- **Output Swing Includes Both Supply Rails**
- **Low Noise . . . 19 nV/√Hz Typ at f = 1 kHz**
- **Low Input Bias Current . . . 1 pA Typ**
- **Fully Specified for Both Single-Supply and Split-Supply Operation**
- **Very Low Power . . . 35 μA Per Channel Typ**
- **Common-Mode Input Voltage Range Includes Negative Rail**
- **Low Input Offset Voltage 850 μV Max at $T_A$ = 25°C (TLC225xA)**
- **Macromodel Included**
- **Performance Upgrades for the TS27L2/L4 and TLC27L2/L4**
- **Available in Q–Temp Automotive HighRel Automotive Applications Configuration Control / Print Support Qualification to Automotive Standards**

## description

The TLC2252 and TLC2254 are dual and quadruple operational amplifiers from Texas Instruments. Both devices exhibit rail-to-rail output performance for increased dynamic range in single- or split-supply applications. The TLC225x family consumes only 35 μA of supply current per channel. This micropower operation makes them good choices for battery-powered applications. The noise performance has been dramatically improved over previous generations of CMOS amplifiers. Looking at Figure 1, the TLC225x has a noise level of 19 nV/√Hz at 1kHz; four times lower than competitive micropower solutions.

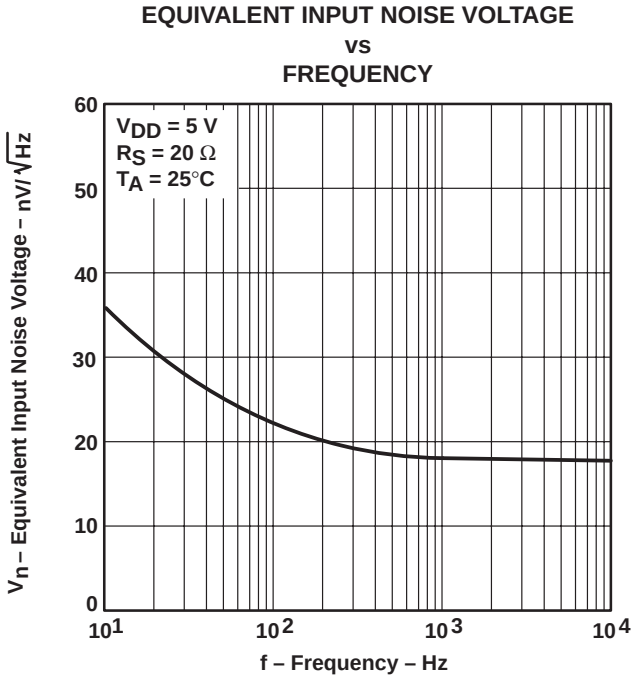



**Figure 1**

The TLC225x amplifiers, exhibiting high input impedance and low noise, are excellent for small-signal conditioning for high-impedance sources, such as piezoelectric transducers. Because of the micropower dissipation levels, these devices work well in hand-held monitoring and remote-sensing applications. In addition, the rail-to-rail output feature with single or split supplies makes this family a great choice when interfacing with analog-to-digital converters (ADCs). For precision applications, the TLC225xA family is available and has a maximum input offset voltage of 850 μV. This family is fully characterized at 5 V and ±5 V.

The TLC2252/4 also makes great upgrades to the TLC27L2/L4 or TS27L2/L4 in standard designs. They offer increased output dynamic range, lower noise voltage, and lower input offset voltage. This enhanced feature set allows them to be used in a wider range of applications. For applications that require higher output drive and wider input voltage ranges, see the TLV2432 and TLV2442 devices. If the design requires single amplifiers, please see the TLV2211/21/31 family. These devices are single rail-to-rail operational amplifiers in the SOT-23 package. Their small size and low power consumption, make them ideal for high density, battery-powered equipment.

**TLC2252 AVAILABLE OPTIONS**

| $T_A$ | $V_{IO}$max AT 25°C | PACKAGED DEVICES | | | | | |
|---|---|---|---|---|---|---|---|
| | | SMALL OUTLINE† (D) | CHIP CARRIER (FK) | CERAMIC DIP (JG) | PLASTIC DIP (P) | TSSOP‡ (PW) | CERAMIC FLATPACK (U) |
| 0°C to 70°C | 1500 µV | TLC2252CD | — | — | TLC2252CP | TLC2252CPWLE | — |
| –40°C to 85°C | 850 µV | TLC2252AID | — | — | TLC2252AIP | TLC2252AIPWLE | — |
| | 1500 µV | TLC2252ID | — | — | TLC2252IP | — | — |
| –40°C to 125°C | 850 µV | TLC2252AQD | — | — | — | — | — |
| | 1500 µV | TLC2252QD | — | — | — | — | — |
| –55°C to 125°C | 850 µV | — | TLC2252AMFK | TLC2252AMJG | — | — | TLC2252AMU |
| | 1500 µV | — | TLC2252MFK | TLC2252MJG | — | — | TLC2252MU |

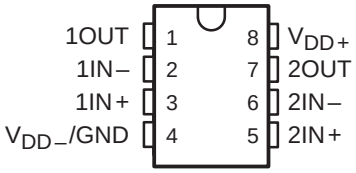
† The D packages are available taped and reeled. Add R suffix to device type (e.g., TLC2262CDR).
‡ The PW package is available only left-ended taped and reeled.
§ Chip forms are tested at 25°C only.

**TLC2254 AVAILABLE OPTIONS**

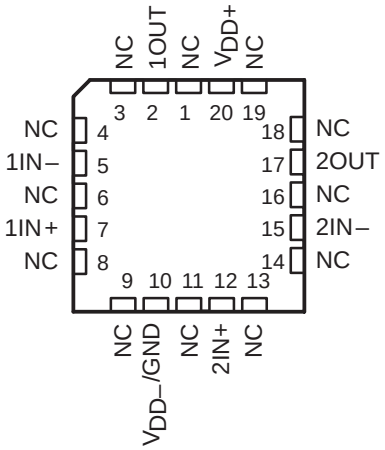
| $T_A$ | $V_{IO}$max AT 25°C | PACKAGED DEVICES | | | | | |
|---|---|---|---|---|---|---|---|
| | | SMALL OUTLINE† (D) | CHIP CARRIER (FK) | CERAMIC DIP (J) | PLASTIC DIP (N) | TSSOP‡ (PW) | CERAMIC FLATPACK (W) |
| 0°C to 70°C | 1500 µV | TLC2254CD | — | — | TLC2254CN | TLC2254CPWLE | — |
| –40°C to 85°C | 850 µV | TLC2254AID | — | — | TLC2254AIN | TLC2254AIPWLE | — |
| | 1500 µV | TLC2254ID | — | — | TLC2254IN | — | — |
| –40°C to 125°C | 850 µV | TLC2254AQD | — | — | — | — | — |
| | 1500 µV | TLC2254QD | — | — | — | — | — |
| –55°C to 125°C | 850 µV | — | TLC2254AMFK | TLC2254AMJ | — | — | TLC2254AMW |
| | 1500 µV | — | TLC2254MFK | TLC2254MJ | — | — | TLC2254MW |

† The D packages are available taped and reeled. Add R suffix to the device type (e.g., TLC2254CDR).
‡ The PW package is available only left-end taped and reeled. Chips are tested at 25°C.
§ Chip forms are tested at 25°C only.

