{IO}$ | Input offset voltage | $V_{IC}$ = 0, $R_S$ = 50 Ω | 25°C | | | 1100 | | | 850 | |
| | | | Full range | | | 1300 | | | 1050 | |
| $\alpha_{VIO}$ | Temperature coefficient of input offset voltage | | Full range | | 2 | | | 2 | | |
| | Input offset voltage long-term drift (see Note 4) | | 25°C | | 0.005 | | | 0.005 | | |
| $I_{IO}$ | Input offset current | | 25°C | | 0.6 | 6 | | 0.5 | 6 | |
| | | | Full range | | | 10 | | | 10 | |
| $I_{IB}$ | Input bias current | | 25°C | | 45 | 70 | | 40 | 70 | |
| | | | Full range | | | 90 | | | 90 | |
| $V_{ICR}$ | Common-mode input voltage range | $R_S$ = 50 Ω | 25°C | 0 to 3.5 | −0.3 to 4 | | 0 to 3.5 | −0.3 to 4 | | 0 to 3.5 |
| | | | Full range | 0 to 3.2 | | | 0 to 3.2 | | | 0 to 3.2 |
| $V_{OM+}$ | Maximum positive peak output voltage swing | $R_L$ = 10 kΩ | 25°C | 3.9 | 4.2 | | 3.9 | 4.2 | | 4 |
| | | | Full range | 3.7 | | | 3.7 | | | 3.8 |
| $V_{OM-}$ | Maximum negative peak output voltage swing | | 25°C | | 0.7 | 0.8 | | 0.7 | 0.8 | |
| | | | Full range | | | 0.95 | | | 0.95 | |
| $A_{VD}$ | Large-signal differential voltage amplification | $V_O$ = 1.4 V to 4 V, $R_L$ = 10 kΩ | 25°C | 0.2 | 1.5 | | 0.3 | 1.5 | | 0.4 |
| | | | Full range | 0.1 | | | 0.1 | | | 0.1 |
| CMRR | Common-mode rejection ratio | $V_{IC}$ = $V_{ICR}$min, $R_S$ = 50 Ω | 25°C | 80 | 90 | | 82 | 92 | | 85 |
| | | | Full range | 80 | | | 82 | | | 85 |
| $k_{SVR}$ | Supply-voltage rejection ratio ($\Delta V_{CC\pm}/\Delta V_{IO}$) | $V_{CC\pm}$ = ±2.5 V to ±15 V | 25°C | 98 | 112 | | 100 | 115 | | 103 |
| | | | Full range | 93 | | | 95 | | | 98 |
| $I_{CC}$ | Supply current | $V_O$ = 0, No load | 25°C | | 800 | 1200 | | 800 | 1200 | |
| | | | Full range | | | 1200 | | | 1200 | |
| $\Delta I_{CC}$ | Supply current change over operating temperature range | | Full range | | 30 | | | 30 | | |

† Full range is −40°C to 85°C.

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

## TLE2024 electrical characteristics at specified free-air temperature, $V_{CC}$ = ±15 V (unless otherwise no

| PARAMETER | | TEST CONDITIONS | $T_A$† | TLE2024I | | | TLE2024AI | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | MIN | TYP | MAX | MIN | TYP | MAX | MIN |
| $V_{IO}$ | Input offset voltage | $V_{IC}$ = 0, $R_S$ = 50 Ω | 25°C | | | 1000 | | | 750 | |
| | | | Full range | | | 1200 | | | 950 | |
| $\alpha_{VIO}$ | Temperature coefficient of input offset voltage | | Full range | | 2 | | | 2 | | |
| | Input offset voltage long-term drift (see Note 4) | | 25°C | | 0.006 | | | 0.006 | | |
| $I_{IO}$ | Input offset current | | 25°C | | 0.6 | 6 | | 0.5 | 6 | |
| | | | Full range | | | 10 | | | 10 | |
| $I_{IB}$ | Input bias current | | 25°C | | 50 | 70 | | 45 | 70 | |
| | | | Full range | | | 90 | | | 90 | |
| $V_{ICR}$ | Common-mode input voltage range | $R_S$ = 50 Ω | 25°C | −15 to 13.5 | −15.3 to 14 | | −15 to 13.5 | −15.3 to 14 | | −1 to 13.5 |
| | | | Full range | −15 to 13.2 | | | −15 to 13.2 | | | −1 to 13.2 |
| $V_{OM+}$ | Maximum positive peak output voltage swing | $R_L$ = 10 kΩ | 25°C | 13.8 | 14.1 | | 13.9 | 14.2 | | 14 |
| | | | Full range | 13.7 | | | 13.7 | | | 13.8 |
| $V_{OM-}$ | Maximum negative peak output voltage swing | | 25°C | −13.7 | −14.1 | | −13.7 | −14.1 | | −13.7 |
| | | | Full range | −13.6 | | | −13.6 | | | −13.6 |
| $A_{VD}$ | Large-signal differential voltage amplification | $V_O$ = ±10 V, $R_L$ = 10 kΩ | 25°C | 0.4 | 2 | | 0.8 | 4 | | 1 |
| | | | Full range | 0.4 | | | 0.8 | | | 1 |
| CMRR | Common-mode rejection ratio | $V_{IC}$ = $V_{ICR}$min, $R_S$ = 50 Ω | 25°C | 92 | 102 | | 94 | 105 | | 97 |
| | | | Full range | 88 | | | 90 | | | 93 |
| $k_{SVR}$ | Supply-voltage rejection ratio ($\Delta V_{CC\pm}/\Delta V_{IO}$) | $V_{CC\pm}$ = ±2.5 V to ±15 V | 25°C | 98 | 112 | | 100 | 115 | | 103 |
| | | | Full range | 93 | | | 95 | | | 98 |
| $I_{CC}$ | Supply current | $V_O$ = 0, No load | 25°C | | 1050 | 1400 | | 1050 | 1400 | |
| | | | Full range | | | 1400 | | | 1400 | |
| $\Delta I_{CC}$ | Supply current change over operating temperature range | | Full range | | 50 | | | 50 | | |

† Full range is −40°C to 85°C.

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

## TLE2021 electrical characteristics at specified free-air temperature, $V_{CC}$ = 5 V (unless otherwise noted

| PARAMETER | | TEST CONDITIONS | | $T_A$† | TLE2021M | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | MIN | TYP | MAX | MIN |
| $V_{IO}$ | Input offset voltage | $V_{IC}$ = 0, | $R_S$ = 50 Ω | 25°C | | 120 | 600 | |
| | | | | Full range | | | 1100 | |
| $\alpha_{VIO}$ | Temperature coefficient of input offset voltage | | | Full range | | 2 | | |
| | Input offset voltage long-term drift (see Note 4) | | | 25°C | | 0.005 | | |
| $I_{IO}$ | Input offset current | | | 25°C | | 0.2 | 6 | |
| | | | | Full range | | | 10 | |
| $I_{IB}$ | Input bias current | | | 25°C | | 25 | 70 | |
| | | | | Full range | | | 90 | |
| $V_{ICR}$ | Common-mode input voltage range | $R_S$ = 50 Ω | | 25°C | 0 to 3.5 | −0.3 to 4 | | 0 to 3.5 |
| | | | | Full range | 0 to 3.2 | | | 0 to 3.2 |
| $V_{OH}$ | High-level output voltage | $R_L$ = 10 kΩ | | 25°C | 4 | 4.3 | | 4 |
| | | | | Full range | 3.8 | | | 3.8 |
| $V_{OL}$ | Low-level output voltage | | | 25°C | | 0.7 | 0.8 | |
| | | | | Full range | | | 0.95 | |
| $A_{VD}$ | Large-signal differential voltage amplification | $V_O$ = 1.4 V to 4 V, | $R_L$ = 10 kΩ | 25°C | 0.3 | 1.5 | | 0.3 |
| | | | | Full range | 0.1 | | | 0.1 |
| CMRR | Common-mode rejection ratio | $V_{IC}$ = $V_{ICR}$min, | $R_S$ = 50 Ω | 25°C | 85 | 110 | | 85 |
| | | | | Full range | 80 | | | 80 |
| $k_{SVR}$ | Supply-voltage rejection ratio ($\Delta V_{CC\pm}/\Delta V_{IO}$) | $V_{CC}$ = 5 V to 30 V | | 25°C | 105 | 120 | | 105 |
| | | | | Full range | 100 | | | 100 |
| $I_{CC}$ | Supply current | $V_O$ = 2.5 V, | No load | 25°C | | 170 | 230 | |
| | | | | Full range | | | 230 | |
| $\Delta I_{CC}$ | Supply current change over operating temperature range | | | Full range | | 9 | | |

† 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 and assuming an activation energy of 0.96 eV.

## TLE2021 electrical characteristics at specified free-air temperature, $V_{CC}$ = ±15 V (unless otherwise not

| PARAMETER | | TEST CONDITIONS | | $T_A$† | TLE2021M | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | MIN | TYP | MAX | MIN |
| $V_{IO}$ | Input offset voltage | $V_{IC}$ = 0, | $R_S$ = 50 Ω | 25°C | | 120 | 500 | |
| | | | | Full range | | | 1000 | |
| $\alpha_{VIO}$ | Temperature coefficient of input offset voltage | | | Full range | | 2 | | |
| | Input offset voltage long-term drift (see Note 4) | | | 25°C | | 0.006 | | |
| $I_{IO}$ | Input offset current | | | 25°C | | 0.2 | 6 | |
| | | | | Full range | | | 10 | |
| $I_{IB}$ | Input bias current | | | 25°C | | 25 | 70 | |
| | | | | Full range | | | 90 | |
| $V_{ICR}$ | Common-mode input voltage range | $R_S$ = 50 Ω | | 25°C | −15 to 13.5 | −15.3 to 14 | | −15 to 13.5 |
| | | | | Full range | −15 to 13.2 | | | −15 to 13.2 |
| $V_{OM+}$ | Maximum positive peak output voltage swing | $R_L$ = 10 kΩ | | 25°C | 14 | 14.3 | | 14 |
| | | | | Full range | 13.8 | | | 13.8 |
| $V_{OM-}$ | Maximum negative peak output voltage swing | | | 25°C | −13.7 | −14.1 | | −13.7 |
| | | | | Full range | −13.6 | | | −13.6 |
| $A_{VD}$ | Large-signal differential voltage amplification | $V_O$ = ±10 V, | $R_L$ = 10 kΩ | 25°C | 1 | 6.5 | | 1 |
| | | | | Full range | 0.5 | | | 0.5 |
| CMRR | Common-mode rejection ratio | $V_{IC}$ = $V_{ICR}$min, | $R_S$ = 50 Ω | 25°C | 100 | 115 | | 100 |
| | | | | Full range | 96 | | | 96 |
| $k_{SVR}$ | Supply-voltage rejection ratio ($\Delta V_{CC\pm}/\Delta V_{IO}$) | $V_{CC\pm}$ = ± 2.5 V to ±15 V | | 25°C | 105 | 120 | | 105 |
| | | | | Full range | 100 | | | 100 |
| $I_{CC}$ | Supply current | $V_O$ = 0, | No load | 25°C | | 200 | 300 | |
| | | | | Full range | | | 300 | |
| $\Delta I_{CC}$ | Supply current change over operating temperature range | | | Full range | | 10 | | |

† 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 and assuming an activation energy of 0.96 eV.

## TLE2022 electrical characteristics at specified free-air temperature, $V_{CC}$ = 5 V (unless otherwise noted

| PARAMETER | | TEST CONDITIONS | | $T_A$† | TLE2022M | | | TLE2022AM | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | MIN | TYP | MAX | MIN | TYP | MAX | MI |
| $V_{IO}$ | Input offset voltage | $V_{IC}$ = 0, | $R_S$ = 50 Ω | 25°C | | | 600 | | | 400 | |
| | | | | Full range | | | 800 | | | 550 | |
| $\alpha_{VIO}$ | Temperature coefficient of input offset voltage | | | Full range | | 2 | | | 2 | | |
| | Input offset voltage long-term drift (see Note 4) | | | 25°C | | 0.005 | | | 0.005 | | |
| $I_{IO}$ | Input offset current | | | 25°C | | 0.5 | 6 | | 0.4 | 6 | |
| | | | | Full range | | | 10 | | | 10 | |
| $I_{IB}$ | Input bias current | | | 25°C | | 35 | 70 | | 33 | 70 | |
| | | | | Full range | | | 90 | | | 90 | |
| $V_{ICR}$ | Common-mode input voltage range | $R_S$ = 50 Ω | | 25°C | 0 to 3.5 | −0.3 to 4 | | 0 to 3.5 | −0.3 to 4 | | t 3. |
| | | | | Full range | 0 to 3.2 | | | 0 to 3.2 | | | t 3. |
| $V_{OH}$ | High-level output voltage | $R_L$ = 10 kΩ | | 25°C | 4 | 4.3 | | 4 | 4.3 | | |
| | | | | Full range | 3.8 | | | 3.8 | | | 3. |
| $V_{OL}$ | Low-level output voltage | | | 25°C | | 0.7 | 0.8 | | 0.7 | 0.8 | |
| | | | | Full range | | | 0.95 | | | 0.95 | |
| $A_{VD}$ | Large-signal differential voltage amplification | $V_O$ = 1.4 V to 4 V, | $R_L$ = 10 kΩ | 25°C | 0.3 | 1.5 | | 0.4 | 1.5 | | 0. |
| | | | | Full range | 0.1 | | | 0.1 | | | 0. |
| CMRR | Common-mode rejection ratio | $V_{IC}$ = $V_{ICR}$min, | $R_S$ = 50 Ω | 25°C | 85 | 100 | | 87 | 102 | | 9 |
| | | | | Full range | 80 | | | 82 | | | 8 |
| $k_{SVR}$ | Supply-voltage rejection ratio ($\Delta V_{CC\pm}/\Delta V_{IO}$) | $V_{CC}$ = 5 V to 30 V | | 25°C | 100 | 115 | | 103 | 118 | | 10 |
| | | | | Full range | 95 | | | 98 | | | 10 |
| $I_{CC}$ | Supply current | $V_O$ = 2.5 V, | No load | 25°C | | 450 | 600 | | 450 | 600 | |
| | | | | Full range | | | 600 | | | 600 | |
| $\Delta I_{CC}$ | Supply current change over operating temperature range | | | Full range | | 37 | | | 37 | | |

† 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 and assuming an activation energy of 0.96 eV.

## TLE2022 electrical characteristics at specified free-air temperature, $V_{CC}$ = ±15 V (unless otherwise no

| PARAMETER | | TEST CONDITIONS | | $T_A$† | TLE2022M | | | TLE2022AM | | | TL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | MIN | TYP | MAX | MIN | TYP | MAX | MIN |
| $V_{IO}$ | Input offset voltage | $V_{IC}$ = 0, | $R_S$ = 50 Ω | 25°C | | 150 | 500 | | 120 | 300 | |
| | | | | Full range | | | 700 | | | 450 | |
| $\alpha_{VIO}$ | Temperature coefficient of input offset voltage | | | Full range | | 2 | | | 2 | | |
| | Input offset voltage long-term drift (see Note 4) | | | 25°C | | 0.006 | | | 0.006 | | |
| $I_{IO}$ | Input offset current | | | 25°C | | 0.5 | 6 | | 0.4 | 6 | |
| | | | | Full range | | | 10 | | | 10 | |
| $I_{IB}$ | Input bias current | | | 25°C | | 35 | 70 | | 33 | 70 | |
| | | | | Full range | | | 90 | | | 90 | |
| $V_{ICR}$ | Common-mode input voltage range | $R_S$ = 50 Ω | | 25°C | −15 to 13.5 | −15.3 to 14 | | −15 to 13.5 | −15.3 to 14 | | −15 to 13.5 |
| | | | | Full range | −15 to 13.2 | | | −15 to 13.2 | | | −15 to 13.2 |
| $V_{OM+}$ | Maximum positive peak output voltage swing | $R_L$ = 10 kΩ | | 25°C | 14 | 14.3 | | 14 | 14.3 | | 14 |
| | | | | Full range | 13.9 | | | 13.9 | | | 13.9 |
| $V_{OM-}$ | Maximum negative peak output voltage swing | | | 25°C | −13.7 | −14.1 | | −13.7 | −14.1 | | −13.7 |
| | | | | Full range | −13.6 | | | −13.6 | | | −13.6 |
| $A_{VD}$ | Large-signal differential voltage amplification | $V_O$ = ±10 V, | $R_L$ = 10 kΩ | 25°C | 0.8 | 4 | | 1 | 7 | | 1.5 |
| | | | | Full range | 0.8 | | | 1 | | | 1.5 |
| CMRR | Common-mode rejection ratio | $V_{IC}$ = $V_{ICR}$min, | $R_S$ = 50 Ω | 25°C | 95 | 106 | | 97 | 109 | | 100 |
| | | | | Full range | 91 | | | 93 | | | 96 |
| $k_{SVR}$ | Supply-voltage rejection ratio ($\Delta V_{CC\pm}/\Delta V_{IO}$) | $V_{CC\pm}$ = ±2.5 V to ±15 V | | 25°C | 100 | 115 | | 103 | 118 | | 105 |
| | | | | Full range | 95 | | | 98 | | | 100 |
| $I_{CC}$ | Supply current | $V_O$ = 0, | No load | 25°C | | 550 | 700 | | 550 | 700 | |
| | | | | Full range | | | 700 | | | 700 | |
| $\Delta I_{CC}$ | Supply current change over operating temperature range | | | Full range | | 60 | | | 60 | | |

† 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 $T_A$ equation and assuming an activation energy of 0.96 eV.

## TLE2024 electrical characteristics at specified free-air temperature, $V_{CC}$ = 5 V (unless otherwise noted

| PARAMETER | | TEST CONDITIONS | $T_A$† | TLE2024M | | | TLE2024AM | | | T |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | MIN | TYP | MAX | MIN | TYP | MAX | MIN |
| $V_{IO}$ | Input offset voltage | $V_{IC}$ = 0, $R_S$ = 50 Ω | 25°C | | | 1100 | | | 850 | |
| | | | Full range | | | 1300 | | | 1050 | |
| $\alpha_{VIO}$ | Temperature coefficient of input offset voltage | | Full range | | 2 | | | 2 | | |
| | Input offset voltage long-term drift (see Note 4) | | 25°C | | 0.005 | | | 0.005 | | |
| $I_{IO}$ | Input offset current | | 25°C | | 0.6 | 6 | | 0.5 | 6 | |
| | | | Full range | | | 10 | | | 10 | |
| $I_{IB}$ | Input bias current | | 25°C | | 45 | 70 | | 40 | 70 | |
| | | | Full range | | | 90 | | | 90 | |
| $V_{ICR}$ | Common-mode input voltage range | $R_S$ = 50 Ω | 25°C | 0 to 3.5 | −0.3 to 4 | | 0 to 3.5 | −0.3 to 4 | | 0 to 3.5 |
| | | | Full range | 0 to 3.2 | | | 0 to 3.2 | | | 0 to 3.2 |
| $V_{OM+}$ | Maximum positive peak output voltage swing | $R_L$ = 10 kΩ | 25°C | 3.9 | 4.2 | | 3.9 | 4.2 | | 4 |
| | | | Full range | 3.7 | | | 3.7 | | | 3.8 |
| $V_{OM-}$ | Maximum negative peak output voltage swing | | 25°C | | 0.7 | 0.8 | | 0.7 | 0.8 | |
| | | | Full range | | | 0.95 | | | 0.95 | |
| $A_{VD}$ | Large-signal differential voltage amplification | $V_O$ = 1.4 V to 4 V, $R_L$ = 10 kΩ | 25°C | 0.2 | 1.5 | | 0.3 | 1.5 | | 0.4 |
| | | | Full range | 0.1 | | | 0.1 | | | 0.1 |
| CMRR | Common-mode rejection ratio | $V_{IC}$ = $V_{ICR}$min, $R_S$ = 50 Ω | 25°C | 80 | 90 | | 82 | 92 | | 85 |
| | | | Full range | 80 | | | 82 | | | 85 |
| $k_{SVR}$ | Supply-voltage rejection ratio ($\Delta V_{CC\pm}/\Delta V_{IO}$) | $V_{CC\pm}$ = ±2.5 V to ±15 V | 25°C | 98 | 112 | | 100 | 115 | | 103 |
| | | | Full range | 93 | | | 95 | | | 98 |
| $I_{CC}$ | Supply current | $V_O$ = 0, No load | 25°C | | 800 | 1200 | | 800 | 1200 | |
| | | | Full range | | | 1200 | | | 1200 | |
| $\Delta I_{CC}$ | Supply current change over operating temperature range | | Full range | | 50 | | | 50 | | |

† 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 and assuming an activation energy of 0.96 eV.

## TLE2024 electrical characteristics at specified free-air temperature, $V_{CC}$ = ±15 V (unless otherwise no

| PARAMETER | | TEST CONDITIONS | $T_A$† | TLE2024M | | | TLE2024AM | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | MIN | TYP | MAX | MIN | TYP | MAX | MIN |
| $V_{IO}$ | Input offset voltage | $V_{IC}$ = 0, $R_S$ = 50 Ω | 25°C | | | 1000 | | | 750 | |
| | | | Full range | | | 1200 | | | 950 | |
| $\alpha_{VIO}$ | Temperature coefficient of input offset voltage | | Full range | | 2 | | | 2 | | |
| | Input offset voltage long-term drift (see Note 4) | | 25°C | | 0.006 | | | 0.006 | | |
| $I_{IO}$ | Input offset current | | 25°C | | 0.6 | 6 | | 0.5 | 6 | |
| | | | Full range | | | 10 | | | 10 | |
| $I_{IB}$ | Input bias current | | 25°C | | 50 | 70 | | 45 | 70 | |
| | | | Full range | | | 90 | | | 90 | |
| $V_{ICR}$ | Common-mode input voltage range | $R_S$ = 50 Ω | 25°C | −15 to 13.5 | −15.3 to 14 | | −15 to 13.5 | −15.3 to 14 | | −1 to 13.5 |
| | | | Full range | −15 to 13.2 | | | −15 to 13.2 | | | −1 to 13.2 |
| $V_{OM+}$ | Maximum positive peak output voltage swing | $R_L$ = 10 kΩ | 25°C | 13.8 | 14.1 | | 13.9 | 14.2 | | 14 |
| | | | Full range | 13.7 | | | 13.7 | | | 13.8 |
| $V_{OM-}$ | Maximum negative peak output voltage swing | | 25°C | −13.7 | −14.1 | | −13.7 | −14.1 | | −13.7 |
| | | | Full range | −13.6 | | | −13.6 | | | −13.6 |
| $A_{VD}$ | Large-signal differential voltage amplification | $V_O$ = ±10 V, $R_L$ = 10 kΩ | 25°C | 0.4 | 2 | | 0.8 | 4 | | 1 |
| | | | Full range | 0.4 | | | 0.8 | | | 1 |
| CMRR | Common-mode rejection ratio | $V_{IC}$ = $V_{ICR}$min, $R_S$ = 50 Ω | 25°C | 92 | 102 | | 94 | 105 | | 97 |
| | | | Full range | 88 | | | 90 | | | 93 |
| $k_{SVR}$ | Supply-voltage rejection ratio ($\Delta V_{CC\pm}/\Delta V_{IO}$) | $V_{CC\pm}$ = ±2.5 V to ±15 V | 25°C | 98 | 112 | | 100 | 115 | | 103 |
| | | | Full range | 93 | | | 95 | | | 98 |
| $I_{CC}$ | Supply current | $V_O$ = 0, No load | 25°C | | 1050 | 1400 | | 1050 | 1400 | |
| | | | Full range | | | 1400 | | | 1400 | |
| $\Delta I_{CC}$ | Supply current change over operating temperature range | | Full range | | 85 | | | 85 | | |

† 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 and assuming an activation energy of 0.96 eV.

## TLE2021 operating characteristics, $V_{CC}$ = 5 V, $T_A$ = 25°C

| PARAMETER | | TEST CONDITIONS | $T_A$ | C SUFFIX | | | I SUFFIX | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | MIN | TYP | MAX | MIN | TYP | MAX | MIN |
| SR | Slew rate at unity gain | $V_O$ = 1 V to 3 V, See Figure 1 | 25°C | | 0.5 | | | 0.5 | | |
| $V_n$ | Equivalent input noise voltage (see Figure 2) | f = 10 Hz | 25°C | | 21 | 50 | | 21 | 50 | |
| | | f = 1 kHz | 25°C | | 17 | 30 | | 17 | 30 | |
| $V_{N(PP)}$ | Peak-to-peak equivalent input noise voltage | f = 0.1 to 1 Hz | 25°C | | 0.16 | | | 0.16 | | |
| | | f = 0.1 to 10 Hz | 25°C | | 0.47 | | | 0.47 | | |
| $I_n$ | Equivalent input noise current | | 25°C | | 0.09 | | | 0.09 | | |
| $B_1$ | Unity-gain bandwidth | See Figure 3 | 25°C | | 1.2 | | | 1.2 | | |
| $\phi_m$ | Phase margin at unity gain | See Figure 3 | 25°C | | 42° | | | 42° | | |

## TLE2021 operating characteristics at specified free-air temperature, $V_{CC}$ = ±15 V

| PARAMETER | | TEST CONDITIONS | $T_A$† | C SUFFIX | | | I SUFFIX | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | MIN | TYP | MAX | MIN | TYP | MAX | MIN |
| SR | Slew rate at unity gain | $V_O$ = 1V to 3 V, See Figure 1 | 25°C | 0.45 | 0.65 | | 0.45 | 0.65 | | 0.45 |
| | | | Full range | 0.45 | | | 0.42 | | | 0.45 |
| $V_n$ | Equivalent input noise voltage (see Figure 2) | f = 10 Hz | 25°C | | 19 | 50 | | 19 | 50 | |
| | | f = 1 kHz | 25°C | | 15 | 30 | | 15 | 30 | |
| $V_{N(PP)}$ | Peak-to-peak equivalent input noise voltage | f = 0.1 to 1 Hz | 25°C | | 0.16 | | | 0.16 | | |
| | | f = 0.1 to 10 Hz | 25°C | | 0.47 | | | 0.47 | | |
| $I_n$ | Equivalent input noise current | | 25°C | | 0.09 | | | 0.09 | | |
| $B_1$ | Unity-gain bandwidth | See Figure 3 | 25°C | | 2 | | | 2 | | |
| $\phi_m$ | Phase margin at unity gain | See Figure 3 | 25°C | | 46° | | | 46° | | |

† Full range is 0°C to 70°C for the C-suffix devices, –40°C to 85°C for the I-suffix devices, and –55°C to 125°C for the M-suffix devices.