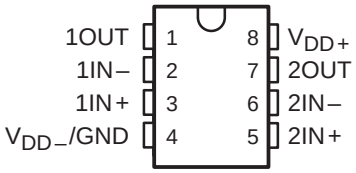
**TLC2252C, TLC2252AC**
**TLC2252I, TLC2252AI**
**TLC2252Q, TLC2252AQ**
**D, P, OR PW PACKAGE**
**(TOP VIEW)**



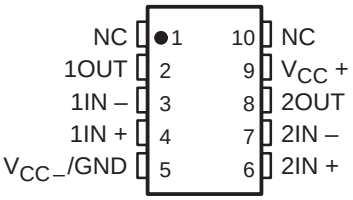

**TLC2252M, TLC2252AM . . . FK PACKAGE**
**(TOP VIEW)**



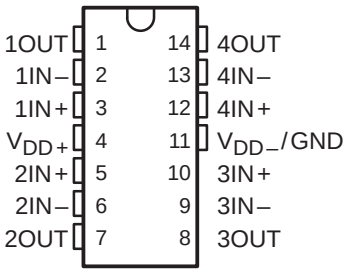

**TLC2252M, TLC2252AM . . . JG PACKAGE**
**(TOP VIEW)**



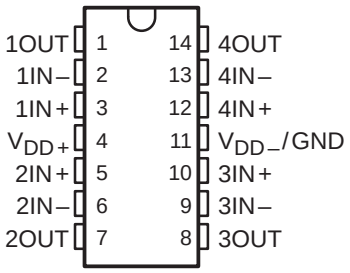

**TLC2262M, TLC2252AM . . . U PACKAGE**
**(TOP VIEW)**



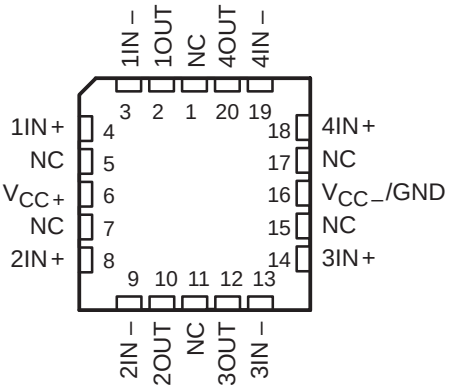

**TLC2254C, TLC2254AC**
**TLC2254I, TLC2254AI**
**TLC2254Q, TLC2254AQ**
**D, N, OR PW PACKAGE**
**(TOP VIEW)**



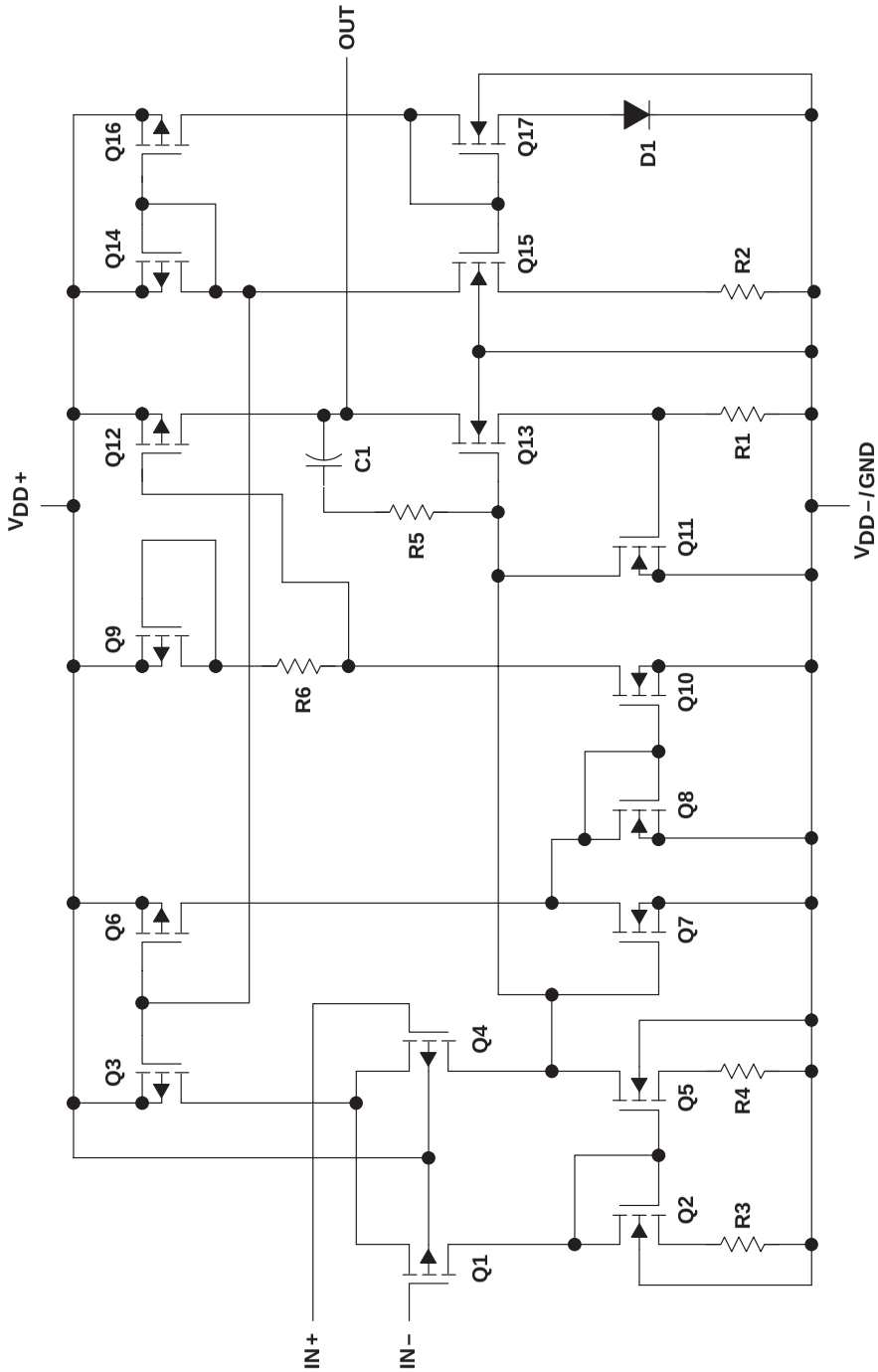

**TLC2254M, TLC2254AM**
**J OR W PACKAGE**
**(TOP VIEW)**




**TLC2254M, TLC2254AM**
**FK PACKAGE**
**(TOP VIEW)**



## equivalent schematic (each amplifier)




| ACTUAL DEVICE COMPONENT COUNT† | | |
|---|---|---|
| COMPONENT | TLC2252 | TLC2254 |
| Transistors | 38 | 76 |
| Resistors | 30 | 56 |
| Diodes | 9 | 18 |
| Capacitors | 3 | 6 |

† Includes both amplifiers and all ESD, bias, and trim circuitry

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

Supply voltage, $V_{DD+}$ (see Note 1) . . . . . 8 V
Supply voltage, $V_{DD-}$ (see Note 1) . . . . . –8 V
Differential input voltage, $V_{ID}$ (see Note 2) . . . . . ±16 V
Input voltage, $V_I$ (any input, see Note 1) . . . . . ±8 V
Input current, $I_I$ (each input) . . . . . ±5 mA
Output current, $I_O$ . . . . . ±50 mA
Total current into $V_{DD+}$ . . . . . ±50 mA
Total current out of $V_{DD-}$ . . . . . ±50 mA
Duration of short-circuit current at (or below) 25°C (see Note 3) . . . . . unlimited
Continuous total 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
Q suffix . . . . . –40°C to 125°C
M suffix . . . . . –55°C to 125°C
Storage temperature range, $T_{stg}$ . . . . . –65°C to 150°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds . . . . . 260°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 $V_{DD+}$ and $V_{DD-}$.
2. Differential voltages are at IN+ with respect to IN–. Excessive current flows when input is brought below $V_{DD-}$ – 0.3 V.
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 | 724 mW | 5.8 mW/°C | 464 mW | 377 mW | 144 mW |
| D–14 | 950 mW | 7.6 mW/°C | 608 mW | 450 mW | 190 mW |
| FK | 1375 mW | 11.0 mW/°C | 880 mW | 715 mW | 275 mW |
| J | 1375 mW | 11.0 mW/°C | 880 mW | 715 mW | 275 mW |
| JG | 1050 mW | 8.4 mW/°C | 672 mW | 546 mW | 275 mW |
| N | 1150 mW | 9.2 mW/°C | 736 mW | 736 mW | — |
| P | 1000 mW | 8.0 mW/°C | 640 mW | 520 mW | — |
| PW–8 | 525 mW | 4.2 mW/°C | 336 mW | 273 mW | — |
| PW–14 | 700 mW | 5.6 mW/°C | 448 mW | 448 mW | — |
| U | 700 mW | 5.5 mW/°C | 246 mW | 330 mW | 150 mW |
| W | 700 mW | 5.5 mW/°C | 246 mW | 330 mW | 150 mW |

### recommended operating conditions

| | C SUFFIX | | I SUFFIX | | Q SUFFIX | | M SUFFIX | | UNIT |
|---|---|---|---|---|---|---|---|---|---|
| | MIN | MAX | MIN | MAX | MIN | MAX | MIN | MAX | |
| Supply voltage, $V_{DD\pm}$ | ±2.2 | ±8 | ±2.2 | ±8 | ±2.2 | ±8 | ±2.2 | ±8 | V |
| Input voltage range, $V_I$ | $V_{DD-}$ | $V_{DD+}$ –1.5 | $V_{DD-}$ | $V_{DD+}$ –1.5 | $V_{DD-}$ | $V_{DD+}$ –1.5 | $V_{DD-}$ | $V_{DD+}$ –1.5 | V |
| Common-mode input voltage, $V_{IC}$ | $V_{DD-}$ | $V_{DD+}$ –1.5 | $V_{DD-}$ | $V_{DD+}$ –1.5 | $V_{DD-}$ | $V_{DD+}$ –1.5 | $V_{DD-}$ | $V_{DD+}$ –1.5 | V |
| Operating free-air temperature, $T_A$ | 0 | 70 | –40 | 85 | –40 | 125 | –55 | 125 | °C |

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

| PARAMETER | | TEST CONDITIONS | | $T_A$† | TLC2252C | | | UNIT |
|---|---|---|---|---|---|---|---|---|
| | | | | | MIN | TYP | MAX | |
| $V_{IO}$ | Input offset voltage | $V_{IC}$ = 0, $V_O$ = 0, | $V_{DD}\pm$ = ±2.5 V, $R_S$ = 50 Ω | 25°C | | 200 | 1500 | µV |
| | | | | Full range | | | 1750 | |
| $\alpha_{VIO}$ | Temperature coefficient of input offset voltage | | | 25°C to 70°C | | 0.5 | | µV/°C |
| | Input offset voltage long-term drift (see Note 4) | | | 25°C | | 0.003 | | µV/mo |
| $I_{IO}$ | Input offset current | | | 25°C | | 0.5 | | pA |
| | | | | Full range | | | 100 | |
| $I_{IB}$ | Input bias current | | | 25°C | | 1 | | pA |
| | | | | Full range | | | 100 | |
| $V_{ICR}$ | Common-mode input voltage range | $R_S$ = 50 Ω, | $\lvert V_{IO}\rvert \le$ 5 mV | 25°C | 0 to 4 | −0.3 to 4.2 | | V |
| | | | | Full range | 0 to 3.5 | | | |
| $V_{OH}$ | High-level output voltage | $I_{OH}$ = −20 µA | | 25°C | | 4.98 | | V |
| | | $I_{OH}$ = −75 µA | | 25°C | 4.9 | 4.94 | | |
| | | | | Full range | 4.8 | | | |
| | | $I_{OH}$ = −150 µA | | 25°C | 4.8 | 4.88 | | |
| $V_{OL}$ | Low-level output voltage | $V_{IC}$ = 2.5 V, | $I_{OL}$ = 50 µA | 25°C | | 0.01 | | V |
| | | $V_{IC}$ = 2.5 V, | $I_{OL}$ = 500 µA | 25°C | | 0.09 | 0.15 | |
| | | | | Full range | | | 0.15 | |
| | | $V_{IC}$ = 2.5 V, | $I_{OL}$ = 1 mA | 25°C | | 0.2 | 0.3 | |
| | | | | Full range | | | 0.3 | |
| | | $V_{IC}$ = 2.5 V, | $I_{OL}$ = 4 mA | 25°C | | 0.7 | 1 | |
| | | | | Full range | | | 1.2 | |
| $A_{VD}$ | Large-signal differential voltage amplification | $V_{IC}$ = 2.5 V, $V_O$ = 1 V to 4 V | $R_L$ = 100 kΩ‡ | 25°C | 100 | 350 | | V/mV |
| | | | | Full range | 10 | | | |
| | | | $R_L$ = 1 MΩ‡ | 25°C | | 1700 | | |
| $r_{id}$ | Differential input resistance | | | 25°C | | $10^{12}$ | | Ω |
| $r_{ic}$ | Common-mode input resistance | | | 25°C | | $10^{12}$ | | Ω |
| $c_{ic}$ | Common-mode input capacitance | f = 10 kHz, | P package | 25°C | | 8 | | pF |
| $z_o$ | Closed-loop output impedance | f = 25 kHz, | $A_V$ = 10 | 25°C | | 200 | | Ω |
| CMRR | Common-mode rejection ratio | $V_{IC}$ = 0 to 2.7 V, $R_S$ = 50 Ω | $V_O$ = 2.5 V, | 25°C | 70 | 83 | | dB |
| | | | | Full range | 70 | | | |
| $k_{SVR}$ | Supply-voltage rejection ratio ($\Delta V_{DD}/\Delta V_{IO}$) | $V_{DD}$ = 4.4 V to 16 V, $V_{IC}$ = $V_{DD}$/2, | No load | 25°C | 80 | 95 | | dB |
| | | | | Full range | 80 | | | |
| $I_{DD}$ | Supply current | $V_O$ = 2.5 V, | No load | 25°C | | 70 | 125 | µA |
| | | | | Full range | | | 150 | |

† Full range is 0°C to 70°C.
‡ Referenced to 2.5 V
NOTE 4: Typical values are based on the input offset voltage shift observed through 500 hours of operating life test at $T_A$ = 150°C extrapolated to $T_A$ = 25°C using the Arrhenius equation and assuming an activation energy of 0.96 eV.

## operating characteristics at specified free-air temperature, $V_{DD}$ = 5 V

| PARAMETER | | TEST CONDITIONS | | $T_A$† | TLC2252C | | | UNIT |
|---|---|---|---|---|---|---|---|---|
| | | | | | MIN | TYP | MAX | |
| SR | Slew rate at unity gain | $V_O$ = 1.5 V to 3.5 V, $R_L$ = 100 kΩ‡, $C_L$ = 100 pF‡ | | 25°C | 0.07 | 0.12 | | V/μs |
| | | | | Full range | 0.05 | | | |
| $V_n$ | Equivalent input noise voltage | f = 10 Hz | | 25°C | | 36 | | nV/√Hz |
| | | f = 1 kHz | | 25°C | | 19 | | |
| $V_{N(PP)}$ | Peak-to-peak equivalent input noise voltage | f = 0.1 Hz to 1 Hz | | 25°C | | 0.7 | | μV |
| | | f = 0.1 Hz to 10 Hz | | 25°C | | 1.1 | | |
| $I_n$ | Equivalent input noise current | | | 25°C | | 0.6 | | fA√Hz |
| THD + N | Total harmonic distortion plus noise | $V_O$ = 0.5 V to 2.5 V, f = 10 kHz, $R_L$ = 50 kΩ‡ | $A_V$ = 1 | 25°C | | 0.2% | | |
| | | | $A_V$ = 10 | | | 1% | | |
| | Gain-bandwidth product | f = 10 kHz, $C_L$ = 100 pF‡ | $R_L$ = 50 kΩ‡, | 25°C | | 0.2 | | MHz |
| $B_{OM}$ | Maximum output-swing bandwidth | $V_{O(PP)}$ = 2 V, $R_L$ = 50 kΩ‡, | $A_V$ = 1, $C_L$ = 100 pF‡ | 25°C | | 30 | | kHz |
| $\phi_m$ | Phase margin at unity gain | $R_L$ = 50 kΩ‡, | $C_L$ = 100 pF‡ | 25°C | | 63° | | |
| | Gain margin | | | 25°C | | 15 | | dB |