## TLE2022 operating characteristics, $V_{CC}$ = 5 V, $T_A$ = 25°C

| PARAMETER | | TEST CONDITIONS | C SUFFIX | | | I SUFFIX | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | MIN | TYP | MAX | MIN | TYP | MAX | MIN |
| SR | Slew rate at unity gain | $V_O$ = 1 V to 3 V, See Figure 1 | | 0.5 | | | 0.5 | | |
| $V_n$ | Equivalent input noise voltage (see Figure 2) | f = 10 Hz | | 21 | 50 | | 21 | 50 | |
| | | f = 1 kHz | | 17 | 30 | | 17 | 30 | |
| $V_{N(PP)}$ | Peak-to-peak equivalent input noise voltage | f = 0.1 to 1 Hz | | 0.16 | | | 0.16 | | |
| | | f = 0.1 to 10 Hz | | 0.47 | | | 0.47 | | |
| $I_n$ | Equivalent input noise current | | | 0.1 | | | 0.1 | | |
| $B_1$ | Unity-gain bandwidth | See Figure 3 | | 1.7 | | | 1.7 | | |
| $\phi_m$ | Phase margin at unity gain | See Figure 3 | | 47° | | | 47° | | |

## TLE2022 operating characteristics at specified free-air temperature, $V_{CC}$ = ±15 V

| PARAMETER | | TEST CONDITIONS | $T_A$ | C SUFFIX† | | | I SUFFIX† | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | MIN | TYP | MAX | MIN | TYP | MAX | MIN |
| SR | Slew rate at unity gain | $V_O$ = ±10 V, See Figure 1 | 25°C | 0.45 | 0.65 | | 0.45 | 0.65 | | 0.45 |
| | | | Full range | 0.45 | | | 0.42 | | | 0.4 |
| $V_n$ | Equivalent input noise voltage (see Figure 2) | f = 10 Hz | 25°C | | 19 | 50 | | 19 | 50 | |
| | | f = 1 kHz | 25°C | | 15 | 30 | | 15 | 30 | |
| $V_{N(PP)}$ | Peak-to-peak equivalent input noise voltage | f = 0.1 to 1 Hz | 25°C | | 0.16 | | | 0.16 | | |
| | | f = 0.1 to 10 Hz | 25°C | | 0.47 | | | 0.47 | | |
| $I_n$ | Equivalent input noise current | | 25°C | | 0.1 | | | 0.1 | | |
| $B_1$ | Unity-gain bandwidth | See Figure 3 | 25°C | | 2.8 | | | 2.8 | | |
| $\phi_m$ | Phase margin at unity gain | See Figure 3 | 25°C | | 52° | | | 52° | | |

† Full range is 0°C to 70°C for the C–suffix devices, –40°C to 85°C for the I suffix devices and –55°C to 125°C for the I–suffix devices.

## TLE2024 operating characteristics, $V_{CC}$ = 5 V, $T_A$ = 25°C

| PARAMETER | | TEST CONDITIONS | C SUFFIX | | | I SUFFIX | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | MIN | TYP | MAX | MIN | TYP | MAX | MIN |
| SR | Slew rate at unity gain | $V_O$ = 1 V to 3 V, See Figure 1 | | 0.5 | | | 0.5 | | |
| $V_n$ | Equivalent input noise voltage (see Figure 2) | f = 10 Hz | | 21 | 50 | | 21 | 50 | |
| | | f = 1 kHz | | 17 | 30 | | 17 | 30 | |
| $V_{N(PP)}$ | Peak-to-peak equivalent input noise voltage | f = 0.1 to 1 Hz | | 0.16 | | | 0.16 | | |
| | | f = 0.1 to 10 Hz | | 0.47 | | | 0.47 | | |
| $I_n$ | Equivalent input noise current | | | 0.1 | | | 0.1 | | |
| $B_1$ | Unity-gain bandwidth | See Figure 3 | | 1.7 | | | 1.7 | | |
| $\phi_m$ | Phase margin at unity gain | See Figure 3 | | 47° | | | 47° | | |

## TLE2024 operating characteristics at specified free-air temperature, $V_{CC}$ = ±15 V (unless otherwise no

| PARAMETER | | TEST CONDITIONS | $T_A$ | C SUFFIX† | | | I SUFFIX† | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | MIN | TYP | MAX | MIN | TYP | MAX | MIN |
| SR | Slew rate at unity gain | $V_O$ = ±10 V, See Figure 1 | 25°C | 0.45 | 0.7 | | 0.45 | 0.7 | | 0.45 |
| | | | Full range | 0.45 | | | 0.42 | | | 0.4 |
| $V_n$ | Equivalent input noise voltage (see Figure 2) | f = 10 Hz | 25°C | | 19 | 50 | | 19 | 50 | |
| | | f = 1 kHz | 25°C | | 15 | 30 | | 15 | 30 | |
| $V_{N(PP)}$ | Peak-to-peak equivalent input noise voltage | f = 0.1 to 1 Hz | 25°C | | 0.16 | | | 0.16 | | |
| | | f = 0.1 to 10 Hz | 25°C | | 0.47 | | | 0.47 | | |
| $I_n$ | Equivalent input noise current | | 25°C | | 0.1 | | | 0.1 | | |
| $B_1$ | Unity-gain bandwidth | See Figure 3 | 25°C | | 2.8 | | | 2.8 | | |
| $\phi_m$ | Phase margin at unity gain | See Figure 3 | 25°C | | 52° | | | 52° | | |

† Full range is 0°C to 70°C for the C–suffix devices, –40°C to 85°C for the I suffix devices and –55°C to 125°C for the I–suffix devices.

## TLE2021Y electrical characteristics at $V_{CC}$ = 5 V, $T_A$ = 25°C (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | | TLE2021Y | | | UNIT |
|---|---|---|---|---|---|---|---|
| | | | | MIN | TYP | MAX | |
| $V_{IO}$ | Input offset voltage | $V_{IC}$ = 0, | $R_S$ = 50 Ω | | 150 | | μV |
| | Input offset voltage long-term drift (see Note 4) | | | | 0.005 | | μV/mo |
| $I_{IO}$ | Input offset current | | | | 0.5 | | nA |
| $I_{IB}$ | Input bias current | | | | 35 | | nA |
| $V_{ICR}$ | Common-mode input voltage range | $R_S$ = 50 Ω | | | – 0.3 to 4 | | V |
| $V_{OH}$ | Maximum high-level output voltage | $R_L$ = 10 kΩ | | | 4.3 | | V |
| $V_{OL}$ | Maximum low-level output voltage | | | | 0.7 | | V |
| $A_{VD}$ | Large-signal differential voltage amplification | $V_O$ = 1.4 to 4 V, | $R_L$ = 10 kΩ | | 1.5 | | V/μV |
| CMRR | Common-mode rejection ratio | $V_{IC}$ = $V_{ICR}$ min, | $R_S$ = 50 Ω | | 100 | | dB |
| $k_{SVR}$ | Supply-voltage rejection ratio ($\Delta V_{CC\pm}/\Delta V_{IO}$) | $V_{CC}$ = 5 V to 30 V | | | 115 | | dB |
| $I_{CC}$ | Supply current | $V_O$ = 2.5 V, | No load | | 400 | | μA |

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.

## TLE2021Y operating characteristics at $V_{CC}$ = 5 V, $T_A$ = 25°C

| PARAMETER | | TEST CONDITIONS | TLE2021Y | | | UNIT |
|---|---|---|---|---|---|---|
| | | | MIN | TYP | MAX | |
| SR | Slew rate at unity gain | $V_O$ = 1 V to 3 V | | 0.5 | | V/μs |
| $V_n$ | Equivalent input noise voltage | f = 10 Hz | | 21 | | nV/√Hz |
| | | f = 1 kHz | | 17 | | |
| $V_{N(PP)}$ | Peak-to-peak equivalent input noise voltage | f = 0.1 to 1 Hz | | 0.16 | | μV |
| | | f = 0.1 to 10 Hz | | 0.47 | | |
| $I_n$ | Equivalent input noise current | | | 0.1 | | pA/√Hz |
| $B_1$ | Unity-gain bandwidth | | | 1.7 | | MHz |
| $\phi_m$ | Phase margin at unity gain | | | 47° | | |

## TLE2022Y electrical characteristics, $V_{CC}$ = 5 V, $T_A$ = 25°C (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | | TLE2022Y | | | UNIT |
|---|---|---|---|---|---|---|---|
| | | | | MIN | TYP | MAX | |
| $V_{IO}$ | Input offset voltage | $V_{IC}$ = 0, | $R_S$ = 50 Ω | | 150 | 600 | μV |
| | Input offset voltage long-term drift (see Note 4) | | | | 0.005 | | μV/mo |
| $I_{IO}$ | Input offset current | | | | 0.5 | | nA |
| $I_{IB}$ | Input bias current | | | | 35 | | nA |
| $V_{ICR}$ | Common-mode input voltage range | $R_S$ = 50 Ω | | | – 0.3 to 4 | | V |
| $V_{OH}$ | Maximum high-level output voltage | $R_L$ = 10 kΩ | | | 4.3 | | V |
| $V_{OL}$ | Maximum low-level output voltage | | | | 0.7 | | V |
| $A_{VD}$ | Large-signal differential voltage amplification | $V_O$ = 1.4 to 4 V, | $R_L$= 10 kΩ | | 1.5 | | V/μV |
| CMRR | Common-mode rejection ratio | $V_{IC}$ = $V_{ICR}$ min, | $R_S$ = 50 Ω | | 100 | | dB |
| $k_{SVR}$ | Supply-voltage rejection ratio ($\Delta V_{CC\pm}/\Delta V_{IO}$) | $V_{CC}$ = 5 V to 30 V | | | 115 | | dB |
| $I_{CC}$ | Supply current | $V_O$ = 2.5 V, | No load | | 450 | | μA |

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.

## TLE2022Y operating characteristics, $V_{CC}$ = 5 V, $T_A$ = 25°C

| PARAMETER | | TEST CONDITIONS | | TLE2022Y | | | UNIT |
|---|---|---|---|---|---|---|---|
| | | | | MIN | TYP | MAX | |
| SR | Slew rate at unity gain | $V_O$ = 1 V to 3 V, | See Figure 1 | | 0.5 | | V/μs |
| $V_n$ | Equivalent input noise voltage (see Figure 2) | f = 10 Hz | | | 21 | | nV/√Hz |
| | | f = 1 kHz | | | 17 | | |
| $V_{N(PP)}$ | Peak-to-peak equivalent input noise voltage | f = 0.1 to 1 Hz | | | 0.16 | | μV |
| | | f = 0.1 to 10 Hz | | | 0.47 | | |
| $I_n$ | Equivalent input noise current | | | | 0.1 | | pA/√Hz |
| $B_1$ | Unity-gain bandwidth | See Figure 3 | | | 1.7 | | MHz |
| $\phi_m$ | Phase margin at unity gain | See Figure 3 | | | 47° | | |

## TLE2024Y electrical characteristics, $V_{CC}$ = 5 V, $T_A$ = 25°C (unless otherwise noted)

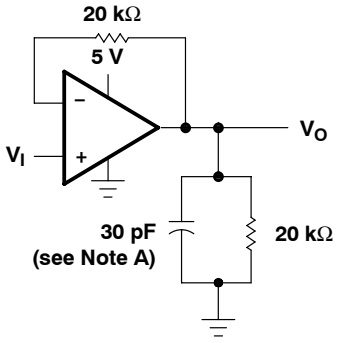
| PARAMETER | | TEST CONDITIONS | | TLE2024Y | | | UNIT |
|---|---|---|---|---|---|---|---|
| | | | | MIN | TYP | MAX | |
| | Input offset voltage long-term drift (see Note 4) | $V_{IC}$ = 0, | $R_S$ = 50 Ω | | 0.005 | | μV/mo |
| $I_{IO}$ | Input offset current | | | | 0.6 | | nA |
| $I_{IB}$ | Input bias current | | | | 45 | | nA |
| $V_{ICR}$ | Common-mode input voltage range | $R_S$ = 50 Ω | | | −0.3 to 4 | | V |
| $V_{OH}$ | High-level output voltage | $R_L$ = 10 kΩ | | | 4.2 | | V |
| $V_{OL}$ | Low-level output voltage | | | | 0.7 | | V |
| $A_{VD}$ | Large-signal differential voltage amplification | $V_O$ = 1.4 V to 4 V, | $R_L$ = 10 kΩ | | 1.5 | | V/μV |
| CMRR | Common-mode rejection ratio | $V_{IC}$ = $V_{ICR}$min, | $R_S$ = 50 Ω | | 90 | | dB |
| $k_{SVR}$ | Supply-voltage rejection ratio ($\Delta V_{CC}/\Delta V_{IO}$) | $V_{CC}$ = 5 V to 30 V | | | 112 | | dB |
| $I_{CC}$ | Supply current | $V_O$ = 2.5 V, | No load | | 800 | | μA |

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.

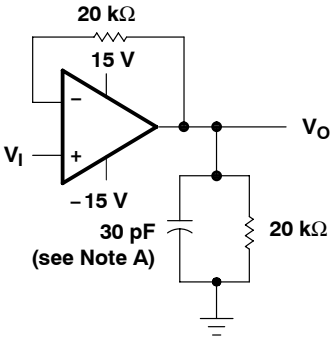
## TLE2024Y operating characteristics, $V_{CC}$ = 5 V, $T_A$ = 25°C

| PARAMETER | | TEST CONDITIONS | | TLE2024Y | | | UNIT |
|---|---|---|---|---|---|---|---|
| | | | | MIN | TYP | MAX | |
| SR | Slew rate at unity gain | $V_O$ = 1 V to 3 V, | See Figure 1 | | 0.5 | | V/μs |
| $V_n$ | Equivalent input noise voltage (see Figure 2) | f = 10 Hz | | | 21 | | nV/√Hz |
| | | f = 1 kHz | | | 17 | | |
| $V_{N(PP)}$ | Peak-to-peak equivalent input noise voltage | f = 0.1 to 1 Hz | | | 0.16 | | μV |
| | | f = 0.1 to 10 Hz | | | 0.47 | | |
| $I_n$ | Equivalent input noise current | | | | 0.1 | | pA/√Hz |
| $B_1$ | Unity-gain bandwidth | See Figure 3 | | | 1.7 | | MHz |
| $\phi_m$ | Phase margin at unity gain | See Figure 3 | | | 47° | | |

## PARAMETER MEASUREMENT INFORMATION



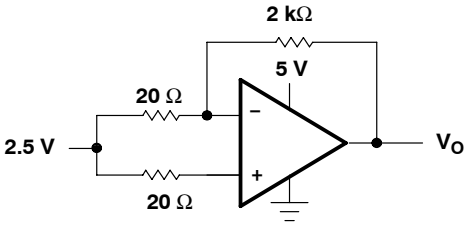

(a) SINGLE SUPPLY



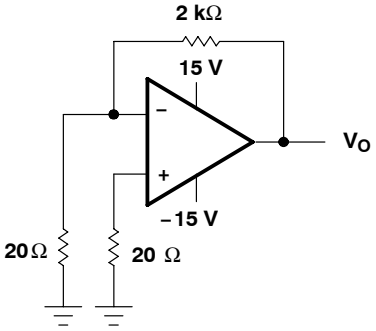

(b) SPLIT SUPPLY

NOTE A: $C_L$ includes fixture capacitance.

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

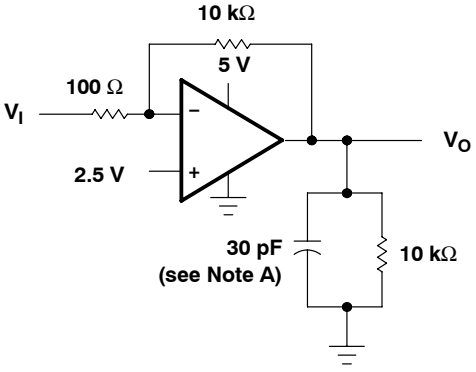



(a) SINGLE SUPPLY

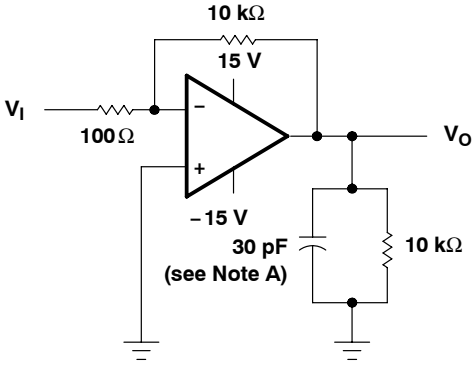



(b) SPLIT SUPPLY

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




(a) SINGLE SUPPLY

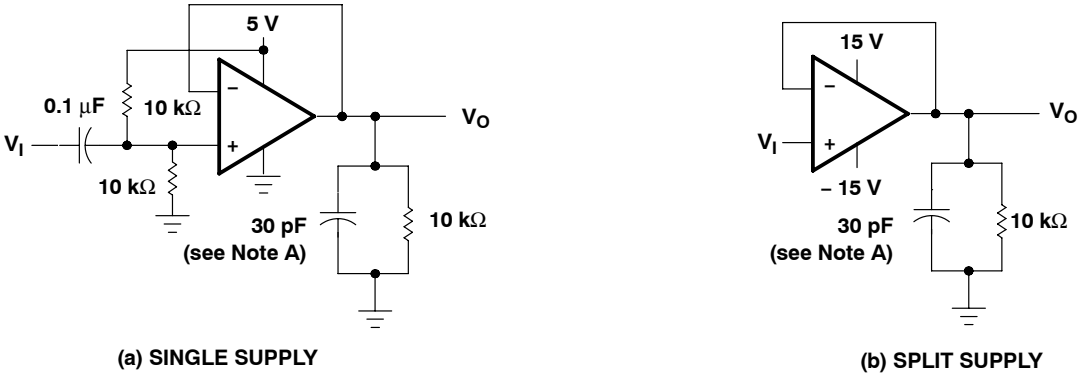



(b) SPLIT SUPPLY

NOTE A: $C_L$ includes fixture capacitance.

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

## PARAMETER MEASUREMENT INFORMATION




NOTE A: $C_L$ includes fixture capacitance.

**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.

## TYPICAL CHARACTERISTICS

### Table of Graphs

| | | | FIGURE |
|---|---|---|---|
| $V_{IO}$ | Input offset voltage | Distribution | 5, 6, 7 |
| $I_{IB}$ | Input bias current | vs Common-mode input voltage<br>vs Free-air temperature | 8, 9, 10<br>11, 12, 13 |
| $I_I$ | Input current | vs Differential input voltage | 14 |
| $V_{OM}$ | Maximum peak output voltage | vs Output current<br>vs Free-air temperature | 15, 16, 17<br>18 |
| $V_{OH}$ | High-level output voltage | vs High-level output current<br>vs Free-air temperature | 19, 20<br>21 |
| $V_{OL}$ | Low-level output voltage | vs Low-level output current<br>vs Free-air temperature | 22<br>23 |
| $V_{O(PP)}$ | Maximum peak-to-peak output voltage | vs Frequency | 24, 25 |
| $A_{VD}$ | Large-signal differential voltage amplification | vs Frequency<br>vs Free-air temperature | 26<br>27, 28, 29 |
| $I_{OS}$ | Short-circuit output current | vs Supply voltage<br>vs Free-air temperature | 30 – 33<br>34 – 37 |
| $I_{CC}$ | Supply current | vs Supply voltage<br>vs Free-air temperature | 38, 39, 40<br>41, 42, 43 |
| CMRR | Common-mode rejection ratio | vs Frequency | 44, 45, 46 |
| SR | Slew rate | vs Free-air temperature | 47, 48, 49 |
| | Voltage-follower small-signal pulse response | | 50, 51 |
| | Voltage-follower large-signal pulse response | | 52 – 57 |
| $V_{N(PP)}$ | Peak-to-peak equivalent input noise voltage | 0.1 to 1 Hz<br>0.1 to 10 Hz | 58<br>59 |
| $V_n$ | Equivalent input noise voltage | vs Frequency | 60 |
| $B_1$ | Unity-gain bandwidth | vs Supply voltage<br>vs Free-air temperature | 61, 62<br>63, 64 |
| $\phi_m$ | Phase margin | vs Supply voltage<br>vs Load capacitance<br>vs Free-air temperature | 65, 66<br>67, 68<br>69, 70 |
| | Phase shift | vs Frequency | 26 |

## TYPICAL CHARACTERISTICS

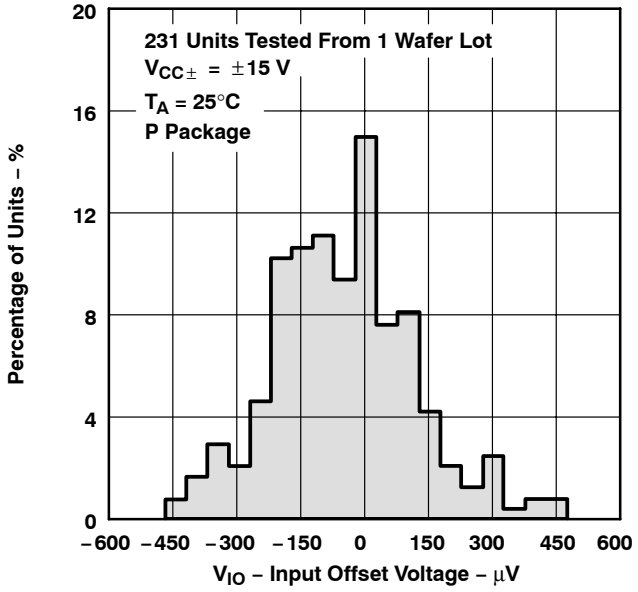



Figure 5

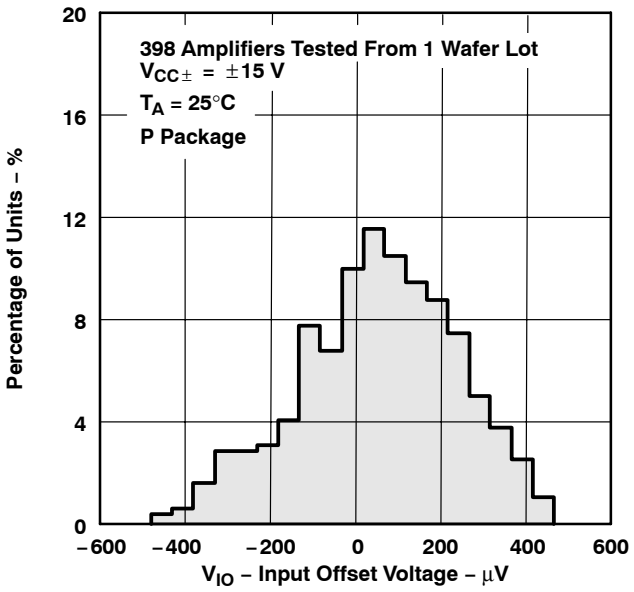



Figure 6

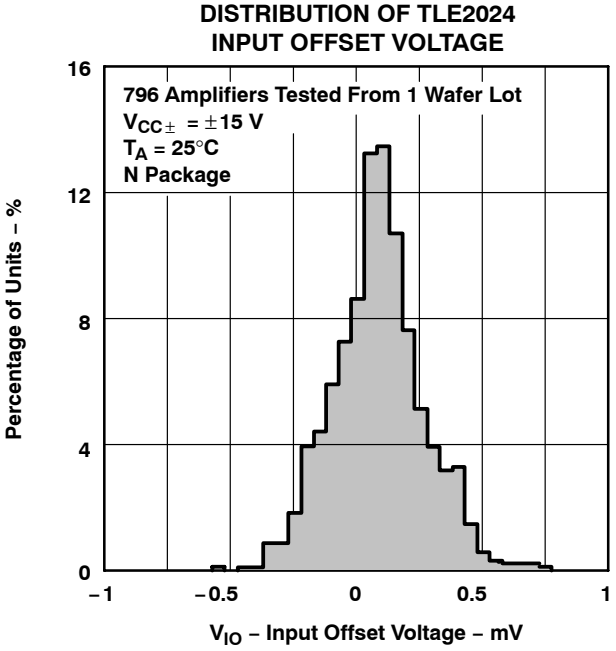



Figure 7

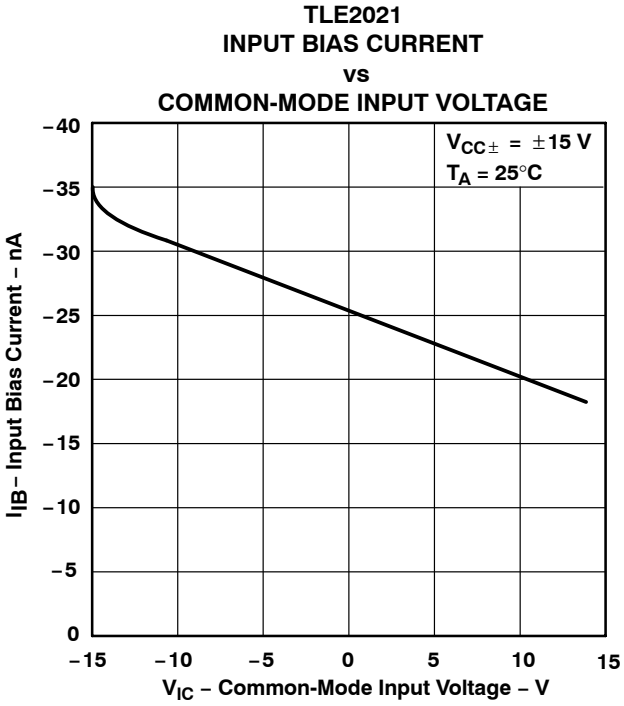



Figure 8

## TYPICAL CHARACTERISTICS

**TLE2022**
**INPUT BIAS CURRENT**
**vs**
**COMMON-MODE INPUT VOLTAGE**

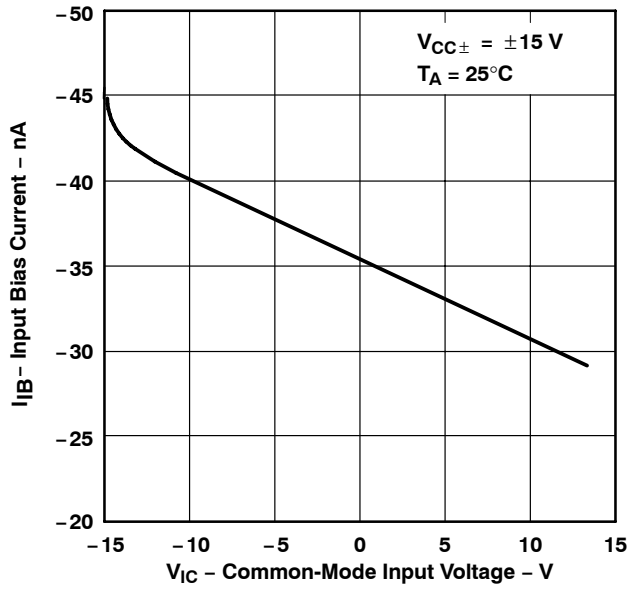



**Figure 9**

**TLE2024**
**INPUT BIAS CURRENT**
**vs**
**COMMON-MODE INPUT VOLTAGE**

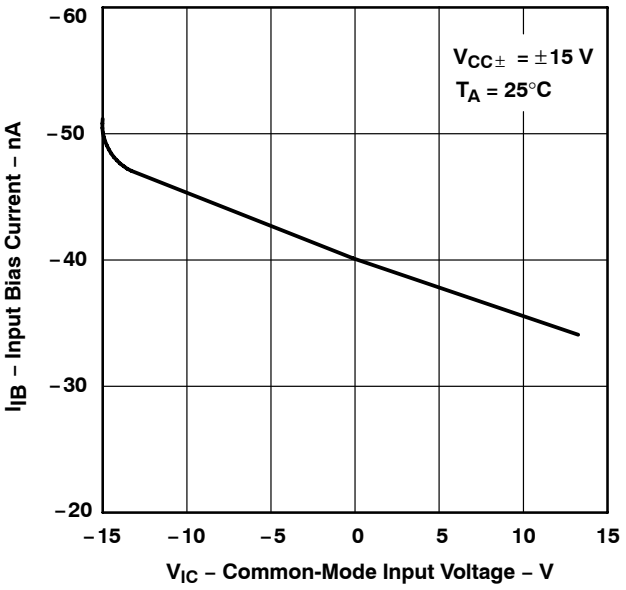



**Figure 10**

**TLE2021**
**INPUT BIAS CURRENT†**
**vs**
**FREE-AIR TEMPERATURE**

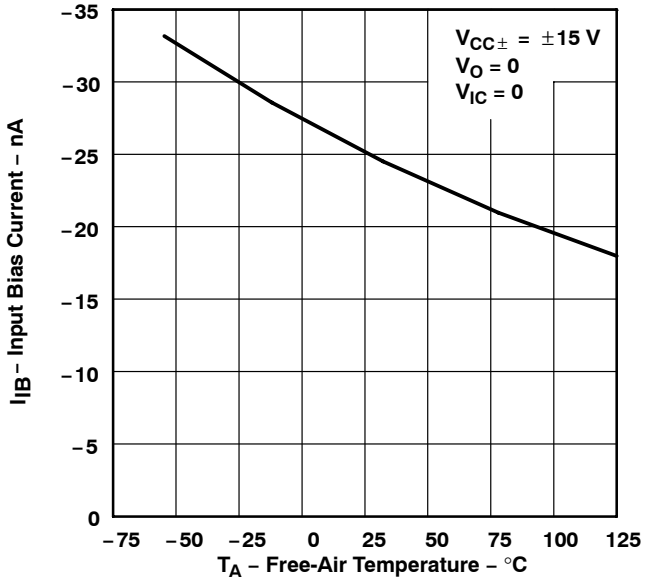



**Figure 11**

**TLE2022**
**INPUT BIAS CURRENT†**
**vs**
**FREE-AIR TEMPERATURE**

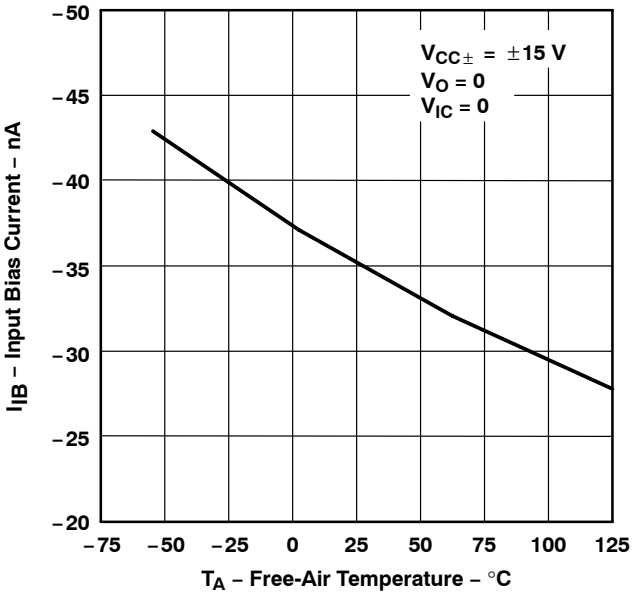



**Figure 12**

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

## TYPICAL CHARACTERISTICS

**TLE2024**
**INPUT BIAS CURRENT† vs FREE-AIR TEMPERATURE**

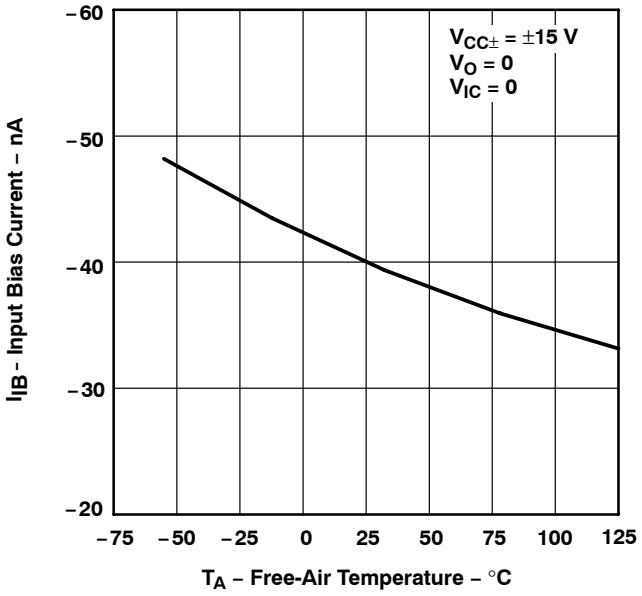



Figure 13

**INPUT CURRENT vs DIFFERENTIAL INPUT VOLTAGE**

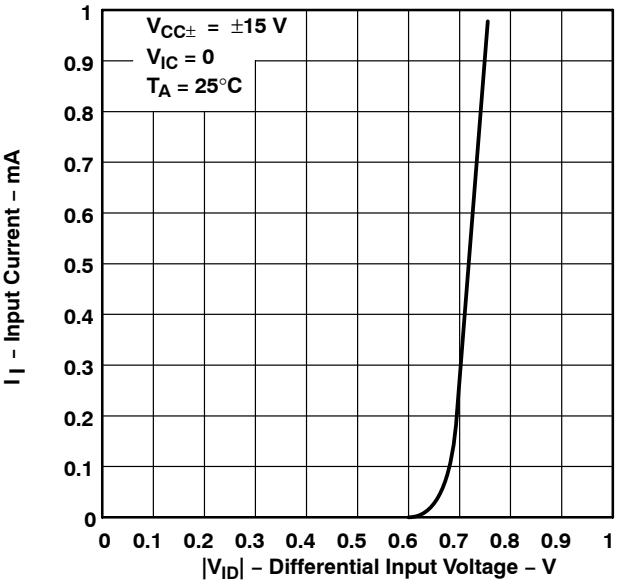



Figure 14

**TLE2021**
**MAXIMUM PEAK OUTPUT VOLTAGE vs OUTPUT CURRENT**

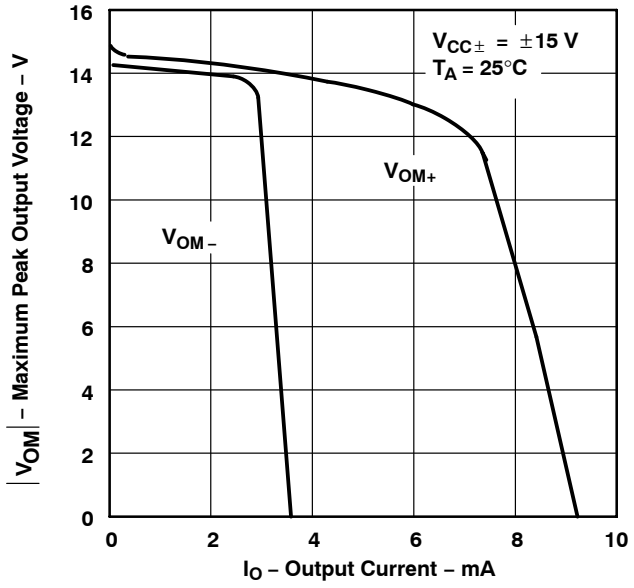



Figure 15

**TLE2022**
**MAXIMUM PEAK OUTPUT VOLTAGE vs OUTPUT CURRENT**

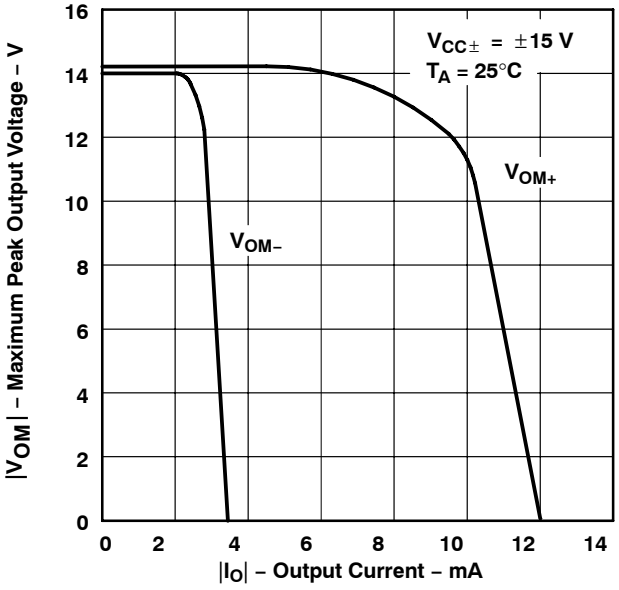



Figure 16

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

## TYPICAL CHARACTERISTICS

TLE2024
MAXIMUM PEAK OUTPUT VOLTAGE
vs
OUTPUT CURRENT

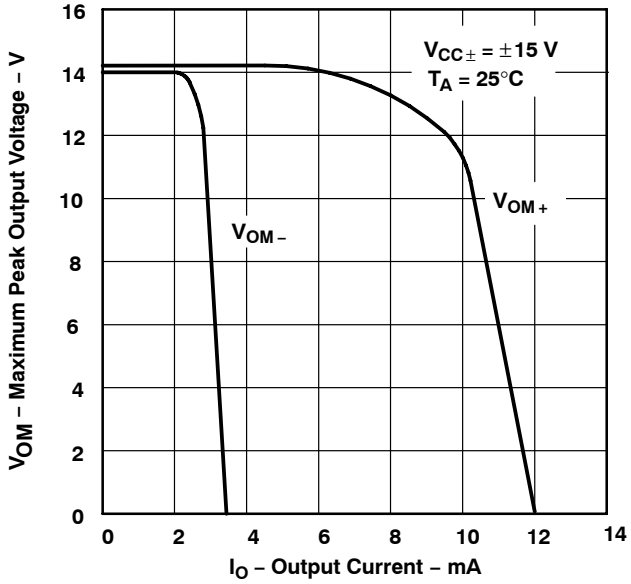



Figure 17

MAXIMUM PEAK OUTPUT VOLTAGE†
vs
FREE-AIR TEMPERATURE

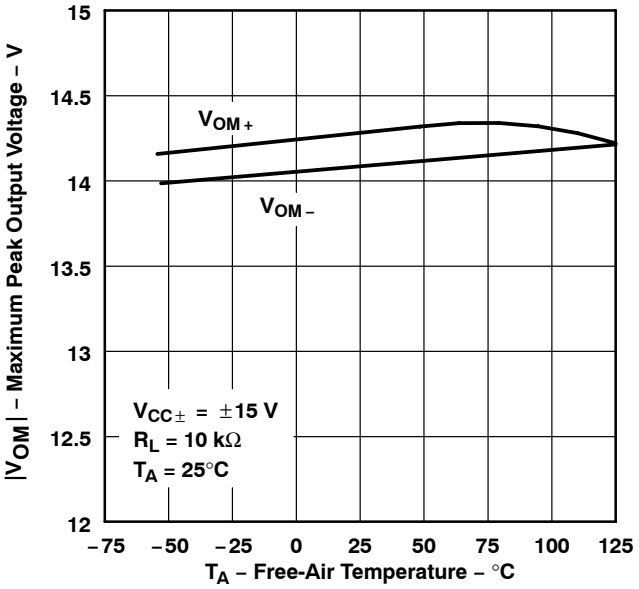



Figure 18

TLE2021
HIGH-LEVEL OUTPUT VOLTAGE
vs
HIGH-LEVEL OUTPUT CURRENT

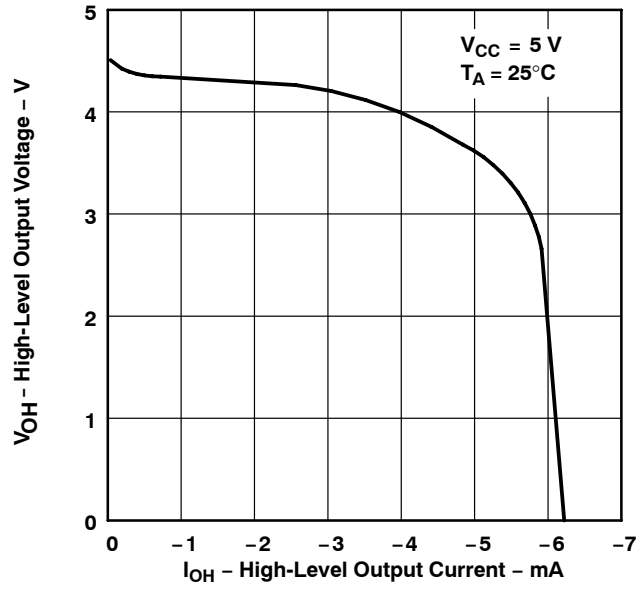



Figure 19

TLE2022 AND TLE2024
HIGH-LEVEL OUTPUT VOLTAGE
vs
HIGH-LEVEL OUTPUT CURRENT

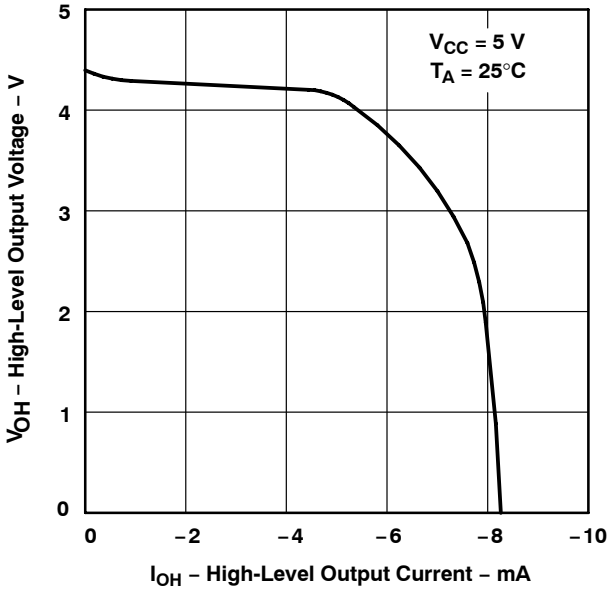



Figure 20

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

## TYPICAL CHARACTERISTICS

**HIGH-LEVEL OUTPUT VOLTAGE† vs FREE-AIR TEMPERATURE**

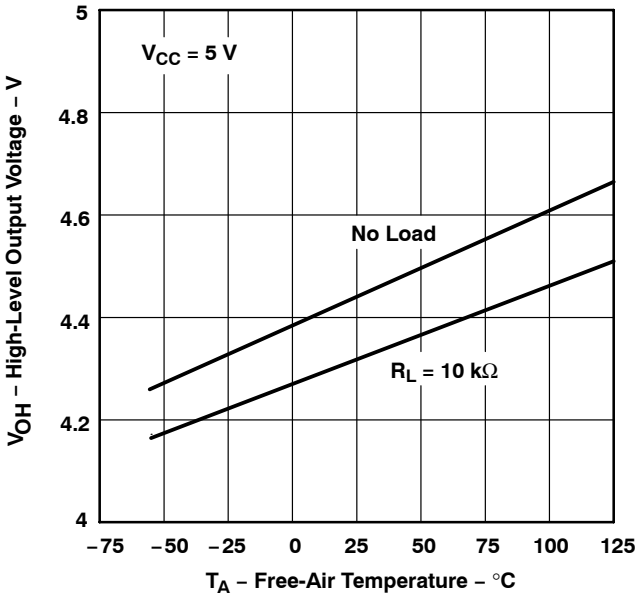



Figure 21

**LOW-LEVEL OUTPUT VOLTAGE vs LOW-LEVEL OUTPUT CURRENT**

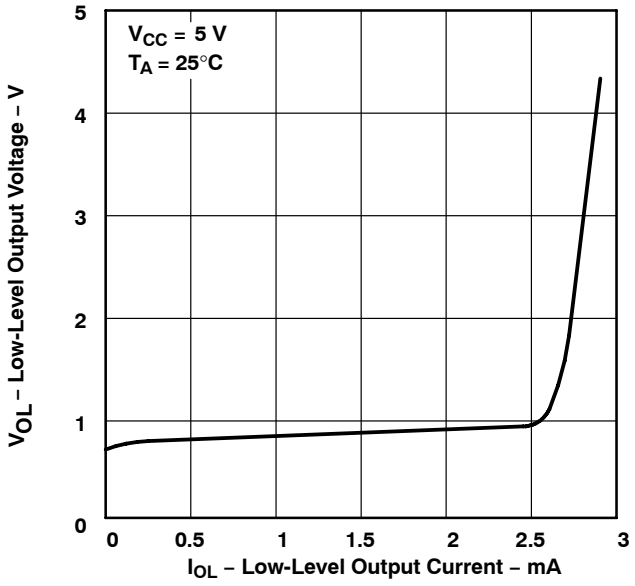



Figure 22

**LOW-LEVEL OUTPUT VOLTAGE† vs FREE-AIR TEMPERATURE**

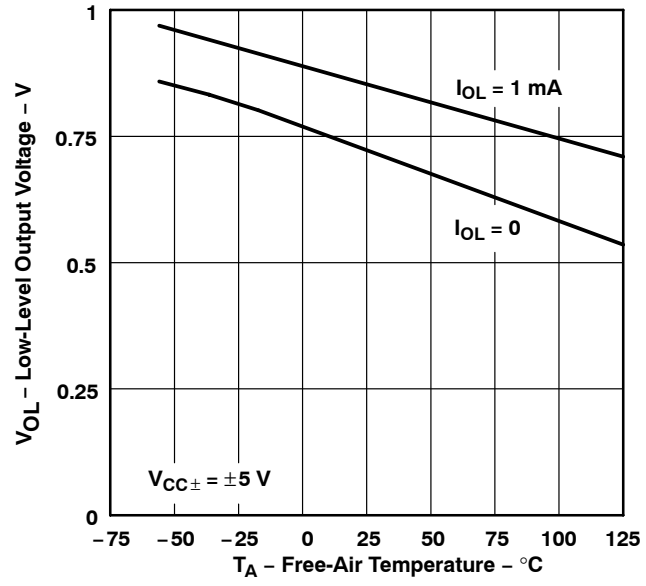



Figure 23

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

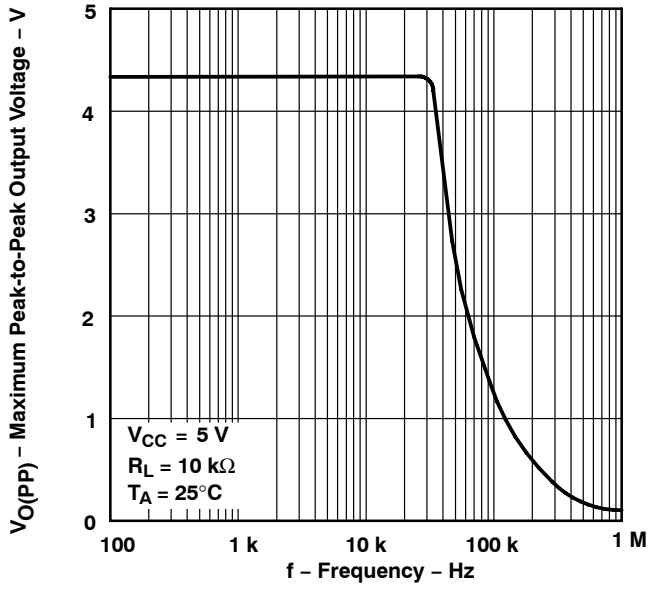



Figure 24

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

## TYPICAL CHARACTERISTICS

MAXIMUM PEAK-TO-PEAK OUTPUT VOLTAGE
vs
FREQUENCY

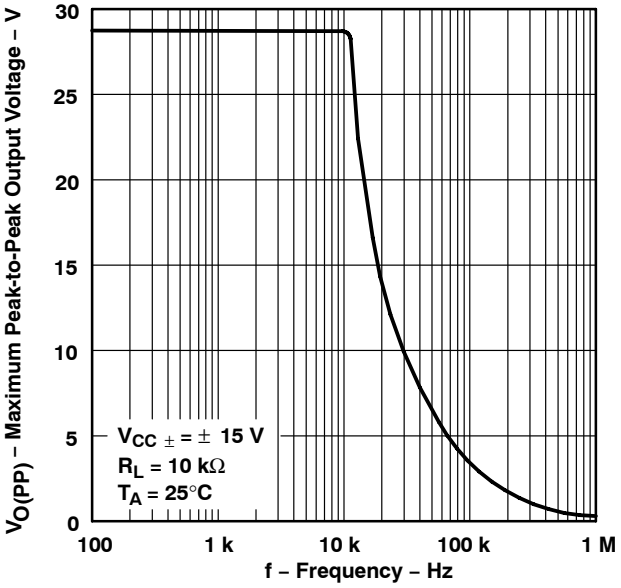



Figure 25

LARGE-SIGNAL DIFFERENTIAL VOLTAGE
AMPLIFICATION AND PHASE SHIFT
vs
FREQUENCY

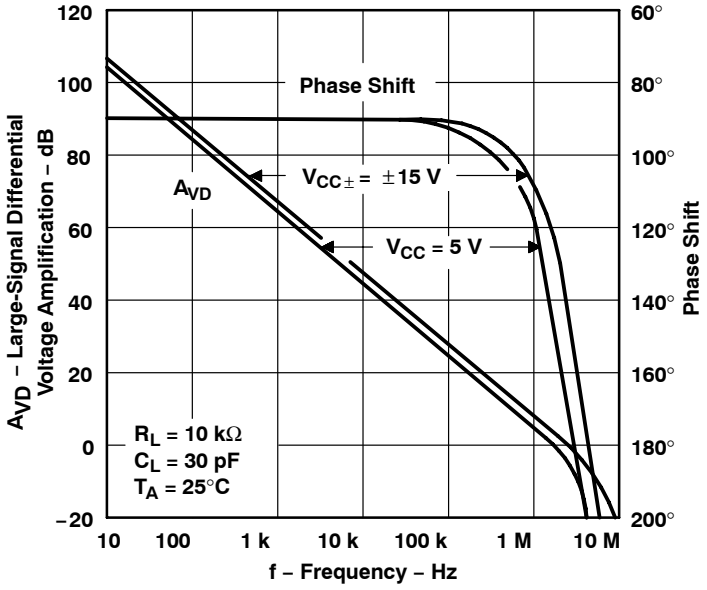



Figure 26

## TYPICAL CHARACTERISTICS

**TLE2021**
**LARGE-SCALE DIFFERENTIAL VOLTAGE AMPLIFICATION†**
**vs**
**FREE-AIR TEMPERATURE**

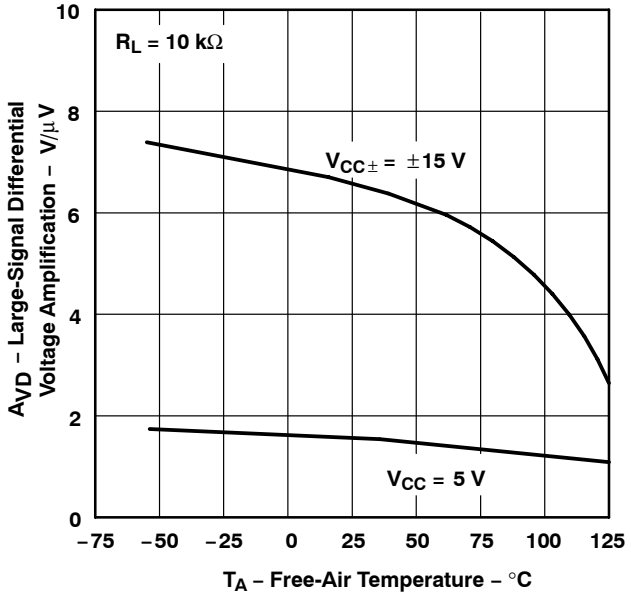



Figure 27

**TLE2022**
**LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION†**
**vs**
**FREE-AIR TEMPERATURE**

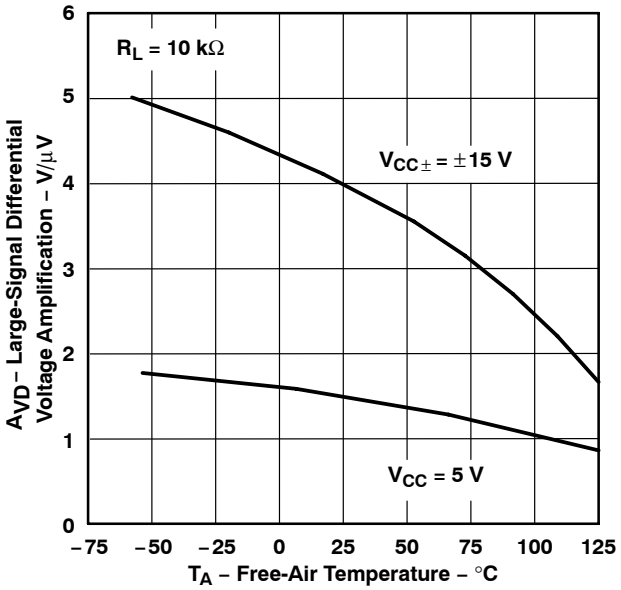



Figure 28

**TLE2024**
**LARGE-SCALE DIFFERENTIAL VOLTAGE AMPLIFICATION†**
**vs**
**FREE-AIR TEMPERATURE**

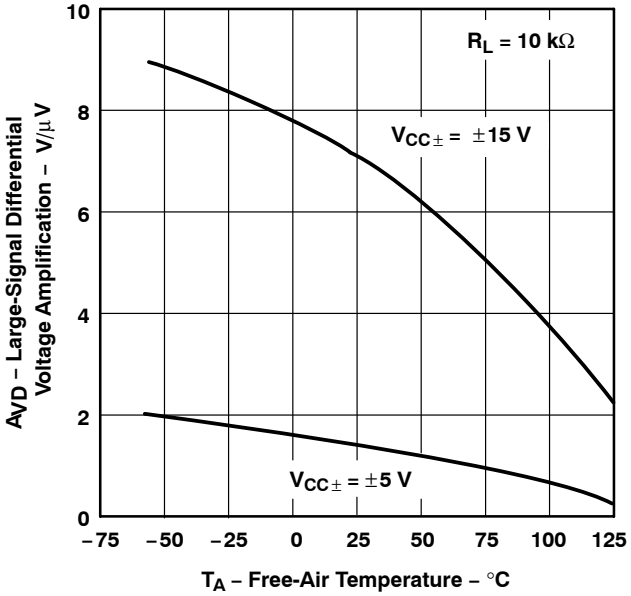



Figure 29

**TLE2021**
**SHORT-CIRCUIT OUTPUT CURRENT**
**vs**
**SUPPLY VOLTAGE**

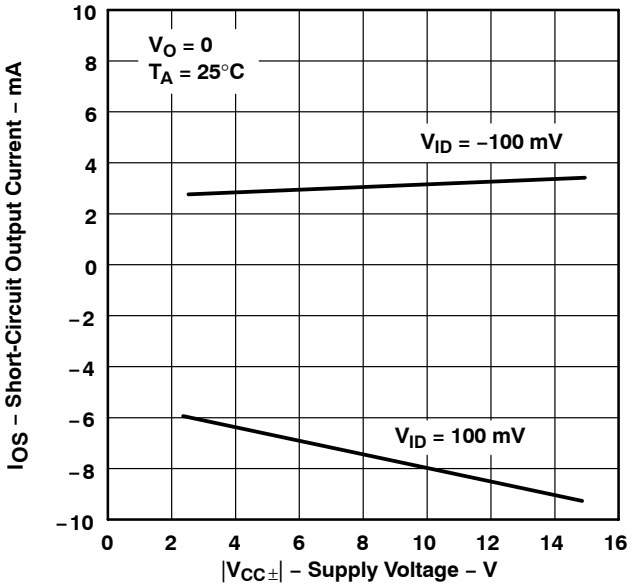



Figure 30

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

## TYPICAL CHARACTERISTICS

**TLE2022 AND TLE2024
SHORT-CIRCUIT OUTPUT CURRENT
vs
SUPPLY VOLTAGE**

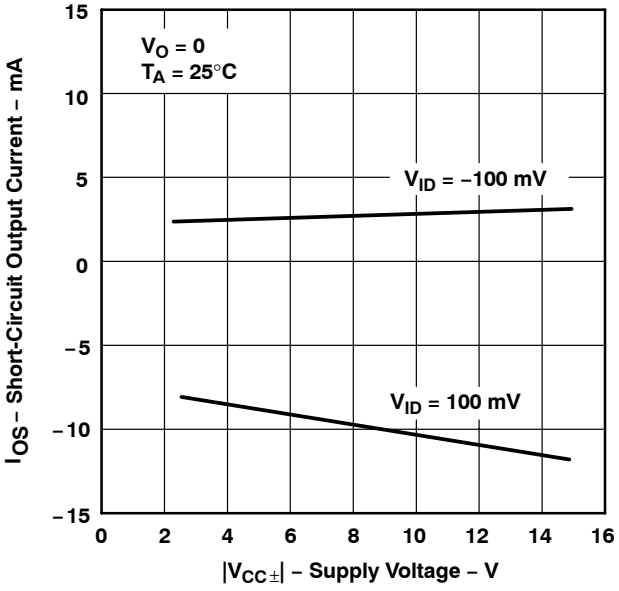



Figure 31

**TLE2021
SHORT-CIRCUIT OUTPUT CURRENT
vs
SUPPLY VOLTAGE**

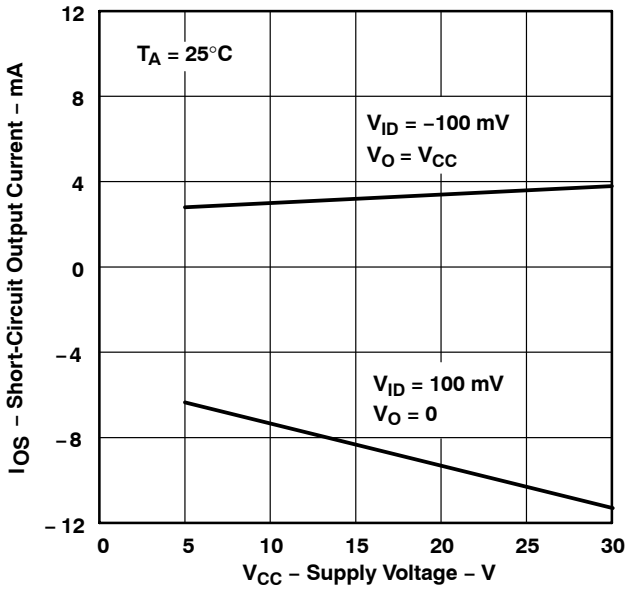



Figure 32

**TLE2022 AND TLE2024
SHORT-CIRCUIT OUTPUT CURRENT
vs
SUPPLY VOLTAGE**

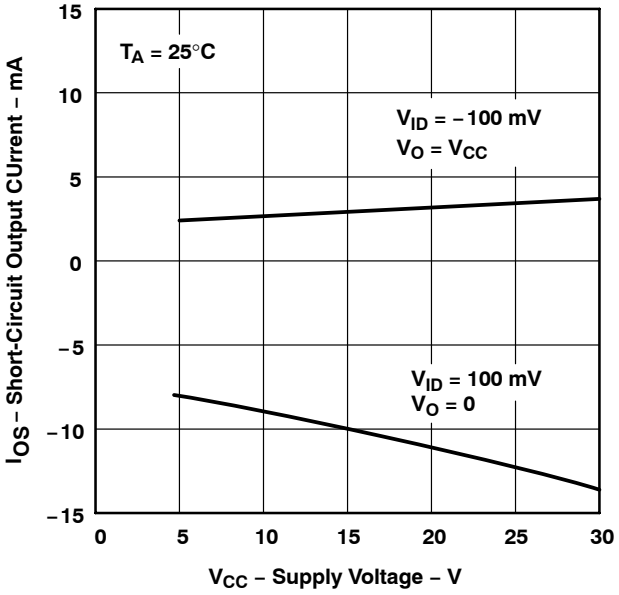



Figure 33

**TLE2021
SHORT-CIRCUIT OUTPUT CURRENT†
vs
FREE-AIR TEMPERATURE**

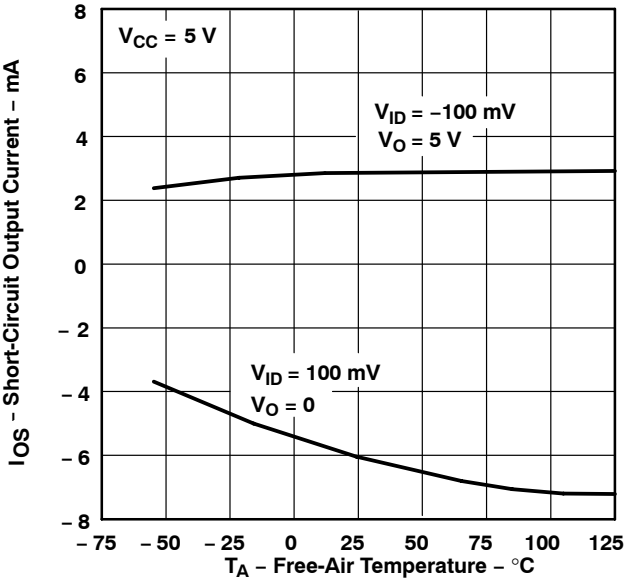



Figure 34

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

## TYPICAL CHARACTERISTICS

**TLE2022 AND TLE2024
SHORT-CIRCUIT OUTPUT CURRENT† vs FREE-AIR TEMPERATURE**

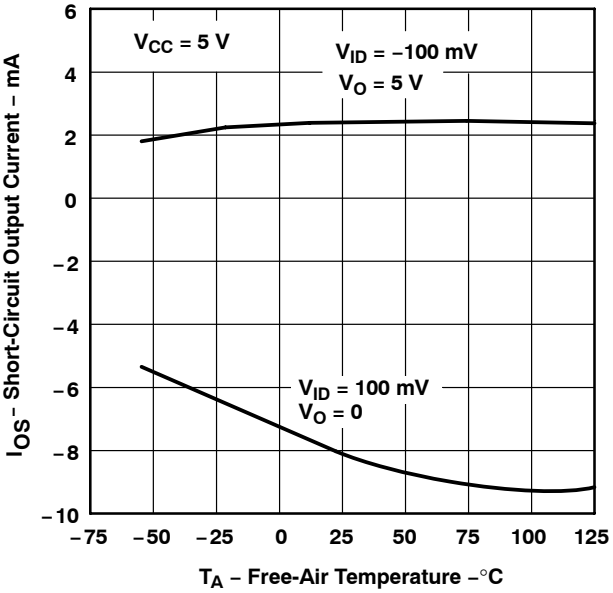



Figure 35

**TLE2021
SHORT-CIRCUIT OUTPUT CURRENT† vs FREE-AIR TEMPERATURE**

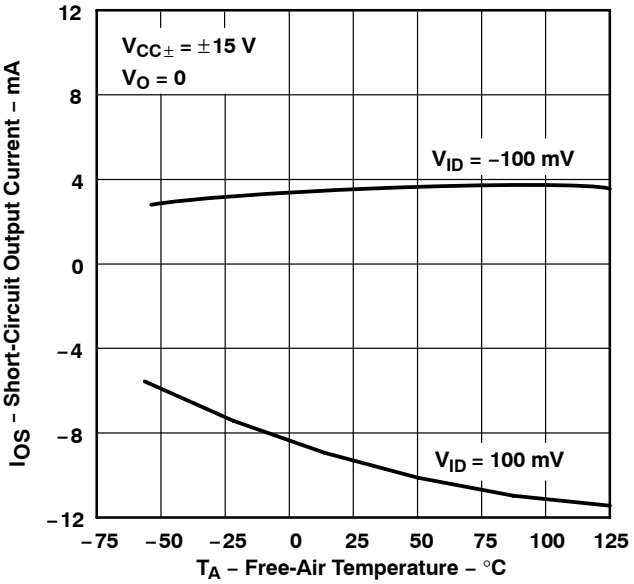



Figure 36

**TLE2022 AND TLE2024
SHORT-CIRCUIT OUTPUT CURRENT† vs FREE-AIR TEMPERATURE**

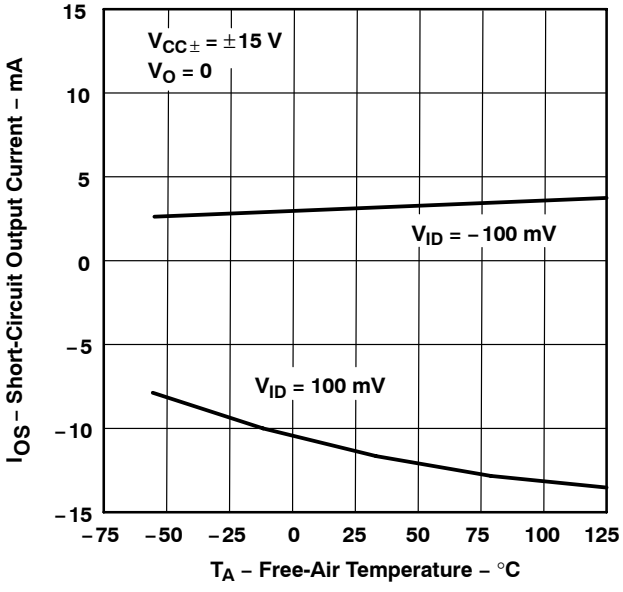



Figure 37

**TLE2021
SUPPLY CURRENT vs SUPPLY VOLTAGE**