† Full range is 0°C to 70°C.
‡ Referenced to 2.5 V

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

| PARAMETER | | TEST CONDITIONS | | $T_A$† | TLC2252C | | | UNIT |
|---|---|---|---|---|---|---|---|---|
| | | | | | MIN | TYP | MAX | |
| $V_{IO}$ | Input offset voltage | $V_{IC}$ = 0, $R_S$ = 50 Ω | $V_O$ = 0, | 25°C | | 200 | 1500 | µV |
| | | | | Full range | | | 1750 | |
| $\alpha_{VIO}$ | Temperature coefficient of input offset voltage | | | 25°C to 70°C | | 0.5 | | µV/°C |
| | Input offset voltage long-term drift (see Note 4) | | | 25°C | | 0.003 | | µV/mo |
| $I_{IO}$ | Input offset current | | | 25°C | | 0.5 | | pA |
| | | | | Full range | | | 100 | |
| $I_{IB}$ | Input bias current | | | 25°C | | 1 | | pA |
| | | | | Full range | | | 100 | |
| $V_{ICR}$ | Common-mode input voltage range | $\|V_{IO}\|$ ≤5 mV, | $R_S$ = 50 Ω | 25°C | −5 to 4 | −5.3 to 4.2 | | V |
| | | | | Full range | −5 to 3.5 | | | |
| $V_{OM+}$ | Maximum positive peak output voltage | $I_O$ = −20 µA | | 25°C | | 4.98 | | V |
| | | $I_O$ = −100 µA | | 25°C | 4.9 | 4.93 | | |
| | | | | Full range | 4.7 | | | |
| | | $I_O$ = −200 µA | | 25°C | 4.8 | 4.86 | | |
| $V_{OM-}$ | Maximum negative peak output voltage | $V_{IC}$ = 0, | $I_O$ = 50 µA | 25°C | | −4.99 | | V |
| | | $V_{IC}$ = 0, | $I_O$ = 500 µA | 25°C | −4.85 | −4.91 | | |
| | | | | Full range | −4.85 | | | |
| | | $V_{IC}$ = 0, | $I_O$ = 1 mA | 25°C | −4.7 | −4.8 | | |
| | | | | Full range | −4.7 | | | |
| | | $V_{IC}$ = 0, | $I_O$ = 4 mA | 25°C | −4 | −4.3 | | |
| | | | | Full range | −3.8 | | | |
| $A_{VD}$ | Large-signal differential voltage amplification | $V_O$ = ±4 V | $R_L$ = 100 kΩ | 25°C | 45 | 650 | | V/mV |
| | | | | Full range | 10 | | | |
| | | | $R_L$ = 1 MΩ | 25°C | | 3000 | | |
| $r_{id}$ | Differential input resistance | | | 25°C | | $10^{12}$ | | Ω |
| $r_{ic}$ | Common-mode input resistance | | | 25°C | | $10^{12}$ | | Ω |
| $c_{ic}$ | Common-mode input capacitance | f = 10 kHz, | P package | 25°C | | 8 | | pF |
| $z_o$ | Closed-loop output impedance | f = 25 kHz, | $A_V$ = 10 | 25°C | | 190 | | Ω |
| CMRR | Common-mode rejection ratio | $V_{IC}$ = −5 V to 2.7 V, $V_O$ = 0, | $R_S$ = 50 Ω | 25°C | 75 | 88 | | dB |
| | | | | Full range | 75 | | | |
| $k_{SVR}$ | Supply-voltage rejection ratio ($\Delta V_{DD\pm}/\Delta V_{IO}$) | $V_{DD\pm}$ = 2.2 V to ±8 V, $V_{IC}$ = 0, | No load | 25°C | 80 | 95 | | dB |
| | | | | Full range | 80 | | | |
| $I_{DD}$ | Supply current | $V_O$ = 0, | No load | 25°C | | 80 | 125 | µA |
| | | | | Full range | | | 150 | |

† Full range is 0°C to 70°C.

NOTE 4: Typical values are based on the input offset voltage shift observed through 500 hours of operating life test at $T_A$ = 150°C extrapolated to $T_A$ = 25°C using the Arrhenius equation and assuming an activation energy of 0.96 eV.

## operating characteristics at specified free-air temperature, $V_{DD\pm}$ = ±5 V

| PARAMETER | | TEST CONDITIONS | | $T_A$† | TLC2252C | | | UNIT |
|---|---|---|---|---|---|---|---|---|
| | | | | | MIN | TYP | MAX | |
| SR | Slew rate at unity gain | $V_O$ = ±1.9 V, $C_L$ = 100 pF | $R_L$ = 100 kΩ, | 25°C | 0.07 | 0.12 | | V/μs |
| | | | | Full range | 0.05 | | | |
| $V_n$ | Equivalent input noise voltage | f = 10 Hz | | 25°C | | 38 | | nV/√Hz |
| | | f = 1 kHz | | 25°C | | 19 | | |
| $V_{N(PP)}$ | Peak-to-peak equivalent input noise voltage | f = 0.1 Hz to 1 Hz | | 25°C | | 0.8 | | μV |
| | | f = 0.1 Hz to 10 Hz | | 25°C | | 1.1 | | |
| $I_n$ | Equivalent input noise current | | | 25°C | | 0.6 | | fA√Hz |
| THD + N | Total harmonic distortion pulse duration | $V_O$ = ±2.3 V, f = 10 kHz, $R_L$ = 50 kΩ | $A_V$ = 1 | 25°C | | 0.2% | | |
| | | | $A_V$ = 10 | | | 1% | | |
| | Gain-bandwidth product | f = 10 kHz, $C_L$ = 100 pF | $R_L$ = 50 kΩ, | 25°C | | 0.21 | | MHz |
| $B_{OM}$ | Maximum output-swing bandwidth | $V_{O(PP)}$ = 4.6 V, $R_L$ = 50 kΩ, | $A_V$ = 1, $C_L$ = 100 pF | 25°C | | 14 | | kHz |
| $\phi_m$ | Phase margin at unity gain | $R_L$ = 50 kΩ, | $C_L$ = 100 pF | 25°C | | 63° | | |
| | Gain margin | | | 25°C | | 15 | | dB |

† Full range is 0°C to 70°C.

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

| PARAMETER | | TEST CONDITIONS | | $T_A$† | TLC2254C | | | UNIT |
|---|---|---|---|---|---|---|---|---|
| | | | | | MIN | TYP | MAX | |
| $V_{IO}$ | Input offset voltage | $V_{IC}$ = 0, $V_O$ = 0, | $V_{DD\pm}$ = ±2.5 V, $R_S$ = 50 Ω | 25°C | | 200 | 1500 | μV |
| | | | | Full range | | | 1750 | |
| $\alpha_{VIO}$ | Temperature coefficient of input offset voltage | | | 25°C to 70°C | | 0.5 | | μV/°C |
| | Input offset voltage long-term drift (see Note 4) | | | 25°C | | 0.003 | | μV/mo |
| $I_{IO}$ | Input offset current | | | 25°C | | 0.5 | | pA |
| | | | | Full range | | | 100 | |
| $I_{IB}$ | Input bias current | | | 25°C | | 1 | | pA |
| | | | | Full range | | | 100 | |
| $V_{ICR}$ | Common-mode input voltage range | $R_S$ = 50 Ω, | $\lvert V_{IO}\rvert \le$ 5 mV | 25°C | 0 to 4 | −0.3 to 4.2 | | V |
| | | | | Full range | 0 to 3.5 | | | |
| $V_{OH}$ | High-level output voltage | $I_{OH}$ = −20 μA | | 25°C | | 4.98 | | V |
| | | $I_{OH}$ = −75 μA | | 25°C | 4.9 | 4.94 | | |
| | | | | Full range | 4.8 | | | |
| | | $I_{OH}$ = −150 μA | | 25°C | 4.8 | 4.88 | | |
| $V_{OL}$ | Low-level output voltage | $V_{IC}$ = 2.5 V, | $I_{OL}$ = 50 μA | 25°C | | 0.01 | | V |
| | | $V_{IC}$ = 2.5 V, | $I_{OL}$ = 500 μA | 25°C | | 0.09 | 0.15 | |
| | | | | Full range | | | 0.15 | |
| | | $V_{IC}$ = 2.5 V, | $I_{OL}$ = 1 mA | 25°C | | 0.2 | 0.3 | |
| | | | | Full range | | | 0.3 | |
| | | $V_{IC}$ = 2.5 V, | $I_{OL}$ = 4 mA | 25°C | | 0.7 | 1 | |
| | | | | Full range | | | 1.2 | |
| $A_{VD}$ | Large-signal differential voltage amplification | $V_{IC}$ = 2.5 V, $V_O$ = 1 V to 4 V | $R_L$ = 100 kΩ‡ | 25°C | 100 | 350 | | V/mV |
| | | | | Full range | 10 | | | |
| | | | $R_L$ = 1 MΩ‡ | 25°C | | 1700 | | |
| $r_{i(d)}$ | Differential input resistance | | | 25°C | | $10^{12}$ | | Ω |
| $r_{i(c)}$ | Common-mode input resistance | | | 25°C | | $10^{12}$ | | Ω |
| $c_{i(c)}$ | Common-mode input capacitance | f = 10 kHz, | N package | 25°C | | 8 | | pF |
| $z_o$ | Closed-loop output impedance | f = 25 kHz, | $A_V$ = 10 | 25°C | | 200 | | Ω |
| CMRR | Common-mode rejection ratio | $V_{IC}$ = 0 to 2.7 V, $R_S$ = 50 Ω | $V_O$ = 2.5 V, | 25°C | 70 | 83 | | dB |
| | | | | Full range | 70 | | | |
| $k_{SVR}$ | Supply-voltage rejection ratio ($\Delta V_{DD}/\Delta V_{IO}$) | $V_{DD}$ = 4.4 V to 16 V, $V_{IC}$ = $V_{DD}$/2, | No load | 25°C | 80 | 95 | | dB |
| | | | | Full range | 80 | | | |
| $I_{DD}$ | Supply current (four amplifiers) | $V_O$ = 2.5 V, | No load | 25°C | | 140 | 250 | μA |
| | | | | Full range | | | 300 | |

† Full range is 0°C to 70°C.
‡ Referenced to 2.5 V

NOTE 4: Typical values are based on the input offset voltage shift observed through 500 hours of operating life test at $T_A$ = 150°C extrapolated to $T_A$ = 25°C using the Arrhenius equation and assuming an activation energy of 0.96 eV.

## operating characteristics at specified free-air temperature, $V_{DD}$ = 5 V

| PARAMETER | | TEST CONDITIONS | | $T_A$† | TLC2254C | | | UNIT |
|---|---|---|---|---|---|---|---|---|
| | | | | | MIN | TYP | MAX | |
| SR | Slew rate at unity gain | $V_O$ = 1.4 V to 2.6 V, $C_L$ = 100 pF‡ | $R_L$ = 100 kΩ‡, | 25°C | 0.07 | 0.12 | | V/μs |
| | | | | Full range | 0.05 | | | |
| $V_n$ | Equivalent input noise voltage | f = 10 Hz | | 25°C | | 36 | | nV/√Hz |
| | | f = 1 kHz | | 25°C | | 19 | | |
| $V_{N(PP)}$ | Peak-to-peak equivalent input noise voltage | f = 0.1 Hz to 1 Hz | | 25°C | | 0.7 | | μV |
| | | f = 0.1 Hz to 10 Hz | | 25°C | | 1.1 | | |
| $I_n$ | Equivalent input noise current | | | 25°C | | 0.6 | | fA/√Hz |
| THD + N | Total harmonic distortion plus noise | $V_O$ = 0.5 V to 2.5 V, f = 10 kHz, $R_L$ = 50 kΩ‡ | $A_V$ = 1 | 25°C | | 0.2% | | |
| | | | $A_V$ = 10 | | | 1% | | |
| | Gain-bandwidth product | f = 10 kHz, $C_L$ = 100 pF‡ | $R_L$ = 50 kΩ‡, | 25°C | | 0.2 | | MHz |
| $B_{OM}$ | Maximum output-swing bandwidth | $V_{O(PP)}$ = 2 V, $R_L$ = 50 kΩ‡, | $A_V$ = 1, $C_L$ = 100 pF‡ | 25°C | | 30 | | kHz |
| $\phi_m$ | Phase margin at unity gain | $R_L$ = 50 kΩ‡, | $C_L$ = 100 pF‡ | 25°C | | 63° | | |
| | Gain margin | | | 25°C | | 15 | | dB |

† Full range is 0°C to 70°C.
‡ Referenced to 2.5 V

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

| PARAMETER | | TEST CONDITIONS | | $T_A$† | TLC2254C | | | UNIT |
|---|---|---|---|---|---|---|---|---|
| | | | | | MIN | TYP | MAX | |
| $V_{IO}$ | Input offset voltage | $V_{IC}$ = 0, $V_O$ = 0, $R_S$ = 50 Ω | | 25°C | | 200 | 1500 | μV |
| | | | | Full range | | | 1750 | |
| $\alpha_{VIO}$ | Temperature coefficient of input offset voltage | | | 25°C to 70°C | | 0.5 | | μV/°C |
| | Input offset voltage long-term drift (see Note 4) | | | 25°C | | 0.003 | | μV/mo |
| $I_{IO}$ | Input offset current | | | 25°C | | 0.5 | | pA |
| | | | | Full range | | | 100 | |
| $I_{IB}$ | Input bias current | | | 25°C | | 1 | | pA |
| | | | | Full range | | | 100 | |
| $V_{ICR}$ | Common-mode input voltage range | $\|V_{IO}\| \le 5$ mV, $R_S$ = 50 Ω | | 25°C | −5 to 4 | −5.3 to 4.2 | | V |
| | | | | Full range | −5 to 3.5 | | | |
| $V_{OM+}$ | Maximum positive peak output voltage | $I_O$ = −20 μA | | 25°C | | 4.98 | | V |
| | | $I_O$ = −100 μA | | 25°C | 4.9 | 4.93 | | |
| | | | | Full range | 4.7 | | | |
| | | $I_O$ = −200 μA | | 25°C | 4.8 | 4.86 | | |
| $V_{OM-}$ | Maximum negative peak output voltage | $V_{IC}$ = 0, | $I_O$ = 50 μA | 25°C | | −4.99 | | V |
| | | $V_{IC}$ = 0, | $I_O$ = 500 μA | 25°C | −4.85 | −4.91 | | |
| | | | | Full range | −4.85 | | | |
| | | $V_{IC}$ = 0, | $I_O$ = 1 mA | 25°C | −4.7 | −4.8 | | |
| | | | | Full range | −4.7 | | | |
| | | $V_{IC}$ = 0, | $I_O$ = 4 mA | 25°C | −4 | −4.3 | | |
| | | | | Full range | −3.8 | | | |
| $A_{VD}$ | Large-signal differential voltage amplification | $V_O$ = ±4 V | $R_L$ = 100 kΩ | 25°C | 40 | 150 | | V/mV |
| | | | | Full range | 10 | | | |
| | | | $R_L$ = 1 MΩ | 25°C | | 3000 | | |
| $r_{i(d)}$ | Differential input resistance | | | 25°C | | $10^{12}$ | | Ω |
| $r_{i(c)}$ | Common-mode input resistance | | | 25°C | | $10^{12}$ | | Ω |
| $c_{i(c)}$ | Common-mode input capacitance | f = 10 kHz, | N package | 25°C | | 8 | | pF |
| $z_o$ | Closed-loop output impedance | f = 25 kHz, | $A_V$ = 10 | 25°C | | 190 | | Ω |
| CMRR | Common-mode rejection ratio | $V_{IC}$ = −5 V to 2.7 V, $V_O$ = 0, | $R_S$ = 50 Ω | 25°C | 75 | 88 | | dB |
| | | | | Full range | 75 | | | |
| $k_{SVR}$ | Supply-voltage rejection ratio ($\Delta V_{DD\pm}/\Delta V_{IO}$) | $V_{DD\pm}$ = ±2.2 V to ±8 V, $V_{IC}$ = 0, | No load | 25°C | 80 | 95 | | dB |
| | | | | Full range | 80 | | | |
| $I_{DD}$ | Supply current (four amplifiers) | $V_O$ = 0, | No load | 25°C | | 160 | 250 | μA |
| | | | | Full range | | | 300 | |

† Full range is 0°C to 70°C.