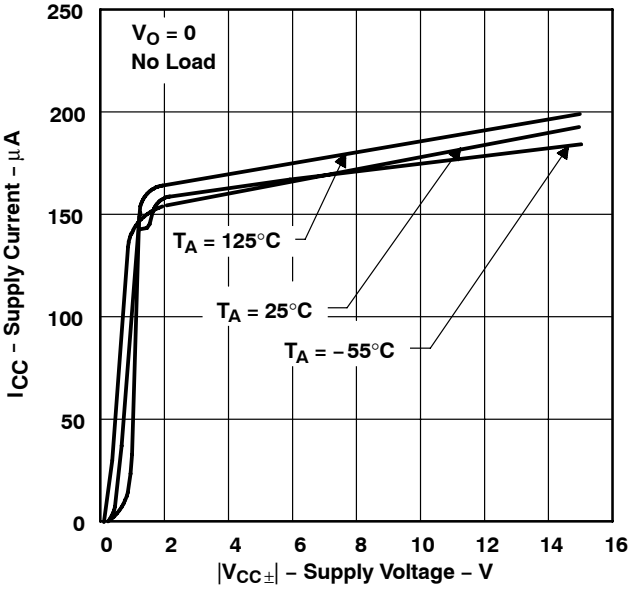



Figure 38

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

## TYPICAL CHARACTERISTICS

TLE2022
SUPPLY CURRENT
vs
SUPPLY VOLTAGE

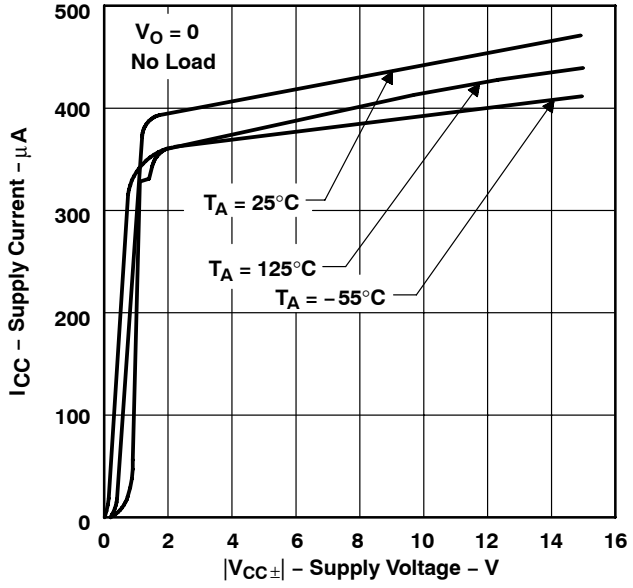



Figure 39

TLE2024
SUPPLY CURRENT
vs
SUPPLY VOLTAGE

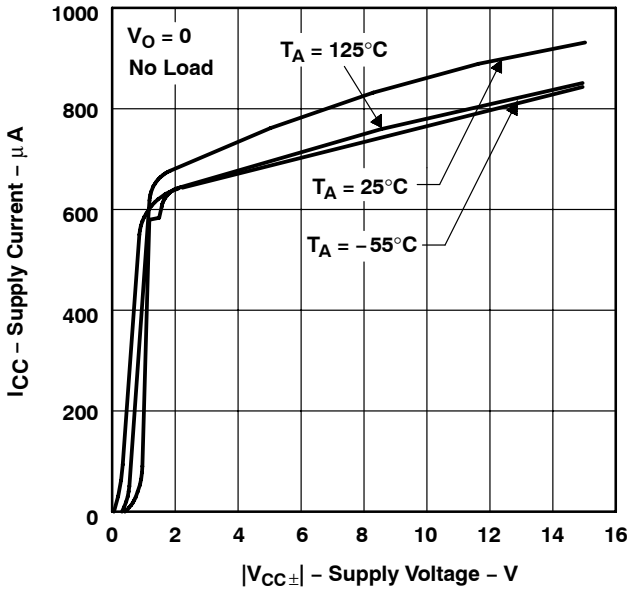



Figure 40

TLE2021
SUPPLY CURRENT†
vs
FREE-AIR TEMPERATURE

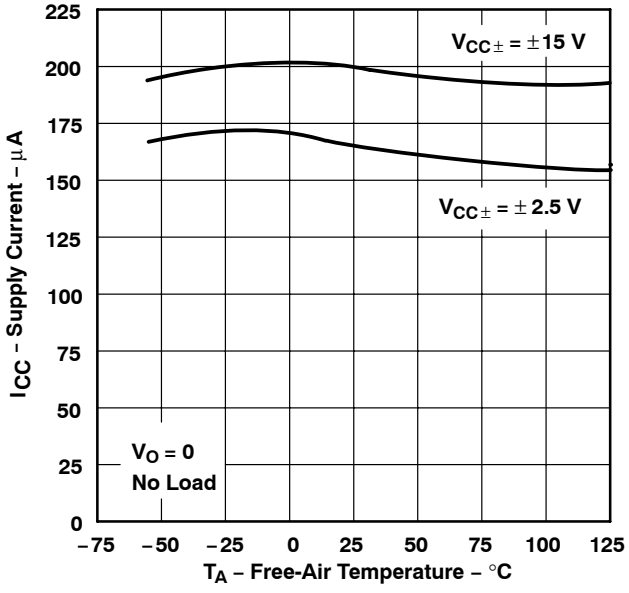



Figure 41

TLE2022
SUPPLY CURRENT†
vs
FREE-AIR TEMPERATURE

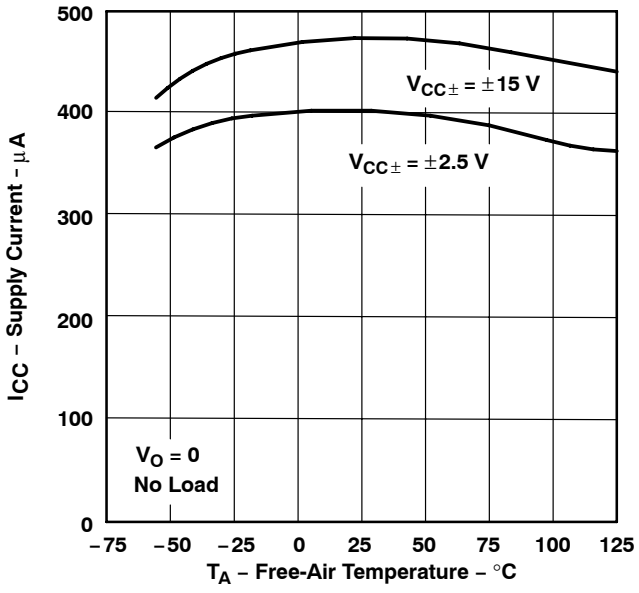



Figure 42

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

## TYPICAL CHARACTERISTICS

**TLE2024**
**SUPPLY CURRENT† vs FREE-AIR TEMPERATURE**

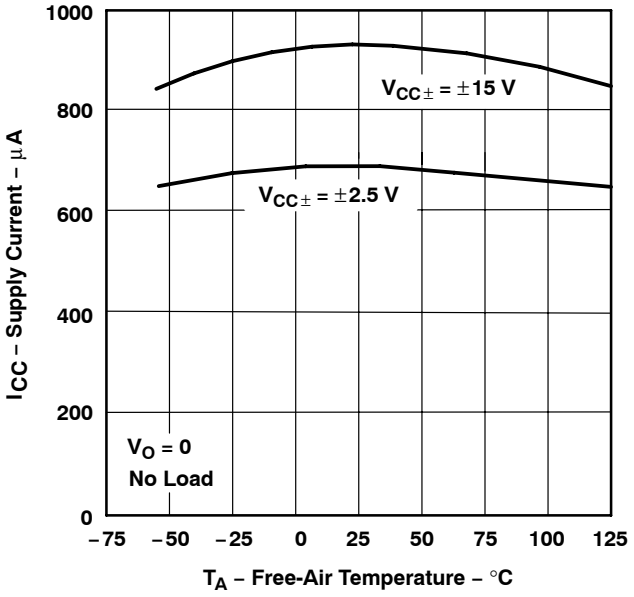



Figure 43

**TLE2021**
**COMMON-MODE REJECTION RATIO vs FREQUENCY**

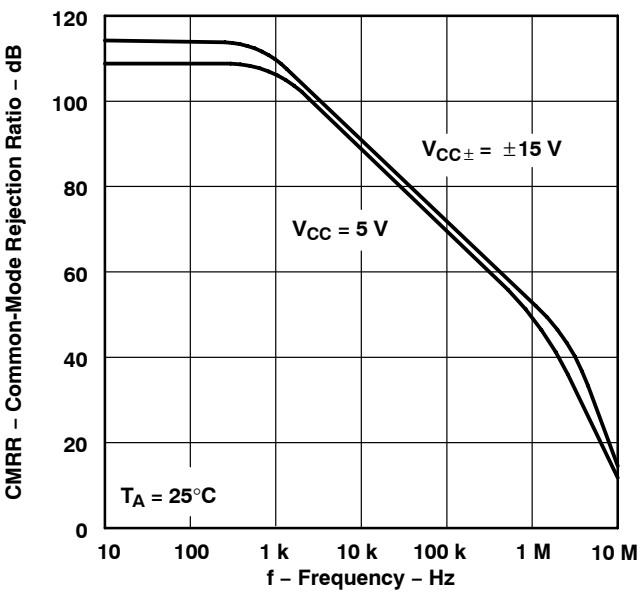



Figure 44

**TLE2022**
**COMMON-MODE REJECTION RATIO vs FREQUENCY**

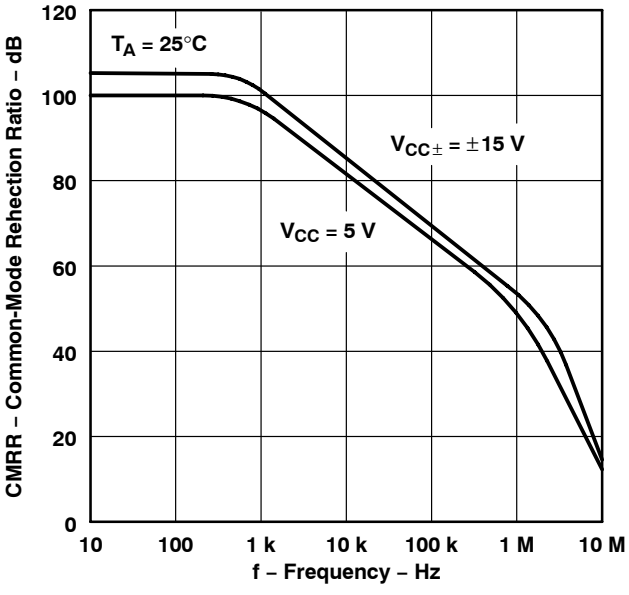



Figure 45

**TLE2024**
**COMMON-MODE REJECTION RATIO vs FREQUENCY**

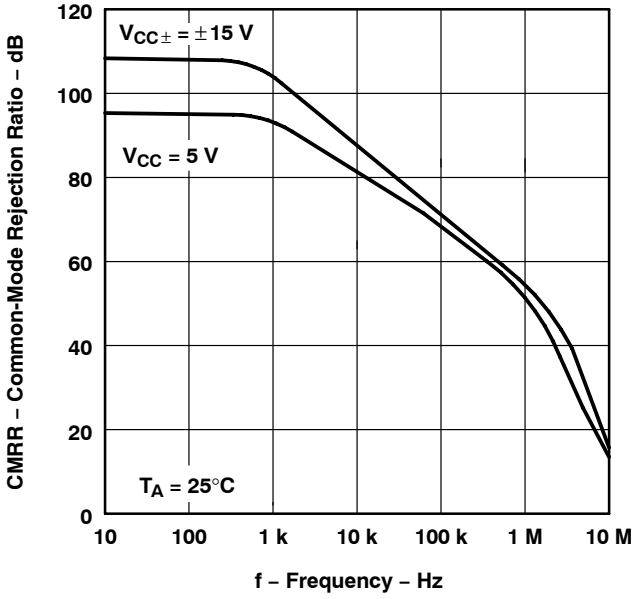



Figure 46

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

## TYPICAL CHARACTERISTICS

**TLE2021**
**SLEW RATE†**
**vs**
**FREE-AIR TEMPERATURE**

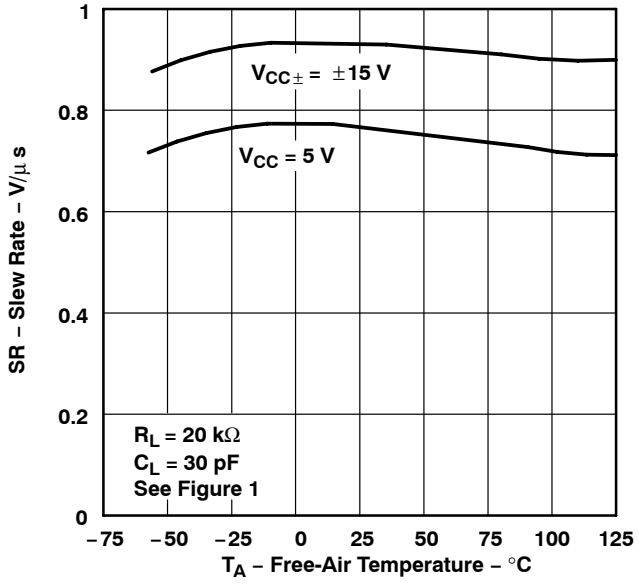



Figure 47

**TLE2022**
**SLEW RATE†**
**vs**
**FREE-AIR TEMPERATURE**

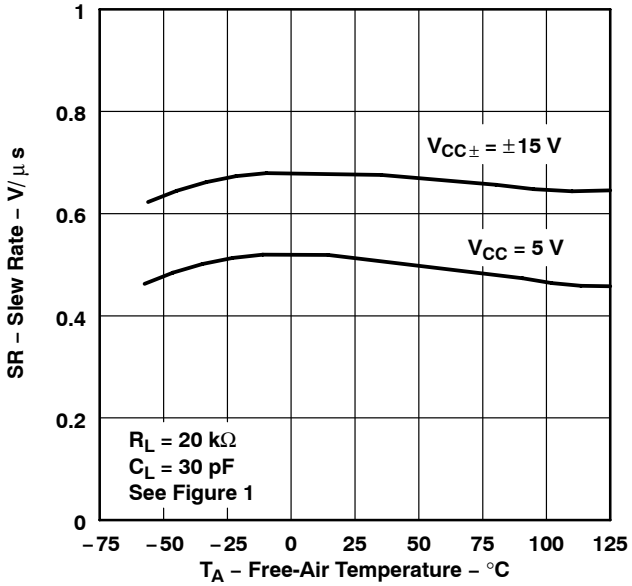



Figure 48

**TLE2024**
**SLEW RATE†**
**vs**
**FREE-AIR TEMPERATURE**

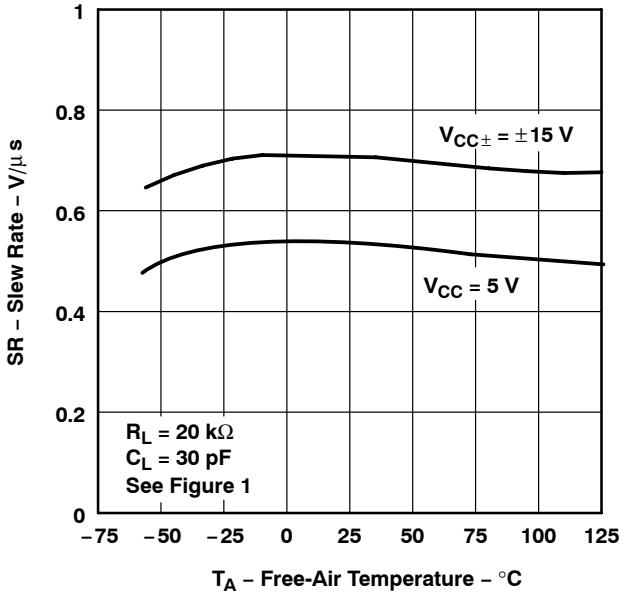



Figure 49

**VOLTAGE-FOLLOWER**
**SMALL-SIGNAL**
**PULSE RESPONSE**

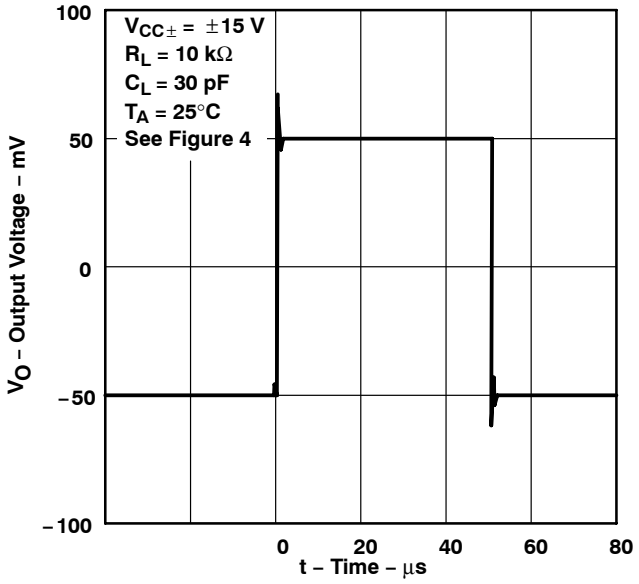



Figure 50

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

## TYPICAL CHARACTERISTICS

**VOLTAGE-FOLLOWER SMALL-SIGNAL PULSE RESPONSE**

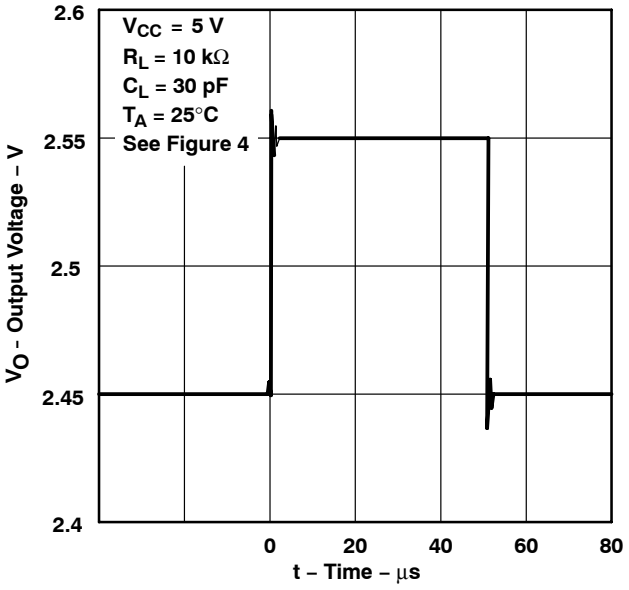



Figure 51

**TLE2021 VOLTAGE-FOLLOWER LARGE-SIGNAL PULSE RESPONSE**

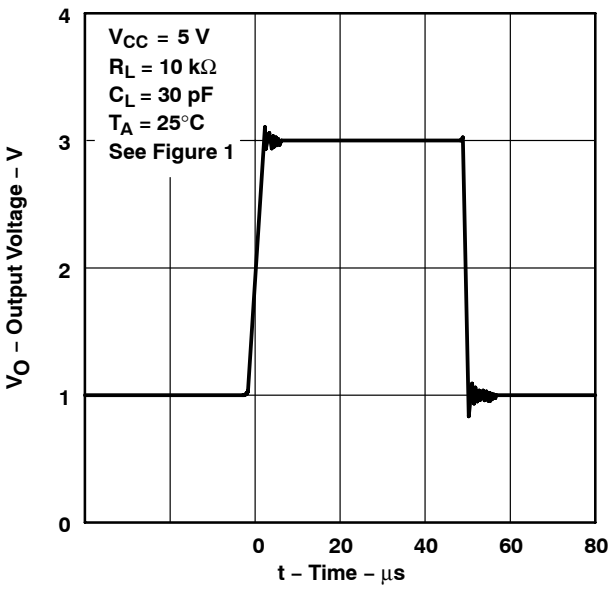



Figure 52

**TLE2022 VOLTAGE-FOLLOWER LARGE-SIGNAL PULSE RESPONSE**

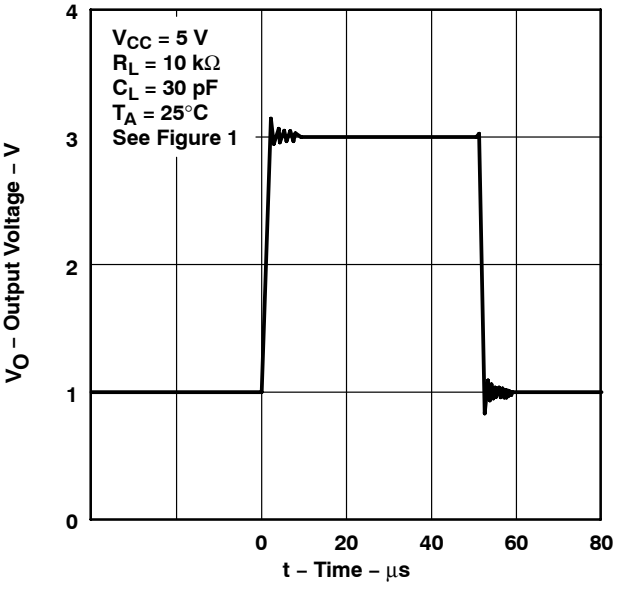



Figure 53

**TLE2024 VOLTAGE-FOLLOWER LARGE-SCALE PULSE RESPONSE**

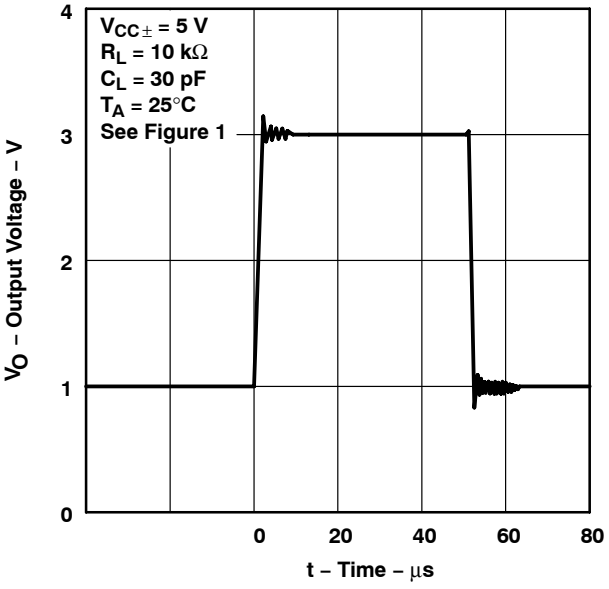



Figure 54

## TYPICAL CHARACTERISTICS

TLE2021
VOLTAGE-FOLLOWER LARGE-SIGNAL
PULSE RESPONSE

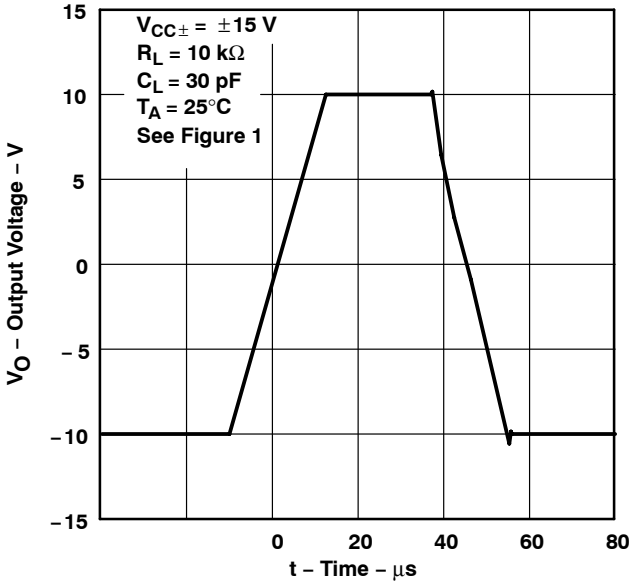



Figure 55

TLE2022
VOLTAGE-FOLLOWER LARGE-SIGNAL
PULSE RESPONSE

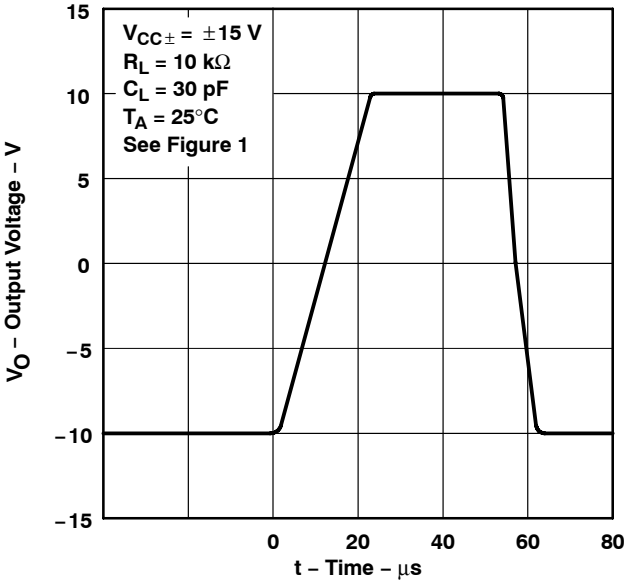



Figure 56

TLE2024
VOLTAGE-FOLLOWER LARGE-SIGNAL
PULSE RESPONSE

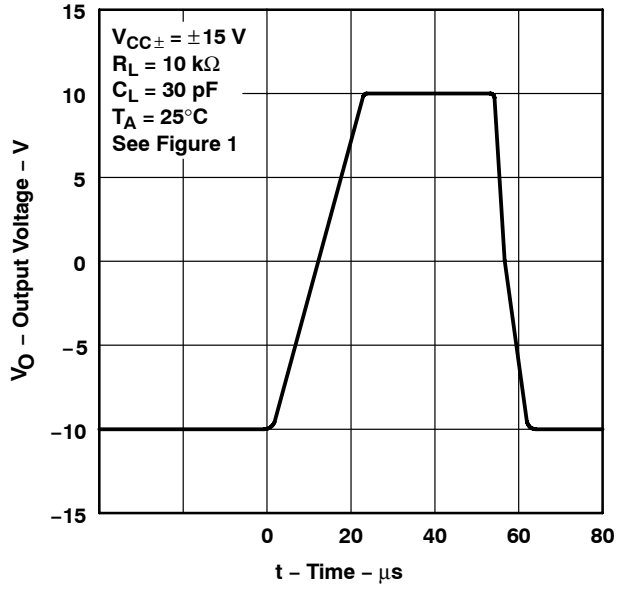



Figure 57

PEAK-TO-PEAK EQUIVALENT
INPUT NOISE VOLTAGE
0.1 TO 1 Hz

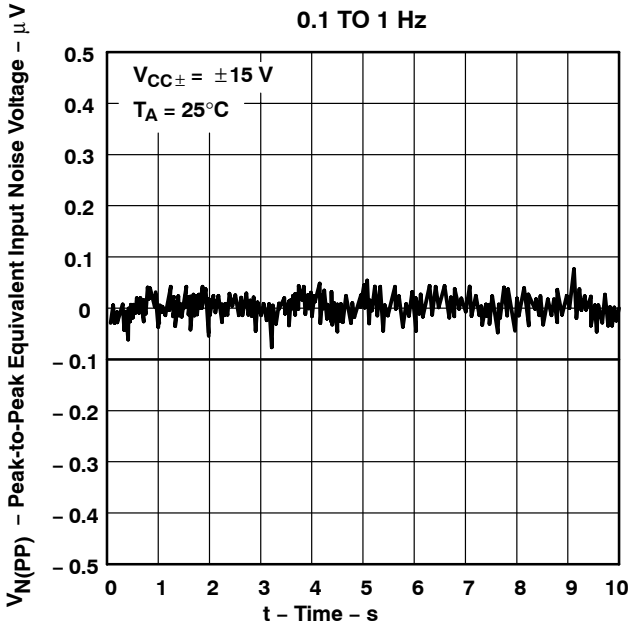



Figure 58

## TYPICAL CHARACTERISTICS

PEAK-TO-PEAK EQUIVALENT INPUT NOISE VOLTAGE 0.1 TO 10 Hz

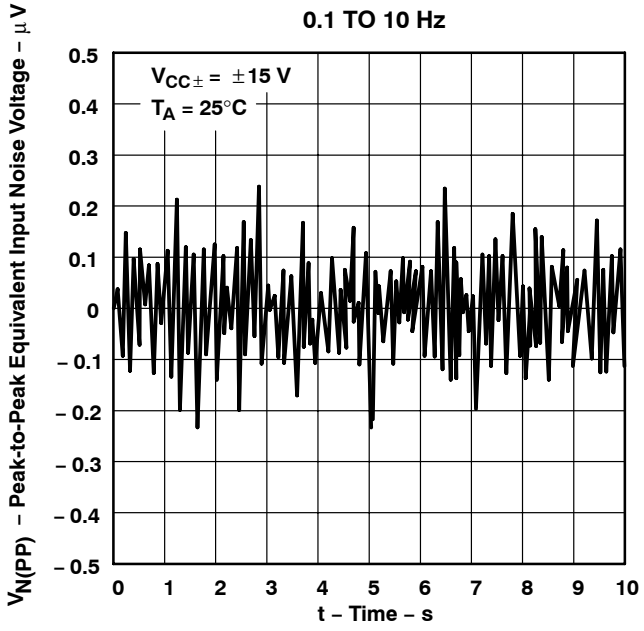



Figure 59

EQUIVALENT INPUT NOISE VOLTAGE vs FREQUENCY

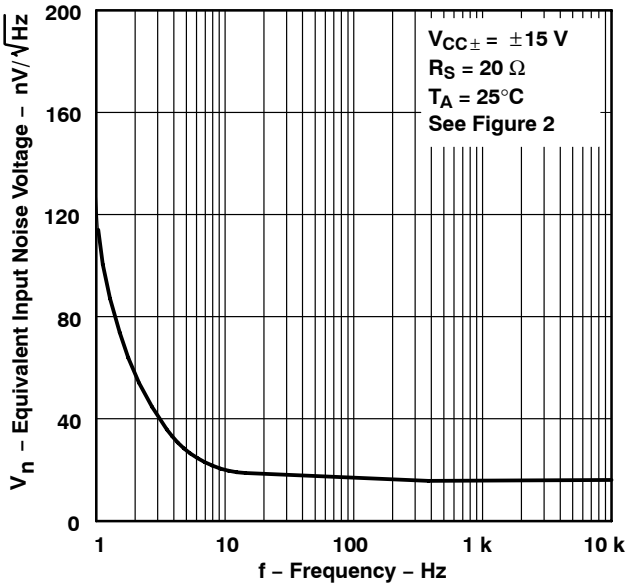



Figure 60

TLE2021 UNITY-GAIN BANDWIDTH vs SUPPLY VOLTAGE

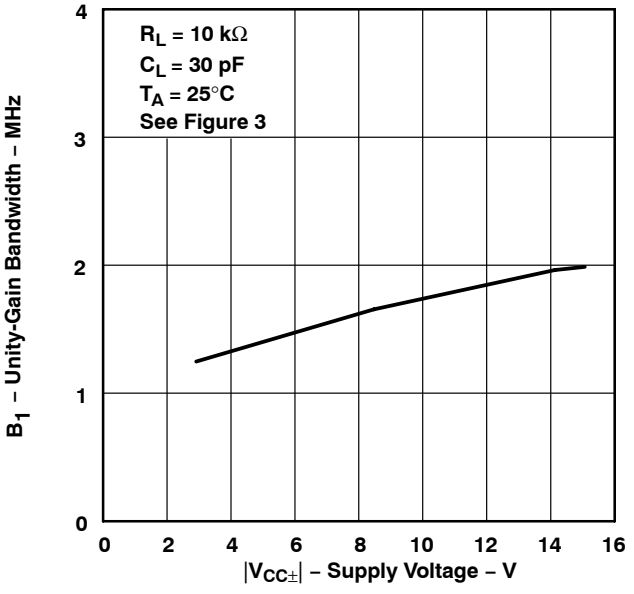



Figure 61

TLE2022 AND TLE2024 UNITY-GAIN BANDWIDTH vs SUPPLY VOLTAGE

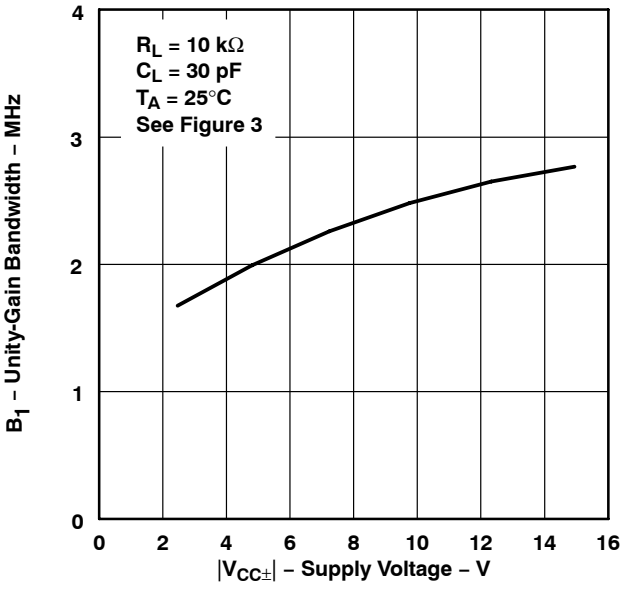



Figure 62

## TYPICAL CHARACTERISTICS

TLE2021
UNITY-GAIN BANDWIDTH†
vs
FREE-AIR TEMPERATURE

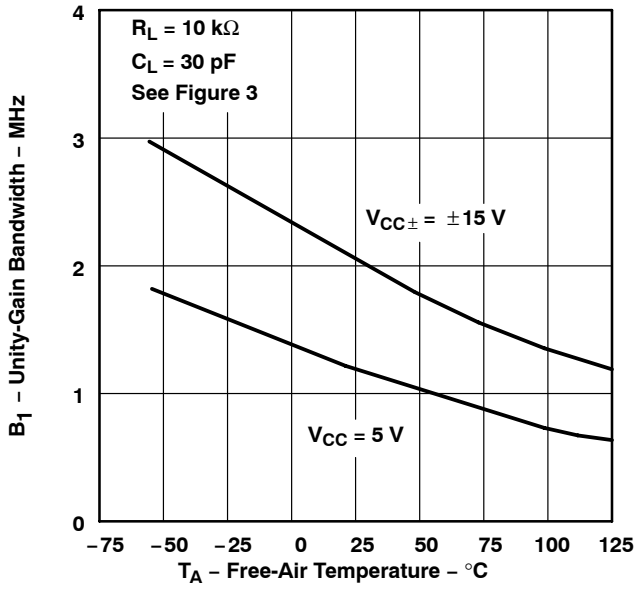



Figure 63

TLE2022 AND TLE2024
UNITY-GAIN BANDWIDTH†
vs
FREE-AIR TEMPERATURE

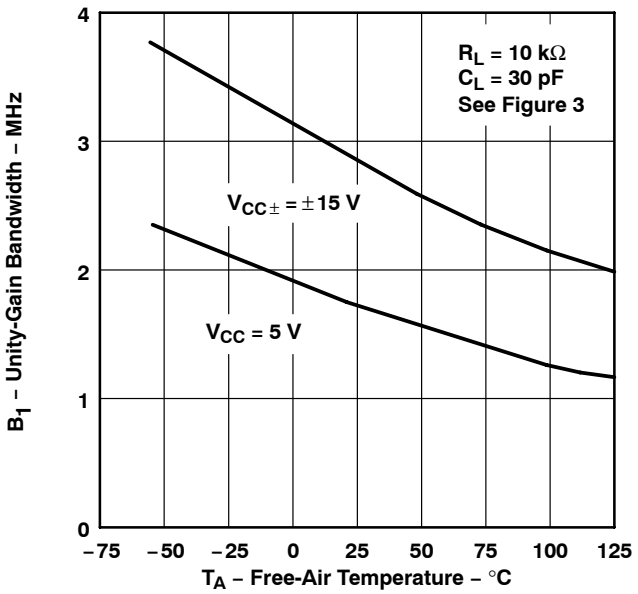



Figure 64

TLE2021
PHASE MARGIN
vs
SUPPLY VOLTAGE

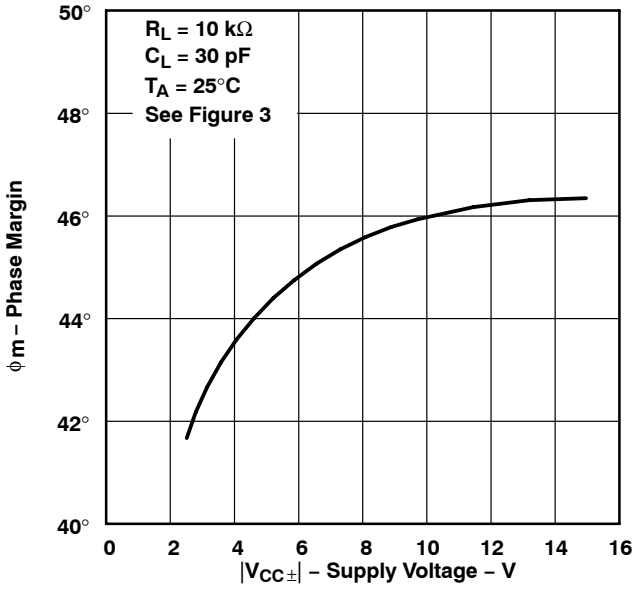



Figure 65

TLE2022 AND TLE2024
PHASE MARGIN
vs
SUPPLY VOLTAGE

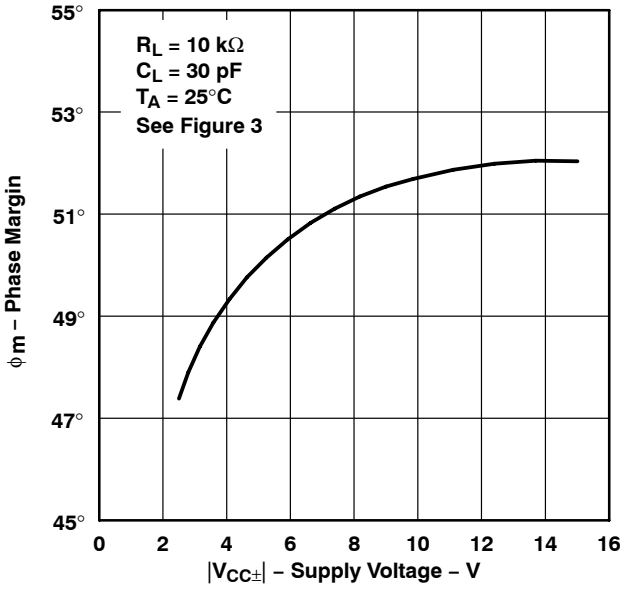



Figure 66

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

## TYPICAL CHARACTERISTICS

TLE2021
PHASE MARGIN
vs
LOAD CAPACITANCE

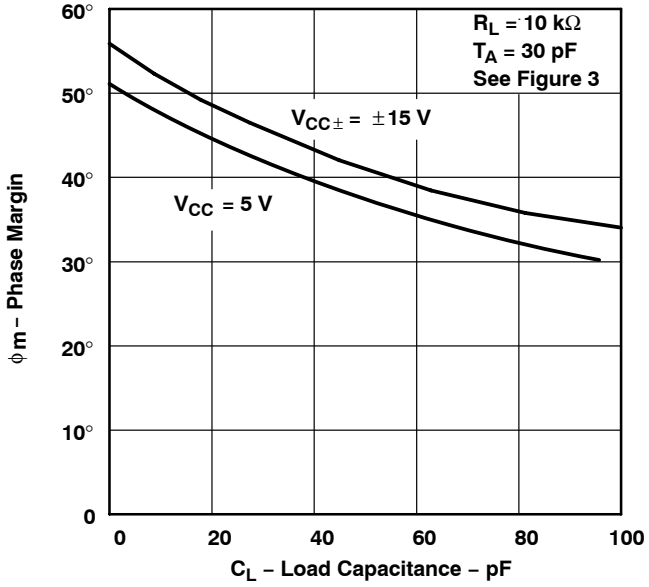



Figure 67

TLE2022 AND TLE2024
PHASE MARGIN
vs
LOAD CAPACITANCE

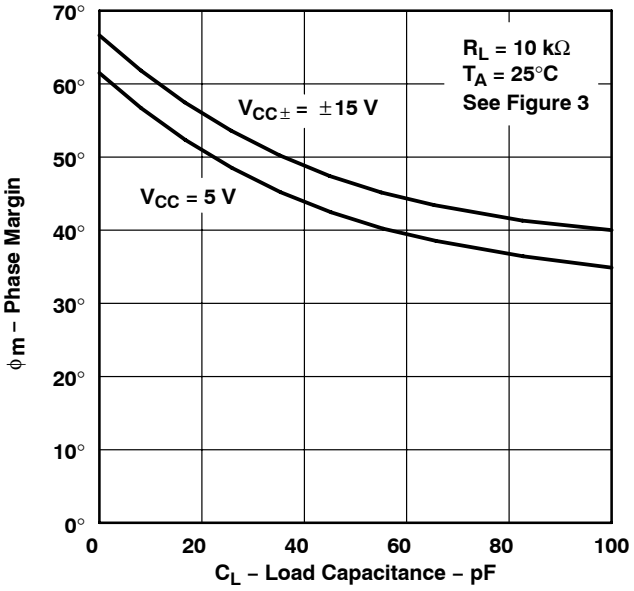



Figure 68

TLE2021
PHASE MARGIN†
vs
FREE-AIR TEMPERATURE

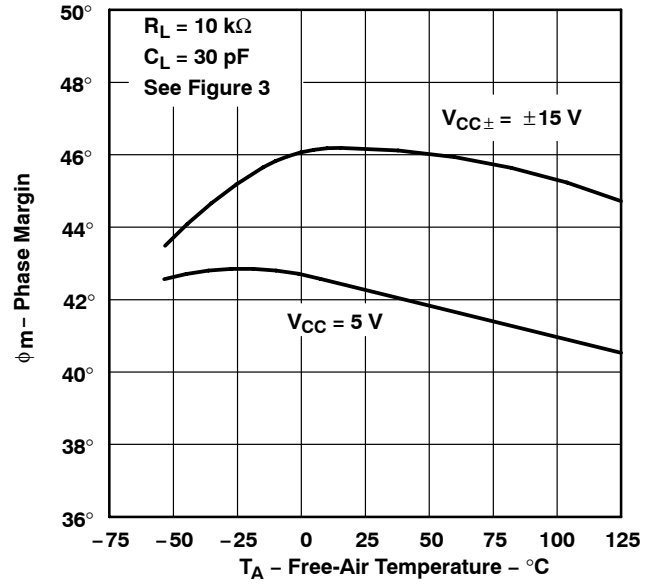



Figure 69

TLE2022 AND TLE2024
PHASE MARGIN†
vs
FREE-AIR TEMPERATURE

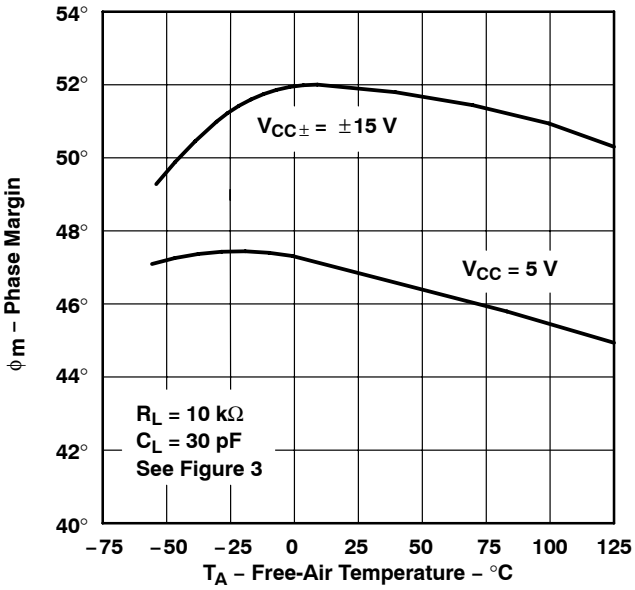



Figure 70

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

## APPLICATION INFORMATION

### voltage-follower applications

The TLE202x 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. 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 71).

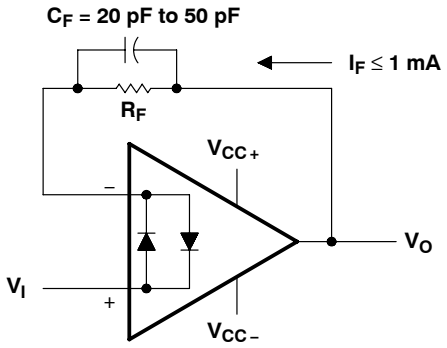