NOTE 4: Typical values are based on the input offset voltage shift observed through 500 hours of operating life test at $T_A$ = 150°C extrapolated to $T_A$ = 25°C using the Arrhenius equation and assuming an activation energy of 0.96 eV.

## operating characteristics at specified free-air temperature, $V_{DD\pm}$ = ±5 V

| PARAMETER | | TEST CONDITIONS | | $T_A$† | TLC2254C | | | UNIT |
|---|---|---|---|---|---|---|---|---|
| | | | | | MIN | TYP | MAX | |
| SR | Slew rate at unity gain | $V_O$ = ±1.9 V, $C_L$ = 100 pF | $R_L$ = 100 kΩ, | 25°C | 0.07 | 0.12 | | V/μs |
| | | | | Full range | 0.05 | | | |
| $V_n$ | Equivalent input noise voltage | f = 10 Hz | | 25°C | | 38 | | nV/√Hz |
| | | f = 1 kHz | | 25°C | | 19 | | |
| $V_{N(PP)}$ | Peak-to-peak equivalent input noise voltage | f = 0.1 Hz to 1 Hz | | 25°C | | 0.8 | | μV |
| | | f = 0.1 Hz to 10 Hz | | 25°C | | 1.1 | | |
| $I_n$ | Equivalent input noise current | | | 25°C | | 0.6 | | fA/√Hz |
| THD + N | Total harmonic distortion plus noise | $V_O$ = ± 2.3 V, f = 20 kHz, $R_L$ = 50 kΩ | $A_V$ = 1 | 25°C | | 0.2% | | |
| | | | $A_V$ = 10 | | | 1% | | |
| | Gain-bandwidth product | f = 10 kHz, $C_L$ = 100 pF | $R_L$ = 50 kΩ, | 25°C | | 0.21 | | MHz |
| $B_{OM}$ | Maximum output-swing bandwidth | $V_{O(PP)}$ = 4.6 V, $R_L$ = 50 kΩ, | $A_V$ = 1, $C_L$ = 100 pF | 25°C | | 14 | | kHz |
| $\phi_m$ | Phase margin at unity gain | $R_L$ = 50 kΩ, | $C_L$ = 100 pF | 25°C | | 63° | | |
| | Gain margin | | | 25°C | | 15 | | dB |

† Full range is 0°C to 70°C.

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

| PARAMETER | | TEST CONDITIONS | | $T_A$† | TLC2252I | | | TLC2252AI | | | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | MIN | TYP | MAX | MIN | TYP | MAX | |
| $V_{IO}$ | Input offset voltage | $V_{DD\pm}$ = ±2.5 V, $V_{IC}$ = 0, | $V_O$ = 0, $R_S$ = 50 Ω | 25°C | | 200 | 1500 | | 200 | 850 | μV |
| | | | | Full range | | | 1750 | | | 1000 | |
| $\alpha_{VIO}$ | Temperature coefficient of input offset voltage | | | 25°C to 85°C | | 0.5 | | | 0.5 | | μV/°C |
| | Input offset voltage long-term drift (see Note 4) | | | 25°C | | 0.003 | | | 0.003 | | μV/mo |
| $I_{IO}$ | Input offset current | | | 25°C | | 0.5 | | | 0.5 | | pA |
| | | | | Full range | | | 1000 | | | 1000 | |
| $I_{IB}$ | Input bias current | | | 25°C | | 1 | | | 1 | | pA |
| | | | | Full range | | | 1000 | | | 1000 | |
| $V_{ICR}$ | Common-mode input voltage range | $R_S$ = 50 Ω, | $\|V_{IO}\| \le$ 5 mV | 25°C | 0 to 4 | −0.3 to 4.2 | | 0 to 4 | −0.3 to 4.2 | | V |
| | | | | Full range | 0 to 3.5 | | | 0 to 3.5 | | | |
| $V_{OH}$ | High-level output voltage | $I_{OH}$ = −20 μA | | 25°C | | 4.98 | | | 4.98 | | V |
| | | $I_{OH}$ = −75 μA | | 25°C | 4.9 | 4.94 | | 4.9 | 4.94 | | |
| | | | | Full range | 4.8 | | | 4.8 | | | |
| | | $I_{OH}$ = −150 μA | | 25°C | 4.8 | 4.88 | | 4.8 | 4.88 | | |
| $V_{OL}$ | Low-level output voltage | $V_{IC}$ = 2.5 V, | $I_{OL}$ = 50 μA | 25°C | | 0.01 | | | 0.01 | | V |
| | | $V_{IC}$ = 2.5 V, | $I_{OL}$ = 500 μA | 25°C | | 0.09 | 0.15 | | 0.09 | 0.15 | |
| | | | | Full range | | | 0.15 | | | 0.15 | |
| | | $V_{IC}$ = 2.5 V, | $I_{OL}$ = 4 mA | 25°C | | 0.8 | 1 | | 0.7 | 1 | |
| | | | | Full range | | | 1.2 | | | 1.2 | |
| $A_{VD}$ | Large-signal differential voltage amplification | $V_{IC}$ = 2.5 V, $V_O$ = 1 V to 4 V | $R_L$ = 100 kΩ‡ | 25°C | 100 | 350 | | 100 | 350 | | V/mV |
| | | | | Full range | 10 | | | 10 | | | |
| | | | $R_L$ = 1 MΩ‡ | 25°C | | 1700 | | | 1700 | | |
| $r_{id}$ | Differential input resistance | | | 25°C | | $10^{12}$ | | | $10^{12}$ | | Ω |
| $r_{ic}$ | Common-mode input resistance | | | 25°C | | $10^{12}$ | | | $10^{12}$ | | Ω |
| $c_{ic}$ | Common-mode input capacitance | f = 10 kHz, | P package | 25°C | | 8 | | | 8 | | pF |
| $z_o$ | Closed-loop output impedance | f = 25 kHz, | $A_V$ = 10 | 25°C | | 200 | | | 200 | | Ω |
| CMRR | Common-mode rejection ratio | $V_{IC}$ = 0 to 2.7 V, $R_S$ = 50 Ω | $V_O$ = 2.5 V, | 25°C | 70 | 83 | | 70 | 83 | | dB |
| | | | | Full range | 70 | | | 70 | | | |
| $k_{SVR}$ | Supply-voltage rejection ratio ($\Delta V_{DD}/\Delta V_{IO}$) | $V_{DD}$ = 4.4 V to 16 V, $V_{IC}$ = $V_{DD}$/2, | No load | 25°C | 80 | 95 | | 80 | 95 | | dB |
| | | | | Full range | 80 | | | 80 | | | |
| $I_{DD}$ | Supply current | $V_O$ = 2.5 V, | No load | 25°C | | 70 | 125 | | 70 | 125 | μA |
| | | | | Full range | | | 150 | | | 150 | |

† Full range is – 40°C to 125°C.
‡ Referenced to 2.5 V
NOTE 4: Typical values are based on the input offset voltage shift observed through 500 hours of operating life test at $T_A$ = 150°C extrapolated to $T_A$ = 25°C using the Arrhenius equation and assuming an activation energy of 0.96 eV.

## operating characteristics at specified free-air temperature, $V_{DD}$ = 5 V

| PARAMETER | | TEST CONDITIONS | | $T_A$† | TLC2252I | | | TLC2252AI | | | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | MIN | TYP | MAX | MIN | TYP | MAX | |
| SR | Slew rate at unity gain | $V_O$ = 1.5 V to 3.5 V, $R_L$ = 100 kΩ‡, $C_L$ = 100 pF‡ | | 25°C | 0.07 | 0.12 | | 0.07 | 0.12 | | V/μs |
| | | | | Full range | 0.05 | | | 0.05 | | | |
| $V_n$ | Equivalent input noise voltage | f = 10 Hz | | 25°C | | 36 | | | 36 | | nV/√Hz |
| | | f = 1 kHz | | 25°C | | 19 | | | 19 | | |
| $V_{N(PP)}$ | Peak-to-peak equivalent input noise voltage | f = 0.1 Hz to 1 Hz | | 25°C | | 0.7 | | | 0.7 | | μV |
| | | f = 0.1 Hz to 10 Hz | | 25°C | | 1.1 | | | 1.1 | | |
| $I_n$ | Equivalent input noise current | | | 25°C | | 0.6 | | | 0.6 | | fA√Hz |
| THD + N | Total harmonic distortion plus noise | $V_O$ = 0.5 V to 2.5 V, f = 10 kHz, $R_L$ = 50 kΩ‡ | $A_V$ = 1 | 25°C | | 0.2% | | | 0.2% | | |
| | | | $A_V$ = 10 | | | 1% | | | 1% | | |
| | Gain-bandwidth product | f = 50 kHz, $C_L$ = 100 pF‡ | $R_L$ = 50 kΩ‡, | 25°C | | 0.2 | | | 0.2 | | MHz |
| $B_{OM}$ | Maximum output-swing bandwidth | $V_{O(PP)}$ = 2 V, $R_L$ = 50 kΩ‡, | $A_V$ = 1, $R_L$ = 50 kΩ‡, | 25°C | | 30 | | | 30 | | kHz |
| $\phi_m$ | Phase margin at unity gain | $R_L$ = 50 kΩ‡, | $C_L$ = 100 pF‡ | 25°C | | 63° | | | 63° | | |
| | Gain margin | | | 25°C | | 15 | | | 15 | | dB |

† Full range is – 40°C to 125°C.
‡ Referenced to 2.5 V

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

| PARAMETER | | TEST CONDITIONS | | $T_A$† | TLC2252I | | | TLC2252AI | | | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | MIN | TYP | MAX | MIN | TYP | MAX | |
| $V_{IO}$ | Input offset voltage | $V_{IC}$ = 0, $R_S$ = 50 Ω | $V_O$ = 0, | 25°C | | 200 | 1500 | | 200 | 850 | μV |
| | | | | Full range | | | 1750 | | | 1000 | |
| $\alpha_{VIO}$ | Temperature coefficient of input offset voltage | | | 25°C to 85°C | | 0.5 | | | 0.5 | | μV/°C |
| | Input offset voltage long-term drift (see Note 4) | | | 25°C | | 0.003 | | | 0.003 | | μV/mo |
| $I_{IO}$ | Input offset current | | | 25°C | | 0.5 | | | 0.5 | | pA |
| | | | | Full range | | | 1000 | | | 1000 | |
| $I_{IB}$ | Input bias current | | | 25°C | | 1 | | | 1 | | pA |
| | | | | Full range | | | 1000 | | | 1000 | |
| $V_{ICR}$ | Common-mode input voltage range | $R_S$ = 50 Ω, | $\lvert V_{IO}\rvert \le$5 mV | 25°C | −5 to 4 | −5.3 to 4.2 | | −5 to 4 | −5.3 to 4.2 | | V |
| | | | | Full range | −5 to 3.5 | | | −5 to 3.5 | | | |
| $V_{OM+}$ | Maximum positive peak output voltage | $I_O$ = −20 μA | | 25°C | | 4.98 | | | 4.98 | | V |
| | | $I_O$ = −100 μA | | 25°C | 4.9 | 4.93 | | 4.9 | 4.93 | | |
| | | | | Full range | 4.7 | | | 4.7 | | | |
| | | $I_O$ = −200 μA | | 25°C | 4.8 | 4.86 | | 4.8 | 4.86 | | |
| $V_{OM-}$ | Maximum negative peak output voltage | $V_{IC}$ = 0, | $I_O$ = 50 μA | 25°C | | −4.99 | | | −4.99 | | V |
| | | $V_{IC}$ = 0, | $I_O$ = 500 μA | 25°C | −4.85 | −4.91 | | −4.85 | −4.91 | | |
| | | | | Full range | −4.85 | | | −4.85 | | | |
| | | $V_{IC}$ = 0, | $I_O$ = 4 mA | 25°C | −4 | −4.3 | | −4 | −4.3 | | |
| | | | | Full range | −3.8 | | | −3.8 | | | |
| $A_{VD}$ | Large-signal differential voltage amplification | $V_O$ = ±4 V | $R_L$ = 50 kΩ | 25°C | 40 | 150 | | 40 | 150 | | V/mV |
| | | | | Full range | 10 | | | 10 | | | |
| | | | $R_L$ = 1 MΩ | 25°C | | 3000 | | | 3000 | | |
| $r_{id}$ | Differential input resistance | | | 25°C | | $10^{12}$ | | | $10^{12}$ | | Ω |
| $r_{ic}$ | Common-mode input resistance | | | 25°C | | $10^{12}$ | | | $10^{12}$ | | Ω |
| $c_{ic}$ | Common-mode input capacitance | f = 10 kHz, | P package | 25°C | | 8 | | | 8 | | pF |
| $z_o$ | Closed-loop output impedance | f = 25 kHz, | $A_V$ = 10 | 25°C | | 190 | | | 190 | | Ω |
| CMRR | Common-mode rejection ratio | $V_{IC}$ = −5 V to 2.7 V, $V_O$ = 0, | $R_S$ = 50 Ω | 25°C | 75 | 88 | | 75 | 88 | | dB |
| | | | | Full range | 75 | | | 75 | | | |
| $k_{SVR}$ | Supply-voltage rejection ratio ($\Delta V_{DD\pm}/\Delta V_{IO}$) | $V_{DD}$ = 4.4 V to 16 V, $V_{IC}$ = $V_{DD}$/2, No load | | 25°C | 80 | 95 | | 80 | 95 | | dB |
| | | | | Full range | 80 | | | 80 | | | |
| $I_{DD}$ | Supply current | $V_O$ = 2.5 V, | No load | 25°C | | 80 | 125 | | 80 | 125 | μA |
| | | | | Full range | | | 150 | | | 150 | |

† Full range is – 40°C to 125°C.

NOTE 4: Typical values are based on the input offset voltage shift observed through 500 hours of operating life test at $T_A$ = 150°C extrapolated to $T_A$ = 25°C using the Arrhenius equation and assuming an activation energy of 0.96 eV.

## operating characteristics at specified free-air temperature, $V_{DD\pm}$ = ±5 V

| PARAMETER | | TEST CONDITIONS | | $T_A$† | TLC2252I | | | TLC2252AI | | | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | MIN | TYP | MAX | MIN | TYP | MAX | |
| SR | Slew rate at unity gain | $V_O$ = ±1.9 V, $C_L$ = 100 pF | $R_L$ = 100 kΩ, | 25°C | 0.07 | 0.12 | | 0.07 | 0.12 | | V/μs |
| | | | | Full range | 0.05 | | | 0.05 | | | |
| $V_n$ | Equivalent input noise voltage | f = 10 Hz | | 25°C | | 38 | | | 38 | | nV/√Hz |
| | | f = 1 kHz | | 25°C | | 19 | | | 19 | | |
| $V_{N(PP)}$ | Peak-to-peak equivalent input noise voltage | f = 0.1 Hz to 1 Hz | | 25°C | | 0.8 | | | 0.8 | | μV |
| | | f = 0.1 Hz to 10 Hz | | 25°C | | 1.1 | | | 1.1 | | |
| $I_n$ | Equivalent input noise current | | | 25°C | | 0.6 | | | 0.6 | | fA√Hz |
| THD + N | Total harmonic distortion plus noise | $V_O$ = ±2.3 V, $R_L$ = 50 kΩ, f = 10 kHz | $A_V$ = 1 | 25°C | | 0.2% | | | 0.2% | | |
| | | | $A_V$ = 10 | | | 1% | | | 1% | | |
| | Gain-bandwidth product | f = 10 kHz, $C_L$ = 100 pF | $R_L$ = 50 kΩ, | 25°C | | 0.21 | | | 0.21 | | MHz |
| $B_{OM}$ | Maximum output-swing bandwidth | $V_{O(PP)}$ = 4.6 V, $R_L$ = 50 kΩ, | $A_V$ = 1, $C_L$ = 100 pF | 25°C | | 14 | | | 14 | | kHz |
| $\phi_m$ | Phase margin at unity gain | $R_L$ = 50 kΩ, | $C_L$ = 100 pF | 25°C | | 63° | | | 63° | | |
| | Gain margin | | | 25°C | | 15 | | | 15 | | dB |

† Full range is –40°C to 125°C.