**Figure 71. Voltage Follower**

### Input offset voltage nulling

The TLE202x series offers external null pins that further reduce the input offset voltage. The circuit in Figure 72 can be connected as shown if this feature is desired. When external nulling is not needed, the null pins may be left disconnected.

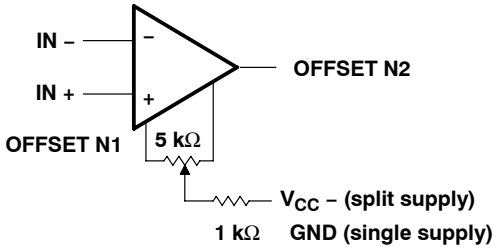



**Figure 72. Input Offset Voltage Null Circuit**

## 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 73, Figure 74, and Figure 75 were generated using the TLE202x 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
- Unity-gain frequency
- Common-mode rejection ratio
- Phase margin
- DC output resistance
- AC output resistance
- Short-circuit output current limit

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).

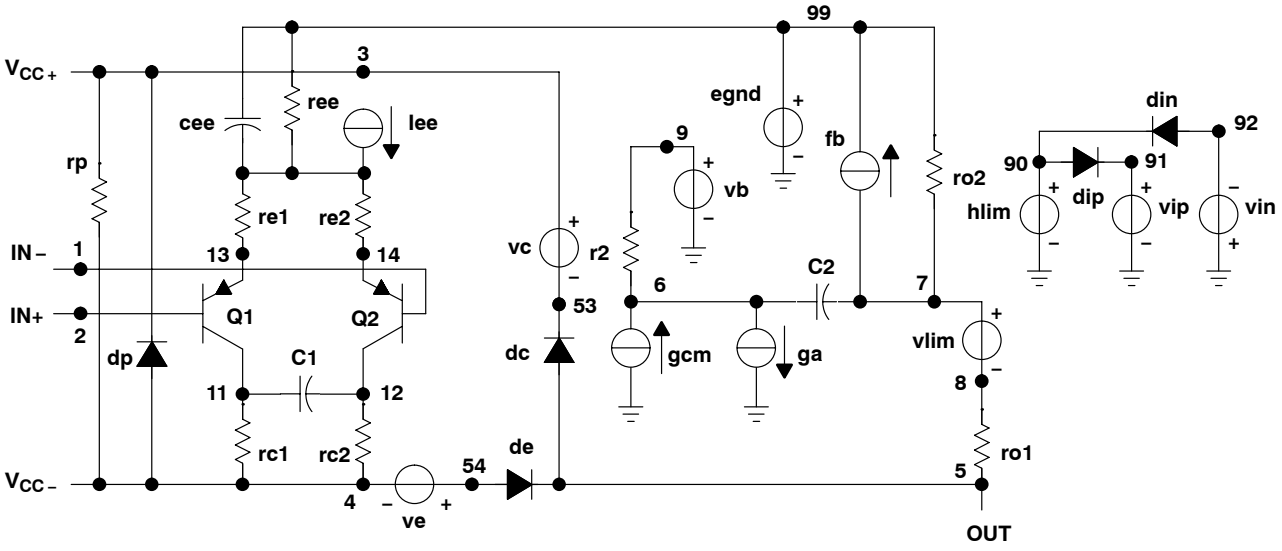



**Figure 73. Boyle Subcircuit**

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

```
.SUBCKT TLE2021  1 2 3 4 5
*
  c1     11   12 6.244E-12
  c2     6    7  13.4E-12
  c3     87   0  10.64E-9
  cpsr   85   86 15.9E-9
  dcm+   81   82 dx
  dcm-   83   81 dx
  dc     5    53 dx
  de     54   5  dx
  dlp    90   91 dx
  dln    92   90 dx
  dp     4    3  dx
  ecmr   84   99 (2 99) 1
  egnd   99   0  poly(2) (3,0) (4,0) 0 .5 .5
  epsr   85   0  poly(1) (3,4) -60E-6 2.0E-6
  ense   89   2  poly(1) (88,0) 120E-6 1
  fb     7    99 poly(6) vb vc ve vlp vln vpsr 0 547.3E6
  + -50E7 50E7 50E7 -50E7 547E6
  ga     6    0  11 12 188.5E-6
  gcm    0    6  10 99 335.2E-12
  gpsr   85   86 (85,86) 100E-6
  grc1   4    11 (4,11) 1.885E-4
  grc2   4    12 (4,12) 1.885E-4
  gre1   13   10 (13,10) 6.82E-4
  gre2   14   10 (14,10) 6.82E-4
  hlim   90   0  vlim 1k
  hcmr   80   1  poly(2) vcm+ vcm- 0 1E2 1E2
  irp    3    4  185E-6
  iee    3    10 dc 15.67E-6
  iio    2    0  2E-9
  i1     88   0  1E-21
  q1     11   89 13 qx
  q2     12   80 14 qx
  R2     6    9  100.0E3
  rcm    84   81 1K
  ree    10   99 14.76E6
  rn1    87   0  2.55E8
  rn2    87   88 11.67E3
  ro1    8    5  62
  ro2    7    99 63
  vcm+   82   99 13.3
  vcm-   83   99 -14.6
  vb     9    0  dc 0
  vc     3    53 dc 1.300
  ve     54   4  dc 1.500
  vlim   7    8  dc 0
  vlp    91   0  dc 3.600
  vln    0    92 dc 3.600
  vpsr   0    86 dc 0
.model dx d(is=800.0E-18)
.model qx pnp(is=800.0E-18 bf=270)
.ends
```

**Figure 74. Boyle Macromodel for the TLE2021**

```
.SUBCKT TLE2022  1  2  3  4  5
*
  c1    11  12 6.814E-12
  c2    6   7  20.00E-12
  dc    5   53 dx
  de    54  5  dx
  dlp   90  91 dx
  dln   92  90 dx
  dp    4   3  dx
  egnd  99  0  poly(2) (3,0) (4,0) 0 .5 .5
  fb    7   99 poly(5) vb vc ve vlp vln 0
+ 45.47E6 -50E6 50E6 50E6 -50E6
  ga 6  0   11 12 377.9E-6
  gcm 0 6   10 99 7.84E-10
  iee   3   10 DC 18.07E-6
  hlim 90   0 vlim 1k
  q1    11  2 13 qx
  q2    12  1 14 qx
  r2    6   9 100.0E3
  rc1   4   11 2.842E3
  rc2   4   12 2.842E3
  ge1   13  10 (10,13) 31.299E-3
  ge2   14  10 (10,14) 31.299E-3
  ree   10  99 11.07E6
  ro1   8   5 250
  ro2   7   99 250
  rp    3   4 137.2E3
  vb    9   0 dc 0
  vc    3   53 dc 1.300
  ve    54  4 dc 1.500
  vlim  7   8 dc 0
  vlp   91  0 dc 3
  vln   0   92 dc 3
.model dx  d(is=800.0E-18)
.model qx  pnp(is=800.0E-18 bf=257.1)
.ends
```

**Figure 75. Boyle Macromodel for the TLE2022**

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## PACKAGING INFORMATION

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead/ Ball Finish | MSL Pea |
|---|---|---|---|---|---|---|---|---|
| 5962-9088101MPA | ACTIVE | CDIP | JG | 8 | 1 | TBD | A42 | N / A for Pkg |
| 5962-9088102M2A | ACTIVE | LCCC | FK | 20 | 1 | TBD | POST-PLATE | N / A for Pkg |
| 5962-9088102MPA | ACTIVE | CDIP | JG | 8 | 1 | TBD | A42 | N / A for Pkg |
| 5962-9088103M2A | ACTIVE | LCCC | FK | 20 | 1 | TBD | POST-PLATE | N / A for Pkg |
| 5962-9088103MCA | ACTIVE | CDIP | J | 14 | 1 | TBD | A42 | N / A for Pkg |
| 5962-9088104Q2A | ACTIVE | LCCC | FK | 20 | 1 | TBD | POST-PLATE | N / A for Pkg |
| 5962-9088104QPA | ACTIVE | CDIP | JG | 8 | 1 | TBD | A42 | N / A for Pkg |
| 5962-9088105Q2A | ACTIVE | LCCC | FK | 20 | 1 | TBD | POST-PLATE | N / A for Pkg |
| 5962-9088105QPA | ACTIVE | CDIP | JG | 8 | 1 | TBD | A42 | N / A for Pkg |
| 5962-9088106Q2A | ACTIVE | LCCC | FK | 20 | 1 | TBD | POST-PLATE | N / A for Pkg |
| 5962-9088106QCA | ACTIVE | CDIP | J | 14 | 1 | TBD | A42 | N / A for Pkg |
| 5962-9088107Q2A | ACTIVE | LCCC | FK | 20 | 1 | TBD | POST-PLATE | N / A for Pkg |
| 5962-9088107QPA | ACTIVE | CDIP | JG | 8 | 1 | TBD | A42 | N / A for Pkg |
| 5962-9088108Q2A | ACTIVE | LCCC | FK | 20 | 1 | TBD | POST-PLATE | N / A for Pkg |
| 5962-9088108QPA | ACTIVE | CDIP | JG | 8 | 1 | TBD | A42 | N / A for Pkg |
| 5962-9088109Q2A | ACTIVE | LCCC | FK | 20 | 1 | TBD | POST-PLATE | N / A for Pkg |
| 5962-9088109QCA | ACTIVE | CDIP | J | 14 | 1 | TBD | A42 | N / A for Pkg |
| TLE2021ACD | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260 |
| TLE2021ACDG4 | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260 |
| TLE2021ACDR | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260 |
| TLE2021ACDRG4 | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260 |
| TLE2021ACP | ACTIVE | PDIP | P | 8 | 50 | Pb-Free (RoHS) | CU NIPDAU | N / A for Pkg |
| TLE2021ACPE4 | ACTIVE | PDIP | P | 8 | 50 | Pb-Free (RoHS) | CU NIPDAU | N / A for Pkg |
| TLE2021ACPS | OBSOLETE | SO | PS | 8 | | TBD | Call TI | Call TI |

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| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead/ Ball Finish | MSL Pea |
|---|---|---|---|---|---|---|---|---|
| TLE2021ACPSG4 | OBSOLETE | SO | PS | 8 | | TBD | Call TI | Call TI |
| TLE2021AID | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260 |
| TLE2021AIDG4 | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260 |
| TLE2021AIP | ACTIVE | PDIP | P | 8 | 50 | Pb-Free (RoHS) | CU NIPDAU | N / A for Pkg |
| TLE2021AIPE4 | ACTIVE | PDIP | P | 8 | 50 | Pb-Free (RoHS) | CU NIPDAU | N / A for Pkg |
| TLE2021AMFKB | ACTIVE | LCCC | FK | 20 | 1 | TBD | POST-PLATE | N / A for Pkg |
| TLE2021AMJGB | ACTIVE | CDIP | JG | 8 | 1 | TBD | A42 | N / A for Pkg |
| TLE2021BMFKB | ACTIVE | LCCC | FK | 20 | 1 | TBD | POST-PLATE | N / A for Pkg |
| TLE2021BMJG | ACTIVE | CDIP | JG | 8 | 1 | TBD | A42 | N / A for Pkg |
| TLE2021BMJGB | ACTIVE | CDIP | JG | 8 | 1 | TBD | A42 | N / A for Pkg |
| TLE2021CD | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260 |
| TLE2021CDG4 | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260 |
| TLE2021CDR | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260 |
| TLE2021CDRG4 | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260 |
| TLE2021CP | ACTIVE | PDIP | P | 8 | 50 | Pb-Free (RoHS) | CU NIPDAU | N / A for Pkg |
| TLE2021CPE4 | ACTIVE | PDIP | P | 8 | 50 | Pb-Free (RoHS) | CU NIPDAU | N / A for Pkg |
| TLE2021CPWLE | OBSOLETE | TSSOP | PW | 8 | | TBD | Call TI | Call TI |
| TLE2021CPWR | ACTIVE | TSSOP | PW | 8 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260 |
| TLE2021CPWRG4 | ACTIVE | TSSOP | PW | 8 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260 |
| TLE2021ID | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260 |

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| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead/ Ball Finish | MSL Pea |
|---|---|---|---|---|---|---|---|---|
| TLE2021IDG4 | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260 |
| TLE2021IDR | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260 |
| TLE2021IDRG4 | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260 |
| TLE2021IP | ACTIVE | PDIP | P | 8 | 50 | Pb-Free (RoHS) | CU NIPDAU | N / A for Pkg |
| TLE2021IPE4 | ACTIVE | PDIP | P | 8 | 50 | Pb-Free (RoHS) | CU NIPDAU | N / A for Pkg |
| TLE2021MD | ACTIVE | SOIC | D | 8 | 75 | TBD | CU NIPDAU | Level-1-220 |
| TLE2021MDG4 | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260 |
| TLE2021MFKB | OBSOLETE | LCCC | FK | 20 | | TBD | Call TI | Call TI |
| TLE2021MJG | ACTIVE | CDIP | JG | 8 | 1 | TBD | A42 | N / A for Pkg |
| TLE2021MJGB | ACTIVE | CDIP | JG | 8 | 1 | TBD | A42 | N / A for Pkg |
| TLE2022ACD | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260 |
| TLE2022ACDG4 | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260 |
| TLE2022ACDR | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260 |
| TLE2022ACDRG4 | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260 |
| TLE2022ACP | ACTIVE | PDIP | P | 8 | 50 | Pb-Free (RoHS) | CU NIPDAU | N / A for Pkg |
| TLE2022ACPE4 | ACTIVE | PDIP | P | 8 | 50 | Pb-Free (RoHS) | CU NIPDAU | N / A for Pkg |
| TLE2022AID | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260 |
| TLE2022AIDG4 | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260 |
| TLE2022AIDR | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260 |
| TLE2022AIDRG4 | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260 |
| TLE2022AIP | ACTIVE | PDIP | P | 8 | 50 | Pb-Free (RoHS) | CU NIPDAU | N / A for Pkg |

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| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead/ Ball Finish | MSL Pea |
|---|---|---|---|---|---|---|---|---|
| TLE2022AIPE4 | ACTIVE | PDIP | P | 8 | 50 | Pb-Free (RoHS) | CU NIPDAU | N / A for Pkg |
| TLE2022AMD | ACTIVE | SOIC | D | 8 | 75 | TBD | CU NIPDAU | Level-1-220 |
| TLE2022AMDG4 | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260 |
| TLE2022AMDR | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260 |
| TLE2022AMDRG4 | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260 |
| TLE2022AMFKB | ACTIVE | LCCC | FK | 20 | 1 | TBD | POST-PLATE | N / A for Pkg |
| TLE2022AMJG | OBSOLETE | CDIP | JG | 8 | | TBD | Call TI | Call TI |
| TLE2022AMJGB | ACTIVE | CDIP | JG | 8 | 1 | TBD | A42 | N / A for Pkg |
| TLE2022BCDR | OBSOLETE | SOIC | D | 8 | | TBD | Call TI | Call TI |
| TLE2022BMFKB | ACTIVE | LCCC | FK | 20 | 1 | TBD | POST-PLATE | N / A for Pkg |
| TLE2022BMJG | OBSOLETE | CDIP | JG | 8 | | TBD | Call TI | Call TI |
| TLE2022BMJGB | ACTIVE | CDIP | JG | 8 | 1 | TBD | A42 | N / A for Pkg |
| TLE2022CD | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260 |
| TLE2022CDG4 | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260 |
| TLE2022CDR | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260 |
| TLE2022CDRG4 | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260 |
| TLE2022CP | ACTIVE | PDIP | P | 8 | 50 | Pb-Free (RoHS) | CU NIPDAU | N / A for Pkg |
| TLE2022CPE4 | ACTIVE | PDIP | P | 8 | 50 | Pb-Free (RoHS) | CU NIPDAU | N / A for Pkg |
| TLE2022CPSR | OBSOLETE | SO | PS | 8 | | TBD | Call TI | Call TI |
| TLE2022ID | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260 |
| TLE2022IDG4 | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260 |

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| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead/ Ball Finish | MSL Pea |
|---|---|---|---|---|---|---|---|---|
| TLE2022IDR | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260 |
| TLE2022IDRG4 | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260 |
| TLE2022IP | ACTIVE | PDIP | P | 8 | 50 | Pb-Free (RoHS) | CU NIPDAU | N / A for Pkg |
| TLE2022IPE4 | ACTIVE | PDIP | P | 8 | 50 | Pb-Free (RoHS) | CU NIPDAU | N / A for Pkg |
| TLE2022MD | ACTIVE | SOIC | D | 8 | 75 | TBD | CU NIPDAU | Level-1-220 |
| TLE2022MDG4 | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260 |
| TLE2022MDR | ACTIVE | SOIC | D | 8 | 2500 | TBD | CU NIPDAU | Level-1-220 |
| TLE2022MDRG4 | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260 |
| TLE2022MFKB | ACTIVE | LCCC | FK | 20 | 1 | TBD | POST-PLATE | N / A for Pkg |
| TLE2022MJG | ACTIVE | CDIP | JG | 8 | 1 | TBD | A42 | N / A for Pkg |
| TLE2022MJGB | ACTIVE | CDIP | JG | 8 | 1 | TBD | A42 | N / A for Pkg |
| TLE2024ACDW | ACTIVE | SOIC | DW | 16 | 40 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260 |
| TLE2024ACDWG4 | ACTIVE | SOIC | DW | 16 | 40 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260 |
| TLE2024ACDWR | ACTIVE | SOIC | DW | 16 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260 |
| TLE2024ACDWRG4 | ACTIVE | SOIC | DW | 16 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260 |
| TLE2024ACN | ACTIVE | PDIP | N | 14 | 25 | Pb-Free (RoHS) | CU NIPDAU | N / A for Pkg |
| TLE2024ACNE4 | ACTIVE | PDIP | N | 14 | 25 | Pb-Free (RoHS) | CU NIPDAU | N / A for Pkg |
| TLE2024AIDW | ACTIVE | SOIC | DW | 16 | 40 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260 |
| TLE2024AIDWG4 | ACTIVE | SOIC | DW | 16 | 40 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260 |
| TLE2024AIN | ACTIVE | PDIP | N | 14 | 25 | Pb-Free (RoHS) | CU NIPDAU | N / A for Pkg |
| TLE2024AINE4 | ACTIVE | PDIP | N | 14 | 25 | Pb-Free (RoHS) | CU NIPDAU | N / A for Pkg |

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead/ Ball Finish | MSL Pea |
|---|---|---|---|---|---|---|---|---|
| TLE2024AMFKB | ACTIVE | LCCC | FK | 20 | 1 | TBD | POST-PLATE | N / A for Pkg |
| TLE2024AMJ | ACTIVE | CDIP | J | 14 | 1 | TBD | A42 | N / A for Pkg |
| TLE2024AMJB | ACTIVE | CDIP | J | 14 | 1 | TBD | A42 | N / A for Pkg |
| TLE2024BCDW | OBSOLETE | SOIC | DW | 16 | | TBD | Call TI | Call TI |
| TLE2024BCN | OBSOLETE | PDIP | N | 14 | | TBD | Call TI | Call TI |
| TLE2024BIDW | OBSOLETE | SOIC | DW | 16 | | TBD | Call TI | Call TI |
| TLE2024BIN | OBSOLETE | PDIP | N | 14 | | TBD | Call TI | Call TI |
| TLE2024BMDW | ACTIVE | SOIC | DW | 16 | 40 | TBD | CU NIPDAU | Level-1-220 |
| TLE2024BMDWG4 | ACTIVE | SOIC | DW | 16 | 40 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260 |
| TLE2024BMFKB | ACTIVE | LCCC | FK | 20 | 1 | TBD | POST-PLATE | N / A for Pkg |
| TLE2024BMJ | NRND | CDIP | J | 14 | 1 | TBD | A42 | N / A for Pkg |
| TLE2024BMJB | ACTIVE | CDIP | J | 14 | 1 | TBD | A42 | N / A for Pkg |
| TLE2024BMN | OBSOLETE | PDIP | N | 14 | | TBD | Call TI | Call TI |
| TLE2024CDW | ACTIVE | SOIC | DW | 16 | 40 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260 |
| TLE2024CDWG4 | ACTIVE | SOIC | DW | 16 | 40 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260 |
| TLE2024CDWR | ACTIVE | SOIC | DW | 16 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260 |
| TLE2024CDWRG4 | ACTIVE | SOIC | DW | 16 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260 |
| TLE2024CN | ACTIVE | PDIP | N | 14 | 25 | Pb-Free (RoHS) | CU NIPDAU | N / A for Pkg |
| TLE2024CNE4 | ACTIVE | PDIP | N | 14 | 25 | Pb-Free (RoHS) | CU NIPDAU | N / A for Pkg |
| TLE2024IDW | ACTIVE | SOIC | DW | 16 | 40 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260 |
| TLE2024IDWG4 | ACTIVE | SOIC | DW | 16 | 40 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260 |
| TLE2024IN | ACTIVE | PDIP | N | 14 | 25 | Pb-Free (RoHS) | CU NIPDAU | N / A for Pkg |

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| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead/ Ball Finish | MSL Pea |
|---|---|---|---|---|---|---|---|---|
| TLE2024INE4 | ACTIVE | PDIP | N | 14 | 25 | Pb-Free (RoHS) | CU NIPDAU | N / A for Pkg |
| TLE2024MDW | ACTIVE | SOIC | DW | 16 | 40 | TBD | CU NIPDAU | Level-1-220 |
| TLE2024MDWG4 | ACTIVE | SOIC | DW | 16 | 100 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260 |
| TLE2024MFKB | ACTIVE | LCCC | FK | 20 | 1 | TBD | POST-PLATE | N / A for Pkg |
| TLE2024MJ | OBSOLETE | CDIP | J | 14 | | TBD | Call TI | Call TI |
| TLE2024MJB | ACTIVE | CDIP | J | 14 | 1 | TBD | A42 | N / A for Pkg |
| TLE2024MN | OBSOLETE | PDIP | N | 14 | | 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
**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.t
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
lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable fo
**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,
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 retard
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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provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate inf
continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical an
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**OTHER QUALIFIED VERSIONS OF TLE2021, TLE2021A, TLE2021AM, TLE2021M, TLE2022, TLE2022A, TLE2022AM, TLE2022B, TLE202 TLE2024, TLE2024A, TLE2024AM, TLE2024B, TLE2024BM, TLE2024M :**

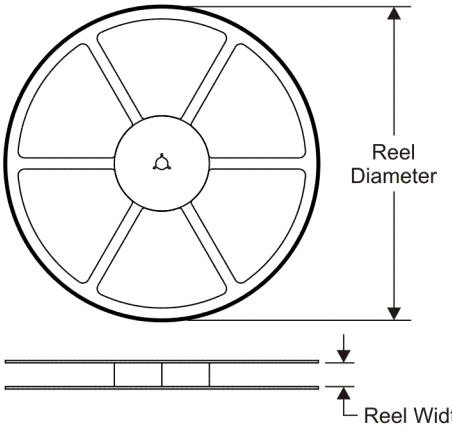
- Catalog: TLE2021A, TLE2021, TLE2022A, TLE2022B, TLE2022, TLE2024A, TLE2024B, TLE2024
- Automotive: TLE2021-Q1, TLE2021A-Q1, TLE2021A-Q1, TLE2021-Q1, TLE2022-Q1, TLE2022A-Q1, TLE2022A-Q1, TLE2022-Q1, TLE2024-Q TLE2024A-Q1, TLE2024-Q1
- Enhanced Product: TLE2021-EP, TLE2021A-EP, TLE2021A-EP, TLE2021-EP, TLE2022-EP, TLE2022A-EP, TLE2022A-EP, TLE2022-EP, TLE202 EP, TLE2024A-EP, TLE2024-EP
- Military: TLE2021M, TLE2021AM, TLE2022M, TLE2022AM, TLE2022BM, TLE2024M, TLE2024AM, TLE2024BM

NOTE: Qualified Version Definitions:

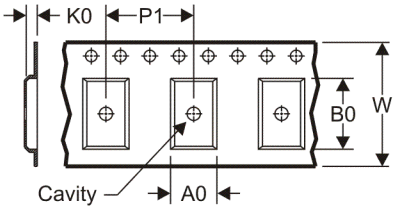
- Catalog - TI's standard catalog product
- Automotive - Q100 devices qualified for high-reliability automotive applications targeting zero defects
- Enhanced Product - Supports Defense, Aerospace and Medical Applications
- Military - QML certified for Military and Defense Applications

## TAPE AND REEL INFORMATION

**REEL DIMENSIONS**

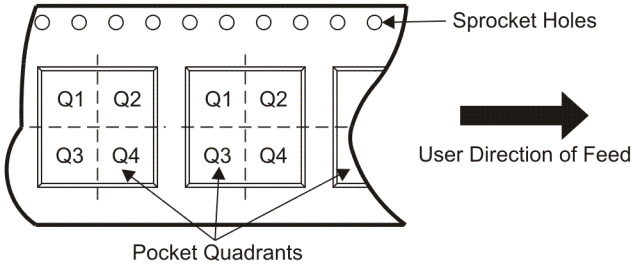



**TAPE DIMENSIONS**




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

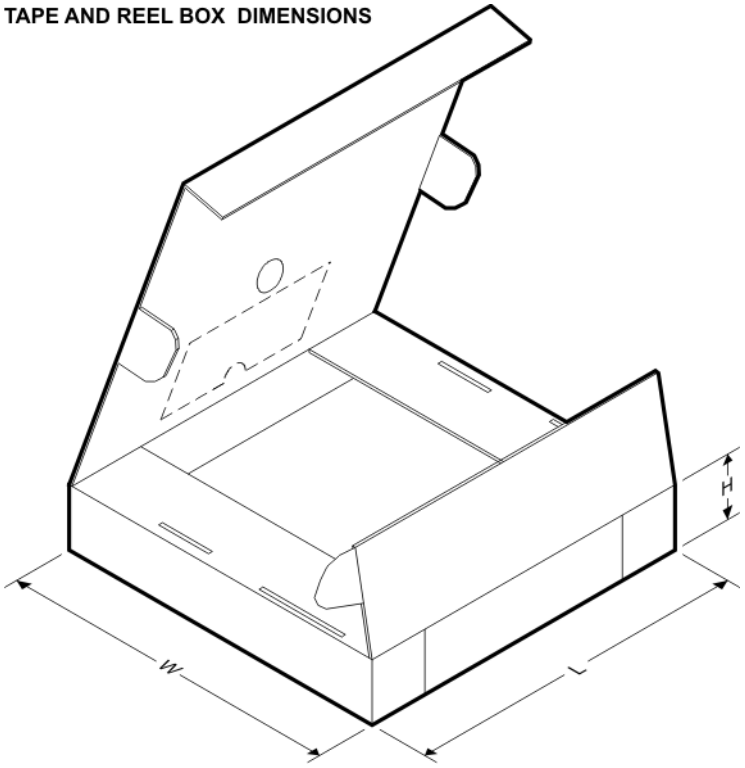
**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**




*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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TLE2021ACDR | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.4 | 5.2 | 2.1 | 8.0 | 12.0 | Q1 |
| TLE2021ACDR | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.4 | 5.2 | 2.1 | 8.0 | 12.0 | Q1 |
| TLE2021CDR | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.4 | 5.2 | 2.1 | 8.0 | 12.0 | Q1 |
| TLE2021CPWR | TSSOP | PW | 8 | 2000 | 330.0 | 12.4 | 7.0 | 3.6 | 1.6 | 8.0 | 12.0 | Q1 |
| TLE2021IDR | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.4 | 5.2 | 2.1 | 8.0 | 12.0 | Q1 |
| TLE2022ACDR | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.4 | 5.2 | 2.1 | 8.0 | 12.0 | Q1 |
| TLE2022AIDR | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.4 | 5.2 | 2.1 | 8.0 | 12.0 | Q1 |
| TLE2022AMDR | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.4 | 5.2 | 2.1 | 8.0 | 12.0 | Q1 |
| TLE2022CDR | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.4 | 5.2 | 2.1 | 8.0 | 12.0 | Q1 |
| TLE2022IDR | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.4 | 5.2 | 2.1 | 8.0 | 12.0 | Q1 |
| TLE2024ACDWR | SOIC | DW | 16 | 2000 | 330.0 | 16.4 | 10.75 | 10.7 | 2.7 | 12.0 | 16.0 | Q1 |
| TLE2024CDWR | SOIC | DW | 16 | 2000 | 330.0 | 16.4 | 10.75 | 10.7 | 2.7 | 12.0 | 16.0 | Q1 |

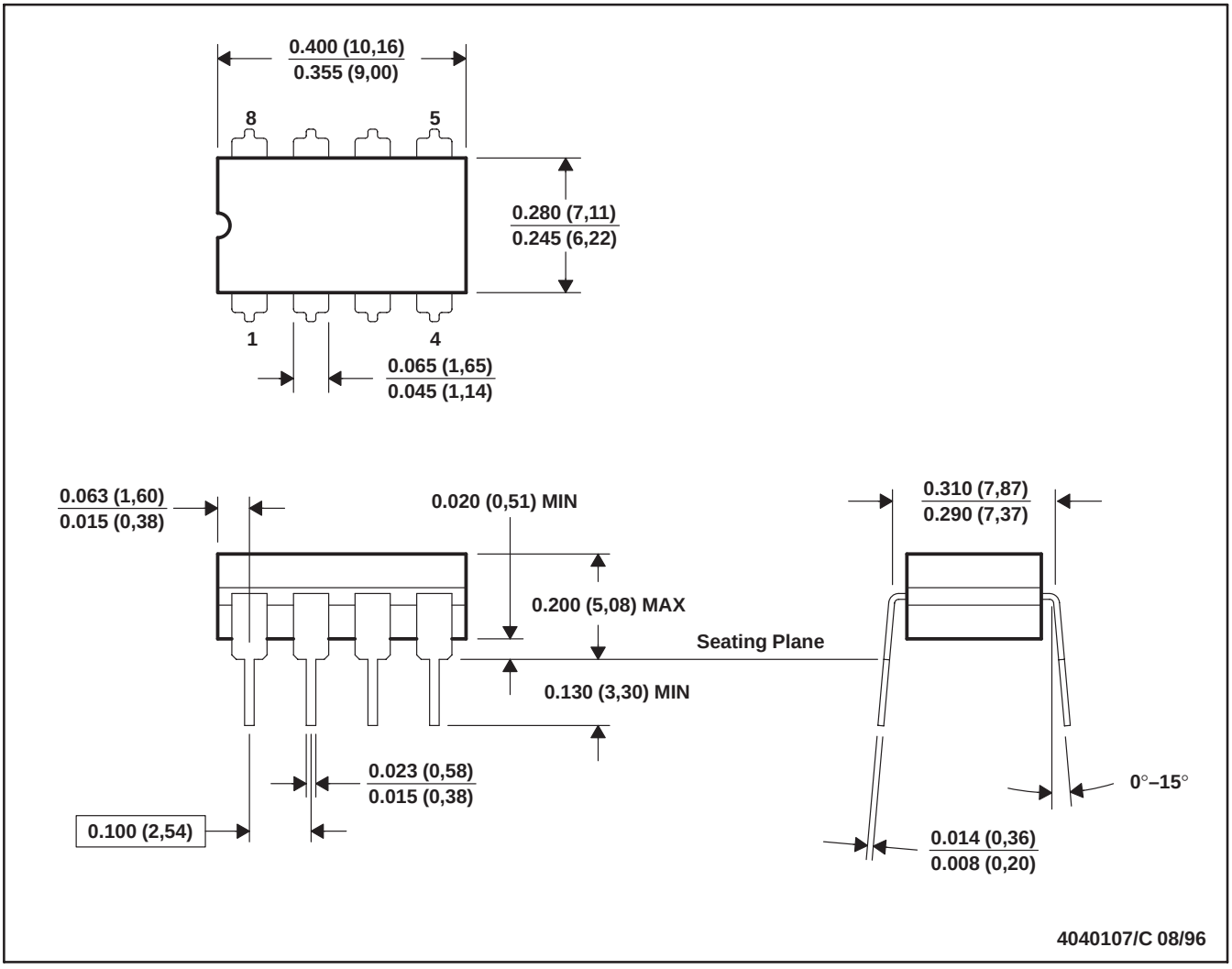
TAPE AND REEL BOX DIMENSIONS




*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|---|---|---|---|---|---|---|---|
| TLE2021ACDR | SOIC | D | 8 | 2500 | 346.0 | 346.0 | 29.0 |
| TLE2021ACDR | SOIC | D | 8 | 2500 | 340.5 | 338.1 | 20.6 |
| TLE2021CDR | SOIC | D | 8 | 2500 | 340.5 | 338.1 | 20.6 |
| TLE2021CPWR | TSSOP | PW | 8 | 2000 | 346.0 | 346.0 | 29.0 |
| TLE2021IDR | SOIC | D | 8 | 2500 | 340.5 | 338.1 | 20.6 |
| TLE2022ACDR | SOIC | D | 8 | 2500 | 340.5 | 338.1 | 20.6 |
| TLE2022AIDR | SOIC | D | 8 | 2500 | 340.5 | 338.1 | 20.6 |
| TLE2022AMDR | SOIC | D | 8 | 2500 | 346.0 | 346.0 | 29.0 |
| TLE2022CDR | SOIC | D | 8 | 2500 | 340.5 | 338.1 | 20.6 |
| TLE2022IDR | SOIC | D | 8 | 2500 | 340.5 | 338.1 | 20.6 |
| TLE2024ACDWR | SOIC | DW | 16 | 2000 | 346.0 | 346.0 | 33.0 |
| TLE2024CDWR | SOIC | DW | 16 | 2000 | 346.0 | 346.0 | 33.0 |

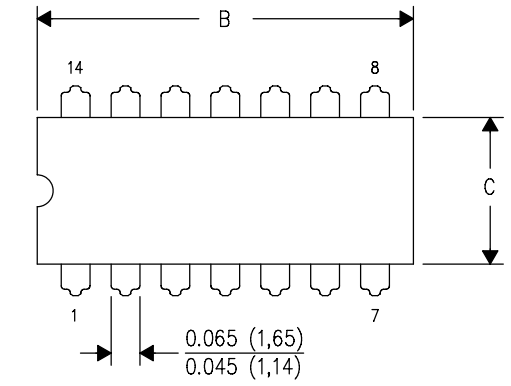
**JG (R-GDIP-T8)** **CERAMIC DUAL-IN-LINE**



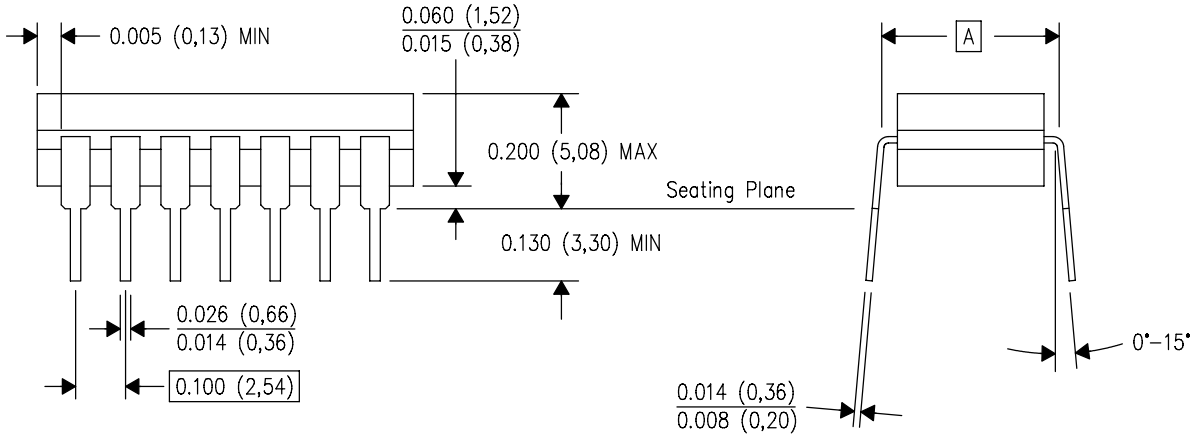

NOTES: A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. This package can be hermetically sealed with a ceramic lid using glass frit.
D. Index point is provided on cap for terminal identification.
E. Falls within MIL STD 1835 GDIP1-T8

# J (R–GDIP–T**) CERAMIC DUAL IN–LINE PACKAGE

14 LEADS SHOWN




| DIM \ PINS ** | 14 | 16 | 18 | 20 |
|---|---|---|---|---|
| A | 0.300 (7,62) BSC | 0.300 (7,62) BSC | 0.300 (7,62) BSC | 0.300 (7,62) BSC |
| B MAX | 0.785 (19,94) | .840 (21,34) | 0.960 (24,38) | 1.060 (26,92) |
| B MIN | — | — | — | — |
| C MAX | 0.300 (7,62) | 0.300 (7,62) | 0.310 (7,87) | 0.300 (7,62) |
| C MIN | 0.245 (6,22) | 0.245 (6,22) | 0.220 (5,59) | 0.245 (6,22) |

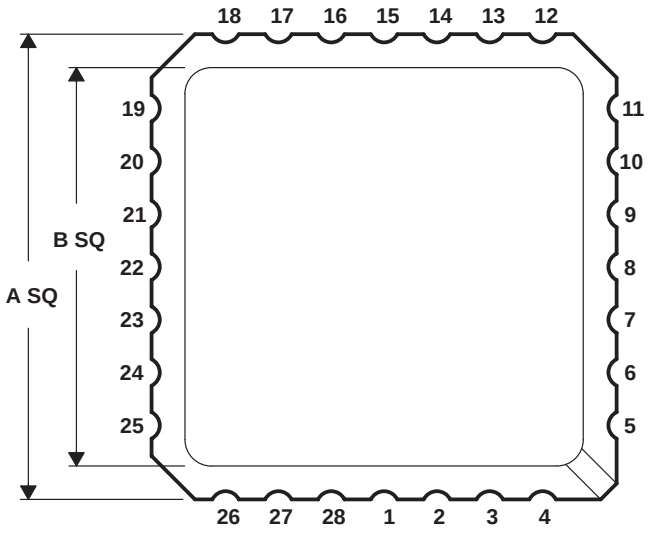



4040083/F 03/03

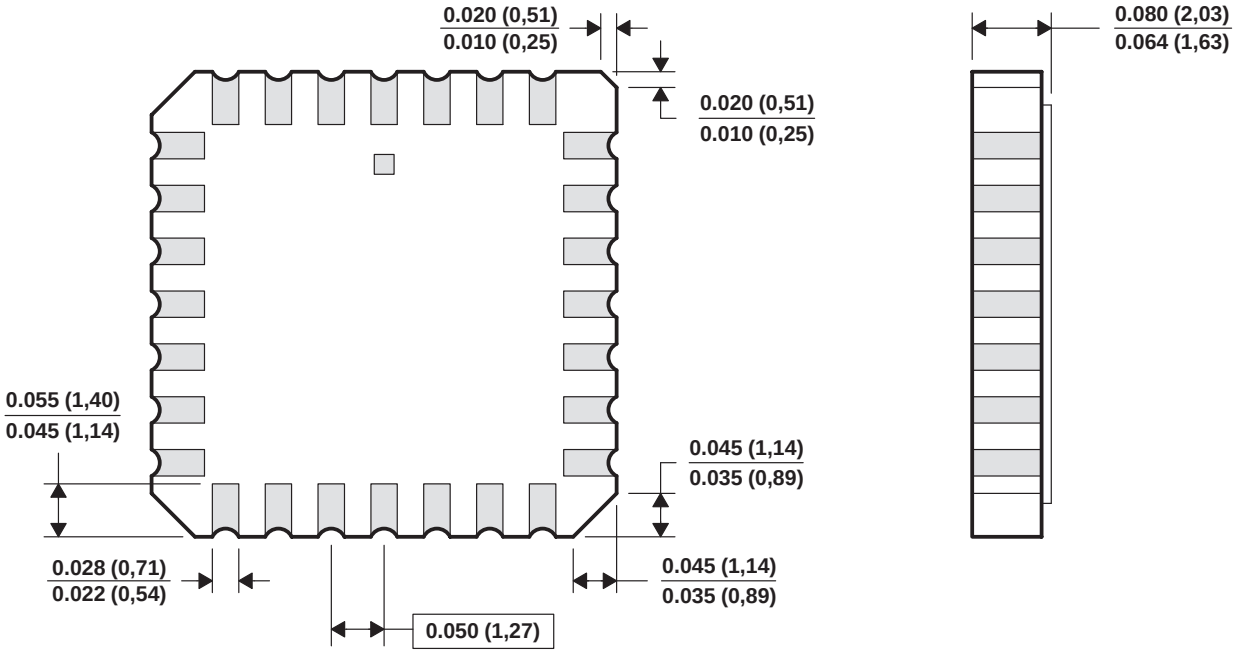
NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. This package is hermetically sealed with a ceramic lid using glass frit.
D. Index point is provided on cap for terminal identification only on press ceramic glass frit seal only.
E. Falls within MIL STD 1835 GDIP1–T14, GDIP1–T16, GDIP1–T18 and GDIP1–T20.

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

**28 TERMINAL SHOWN**



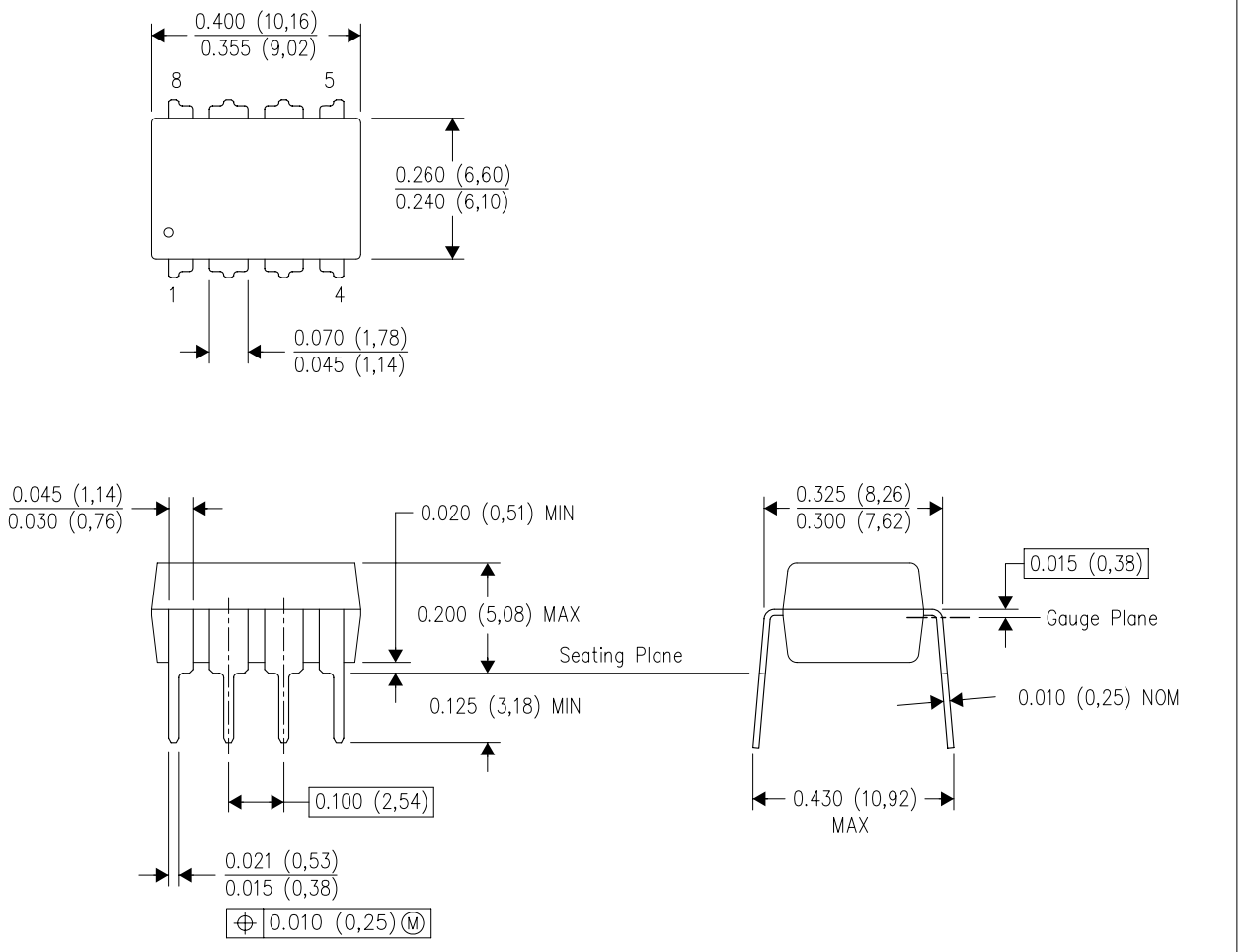

| NO. OF TERMINALS ** | A | | B | |
|---|---|---|---|---|
| | MIN | MAX | MIN | MAX |
| 20 | 0.342 (8,69) | 0.358 (9,09) | 0.307 (7,80) | 0.358 (9,09) |
| 28 | 0.442 (11,23) | 0.458 (11,63) | 0.406 (10,31) | 0.458 (11,63) |
| 44 | 0.640 (16,26) | 0.660 (16,76) | 0.495 (12,58) | 0.560 (14,22) |
| 52 | 0.739 (18,78) | 0.761 (19,32) | 0.495 (12,58) | 0.560 (14,22) |
| 68 | 0.938 (23,83) | 0.962 (24,43) | 0.850 (21,6) | 0.858 (21,8) |
| 84 | 1.141 (28,99) | 1.165 (29,59) | 1.047 (26,6) | 1.063 (27,0) |




4040140/D 10/96

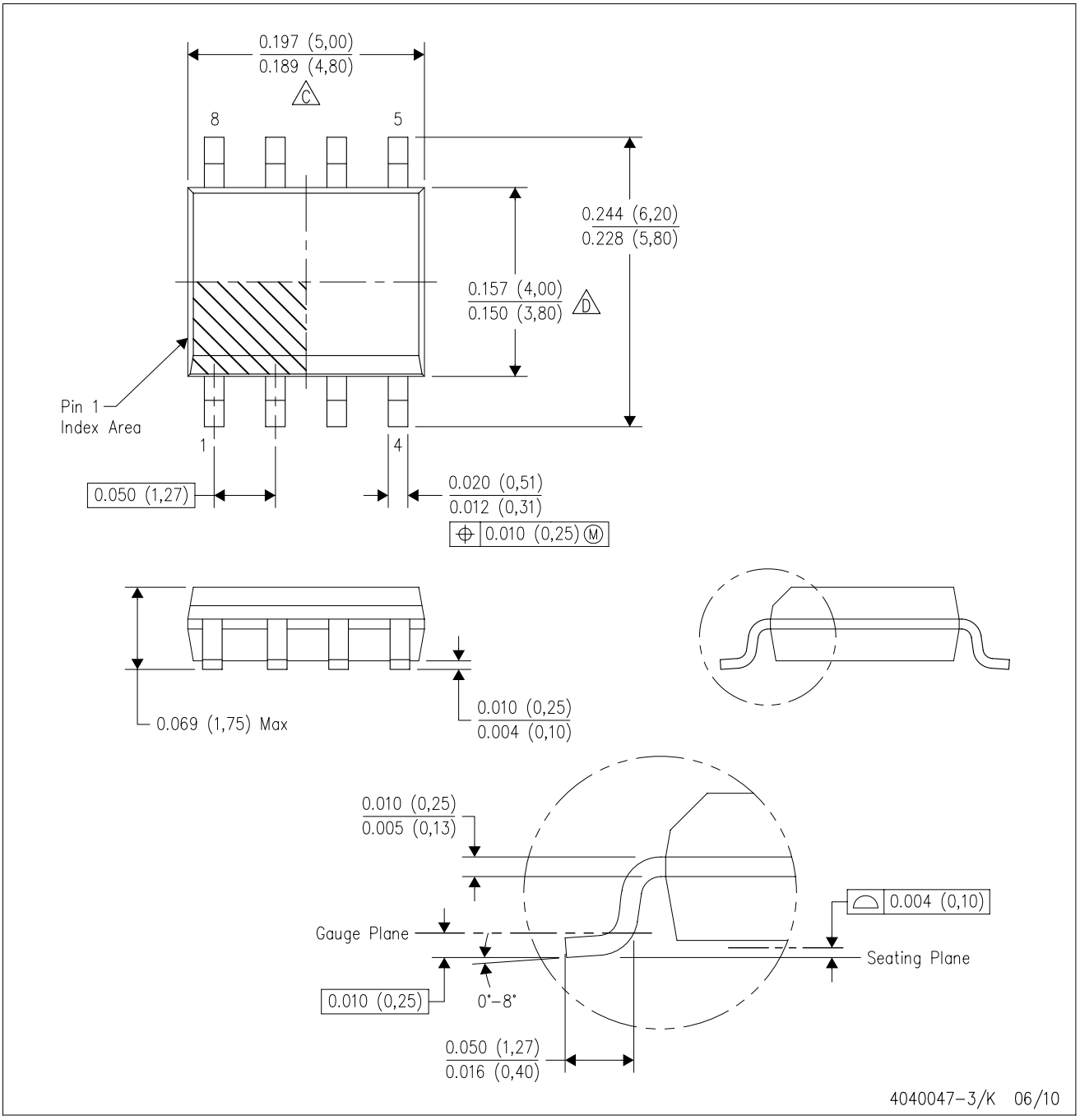
NOTES: A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. This package can be hermetically sealed with a metal lid.
D. The terminals are gold plated.
E. Falls within JEDEC MS-004

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



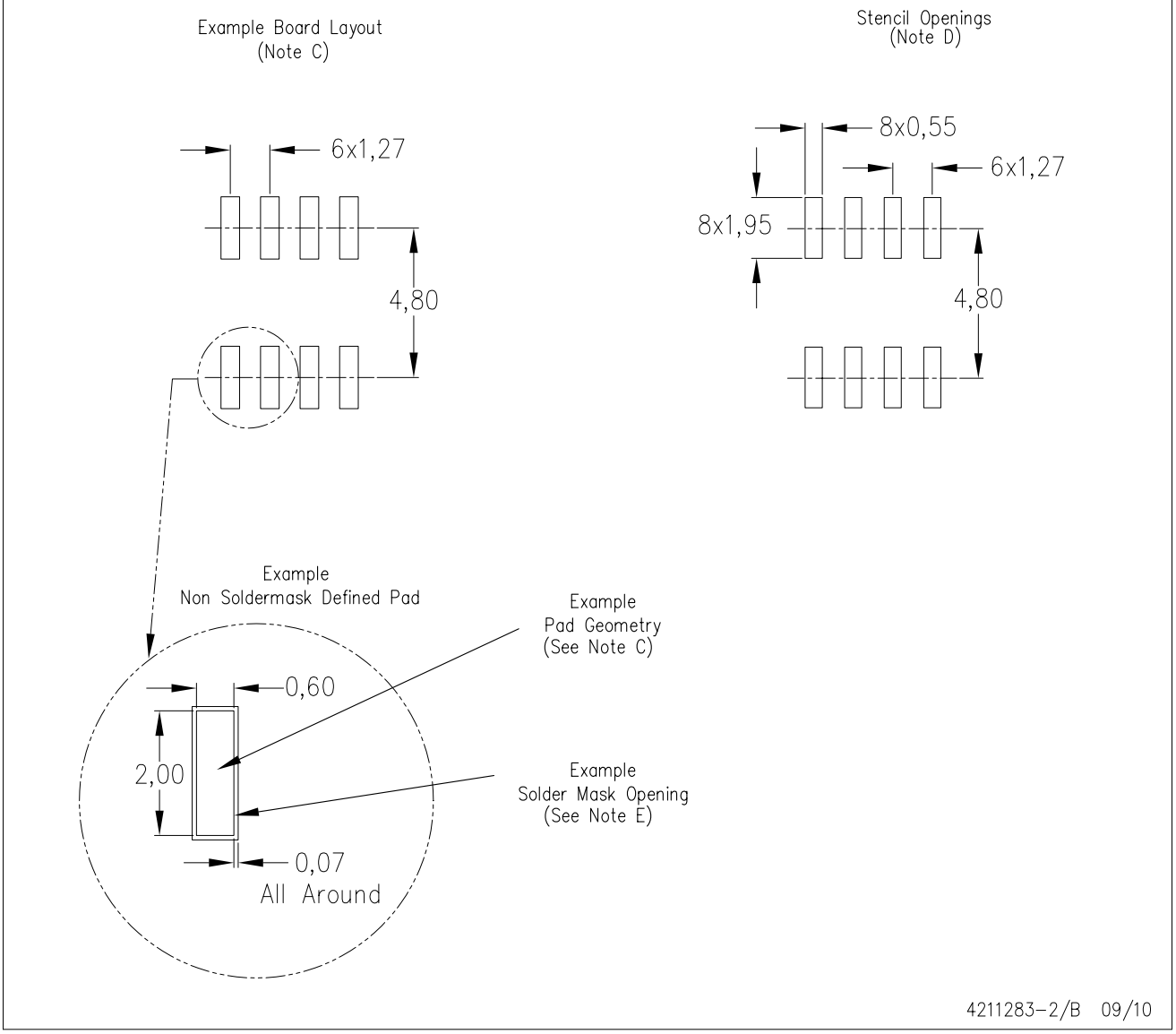

NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Falls within JEDEC MS–001 variation BA.

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



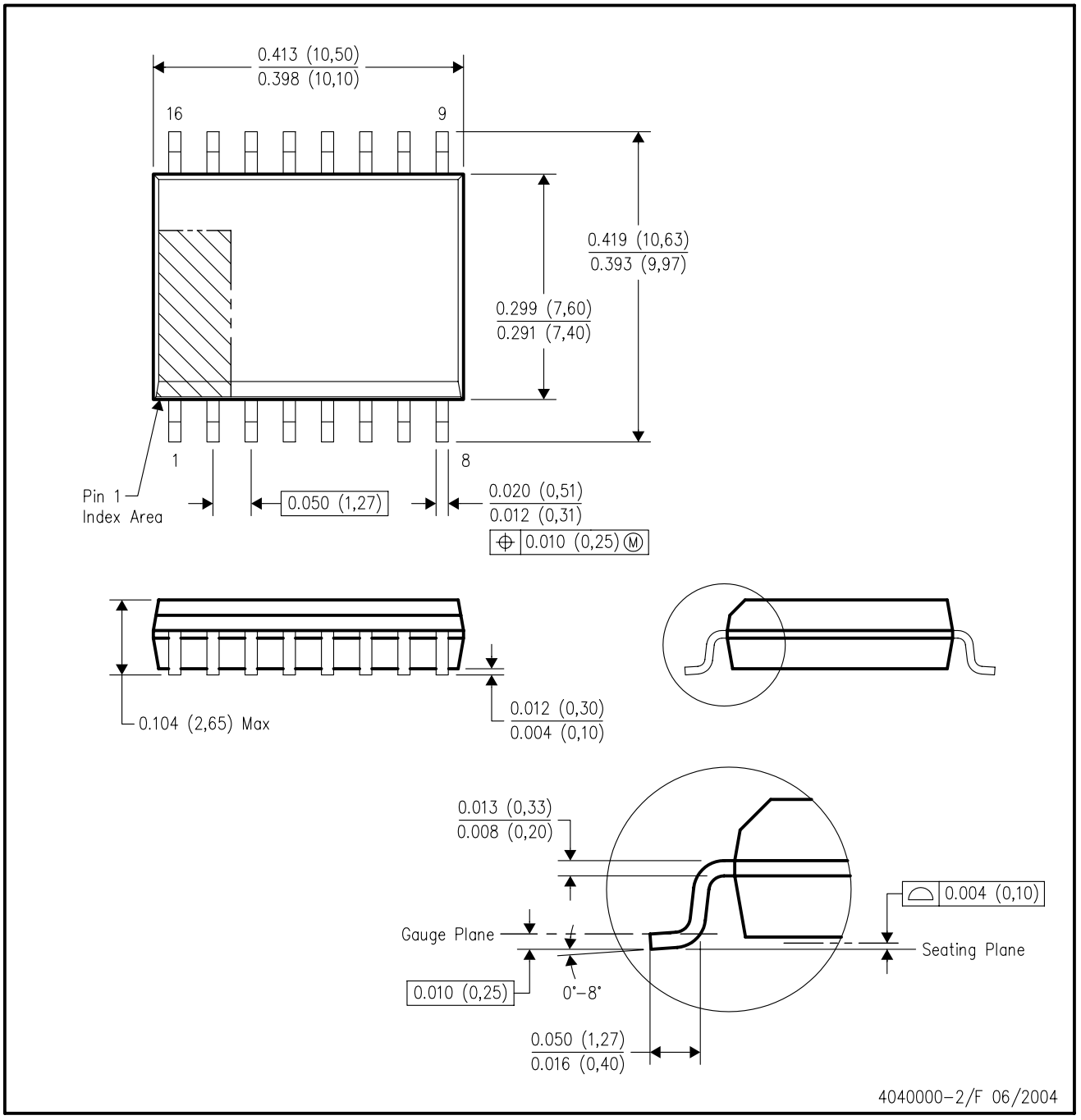

NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed .006 (0,15) per end.
D. Body width does not include interlead flash. Interlead flash shall not exceed .017 (0,43) per 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.

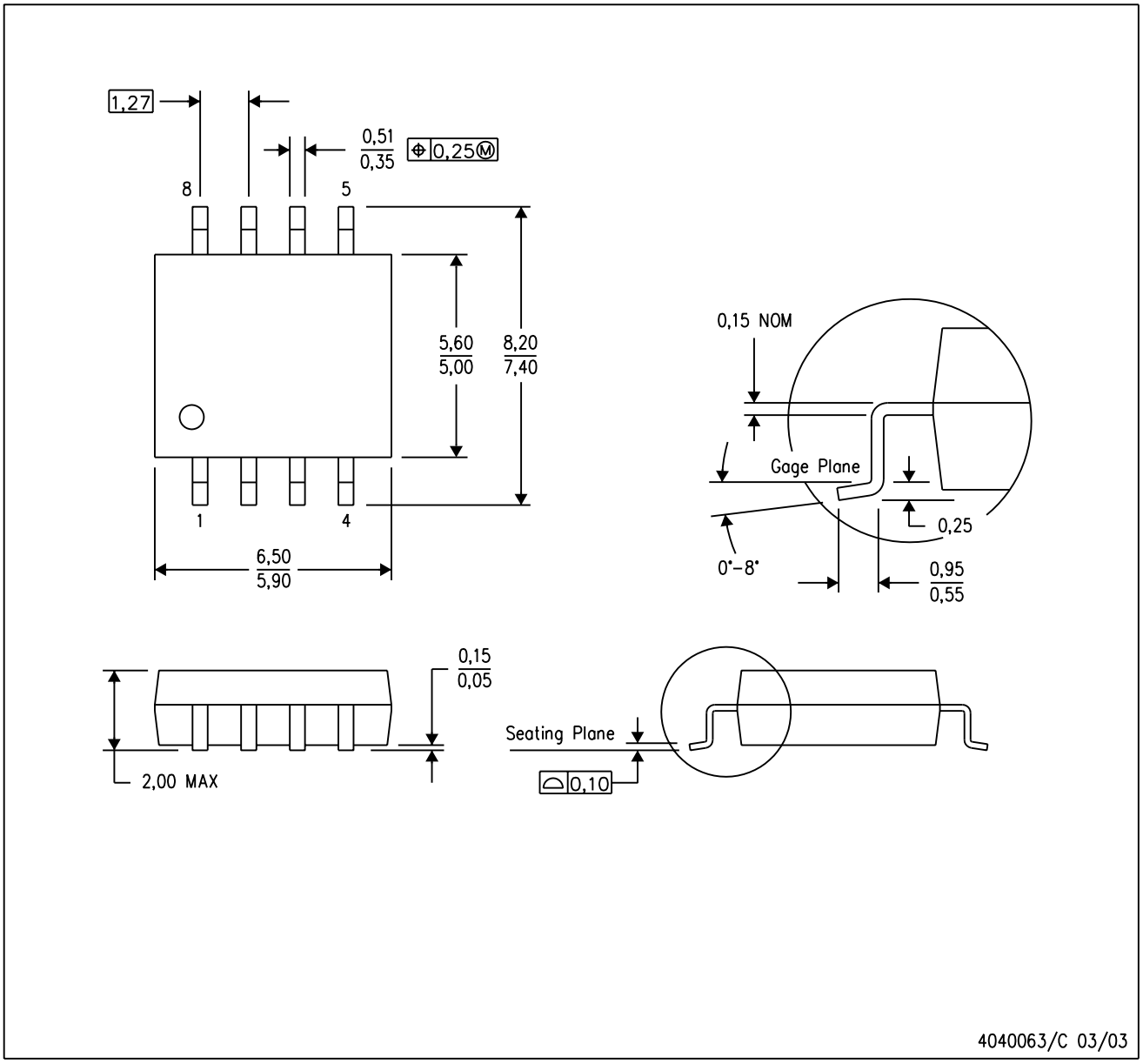
## DW (R–PDSO–G16) PLASTIC SMALL–OUTLINE PACKAGE




NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion not to exceed 0.006 (0,15).
D. Falls within JEDEC MS–013 variation AA.

## MECHANICAL DATA

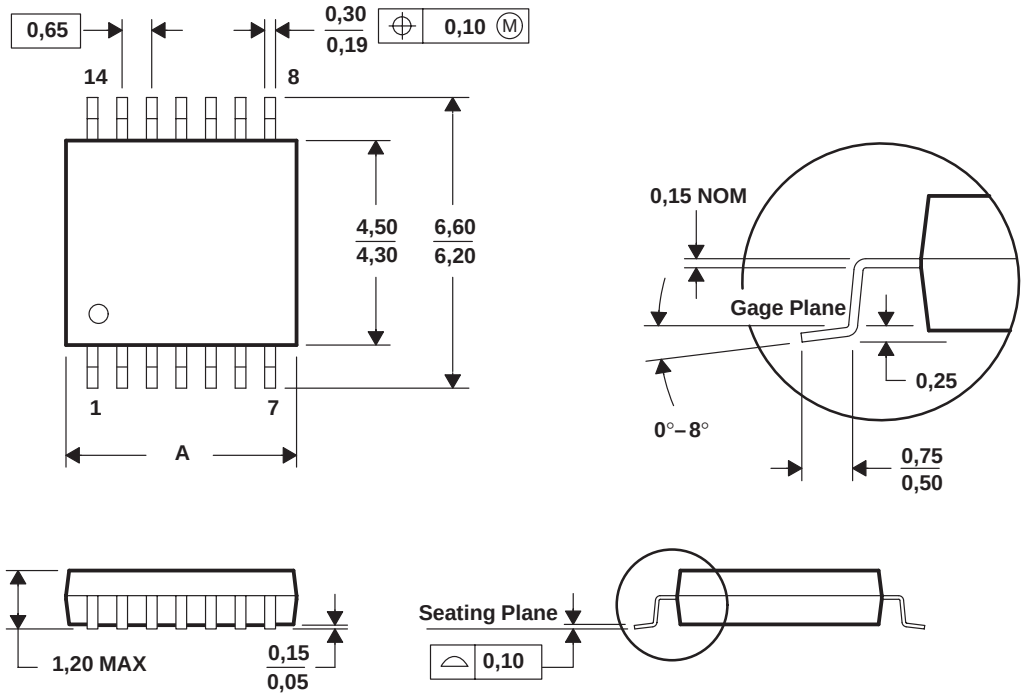
**PS (R-PDSO-G8)** **PLASTIC SMALL-OUTLINE PACKAGE**




NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion, not to exceed 0,15.

**PW (R-PDSO-G**)** **PLASTIC SMALL-OUTLINE PACKAGE**

**14 PINS SHOWN**




| DIM \ PINS ** | 8 | 14 | 16 | 20 | 24 | 28 |
|---|---|---|---|---|---|---|
| A MAX | 3,10 | 5,10 | 5,10 | 6,60 | 7,90 | 9,80 |
| A MIN | 2,90 | 4,90 | 4,90 | 6,40 | 7,70 | 9,60 |

**4040064/F 01/97**

NOTES: A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion not to exceed 0,15.
D. Falls within JEDEC MO-153

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| DSP | dsp.ti.com | Computers and Peripherals | www.ti.com/computers |
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