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

| PARAMETER | | TEST CONDITIONS | | $T_A$† | TLC2254I | | | TLC2254AI | | | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | MIN | TYP | MAX | MIN | TYP | MAX | |
| $V_{IO}$ | Input offset voltage | $V_{DD\pm}$ = ±2.5 V, $V_{IC}$ = 0, $V_O$ = 0, $R_S$ = 50 Ω | | 25°C | | 200 | 1500 | | 200 | 850 | μV |
| | | | | Full range | | | 1750 | | | 1000 | |
| $\alpha_{VIO}$ | Temperature coefficient of input offset voltage | | | 25°C to 125°C | | 0.5 | | | 0.5 | | μV/°C |
| | Input offset voltage long-term drift (see Note 4) | | | 25°C | | 0.003 | | | 0.003 | | μV/mo |
| $I_{IO}$ | Input offset current | | | 25°C | | 0.5 | | | 0.5 | | pA |
| | | | | Full range | | | 1000 | | | 1000 | |
| $I_{IB}$ | Input bias current | | | 25°C | | 1 | | | 1 | | pA |
| | | | | Full range | | | 1000 | | | 1000 | |
| $V_{ICR}$ | Common-mode input voltage range | $R_S$ = 50 Ω, | $\lvert V_{IO}\rvert \le$ 5 mV | 25°C | 0 to 4 | −0.3 to 4.2 | | 0 to 4 | −0.3 to 4.2 | | V |
| | | | | Full range | 0 to 3.5 | | | 0 to 3.5 | | | |
| $V_{OH}$ | High-level output voltage | $I_{OH}$ = −20 μA | | 25°C | | 4.98 | | | 4.98 | | V |
| | | $I_{OH}$ = −75 μA | | 25°C | 4.9 | 4.94 | | 4.9 | 4.94 | | |
| | | | | Full range | 4.8 | | | 4.8 | | | |
| | | $I_{OH}$ = −150 μA | | 25°C | 4.8 | 4.88 | | 4.8 | 4.88 | | |
| $V_{OL}$ | Low-level output voltage | $V_{IC}$ = 2.5 V, | $I_{OL}$ = 50 μA | 25°C | | 0.01 | | | 0.01 | | V |
| | | $V_{IC}$ = 2.5 V, | $I_{OL}$ = 500 μA | 25°C | | 0.09 | 0.15 | | 0.09 | 0.15 | |
| | | | | Full range | | | 0.15 | | | 0.15 | |
| | | $V_{IC}$ = 2.5 V, | $I_{OL}$ = 4 mA | 25°C | | 0.8 | 1 | | 0.7 | 1 | |
| | | | | Full range | | | 1.2 | | | 1.2 | |
| $A_{VD}$ | Large-signal differential voltage amplification | $V_{IC}$ = 2.5 V, $V_O$ = 1 V to 4 V | $R_L$ = 100 kΩ‡ | 25°C | 100 | 350 | | 100 | 350 | | V/mV |
| | | | | Full range | 10 | | | 10 | | | |
| | | | $R_L$ = 1 MΩ‡ | 25°C | | 1700 | | | 1700 | | |
| $r_{i(d)}$ | Differential input resistance | | | 25°C | | $10^{12}$ | | | $10^{12}$ | | Ω |
| $r_{i(c)}$ | Common-mode input resistance | | | 25°C | | $10^{12}$ | | | $10^{12}$ | | Ω |
| $c_{i(c)}$ | Common-mode input capacitance | f = 10 kHz, | N package | 25°C | | 8 | | | 8 | | pF |
| $z_o$ | Closed-loop output impedance | f = 25 kHz, | $A_V$ = 10 | 25°C | | 200 | | | 200 | | Ω |
| CMRR | Common-mode rejection ratio | $V_{IC}$ = 0 to 2.7 V, $V_O$ = 2.5 V, $R_S$ = 50 Ω | | 25°C | 70 | 83 | | 70 | 83 | | dB |
| | | | | Full range | 70 | | | 70 | | | |
| $k_{SVR}$ | Supply-voltage rejection ratio ($\Delta V_{DD}/\Delta V_{IO}$) | $V_{DD}$ = 4.4 V to 16 V, $V_{IC}$ = $V_{DD}$/2, | No load | 25°C | 80 | 95 | | 80 | 95 | | dB |
| | | | | Full range | 80 | | | 80 | | | |
| $I_{DD}$ | Supply current (four amplifiers) | $V_O$ = 2.5 V, | No load | 25°C | | 140 | 250 | | 140 | 250 | μA |
| | | | | Full range | | | 300 | | | 300 | |

† Full range is – 40°C to 125°C.
‡ Referenced to 2.5 V
NOTE 4: Typical values are based on the input offset voltage shift observed through 500 hours of operating life test at $T_A$ = 150°C extrapolated to $T_A$ = 25°C using the Arrhenius equation and assuming an activation energy of 0.96 eV.

## operating characteristics at specified free-air temperature, $V_{DD}$ = 5 V

| PARAMETER | | TEST CONDITIONS | | $T_A$† | TLC2254I | | | TLC2254AI | | | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | MIN | TYP | MAX | MIN | TYP | MAX | |
| SR | Slew rate at unity gain | $V_O$ = 1.4 V to 2.6 V, $R_L$ = 100 kΩ‡, $C_L$ = 100 pF‡ | | 25°C | 0.07 | 0.12 | | 0.07 | 0.12 | | V/μs |
| | | | | Full range | 0.05 | | | 0.05 | | | |
| $V_n$ | Equivalent input noise voltage | f = 10 Hz | | 25°C | | 36 | | | 36 | | nV/√Hz |
| | | f = 1 kHz | | 25°C | | 19 | | | 19 | | |
| $V_{N(PP)}$ | Peak-to-peak equivalent input noise voltage | f = 0.1 Hz to 1 Hz | | 25°C | | 0.7 | | | 0.7 | | μV |
| | | f = 0.1 Hz to 10 Hz | | 25°C | | 1.1 | | | 1.1 | | |
| $I_n$ | Equivalent input noise current | | | 25°C | | 0.6 | | | 0.6 | | fA/√Hz |
| THD + N | Total harmonic distortion plus noise | $V_O$ = 0.5 V to 2.5 V, f = 20 kHz, $R_L$ = 50 kΩ‡ | $A_V$ = 1 | 25°C | | 0.2% | | | 0.2% | | |
| | | | $A_V$ = 10 | | | 1% | | | 1% | | |
| | Gain-bandwidth product | f = 50 kHz, $C_L$ = 100 pF‡ | $R_L$ = 50 kΩ‡, | 25°C | | 0.2 | | | 0.2 | | MHz |
| $B_{OM}$ | Maximum output-swing bandwidth | $V_{O(PP)}$ = 2 V, $R_L$ = 50 kΩ‡, | $A_V$ = 1, $C_L$ = 100 pF‡ | 25°C | | 30 | | | 30 | | kHz |
| $\phi_m$ | Phase margin at unity gain | $R_L$ = 50 kΩ‡, | $C_L$ = 100 pF‡ | 25°C | | 63° | | | 63° | | |
| | Gain margin | | | 25°C | | 15 | | | 15 | | dB |

† Full range is – 40°C to 125°C.
‡ Referenced to 2.5 V

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

| PARAMETER | | TEST CONDITIONS | | $T_A$† | TLC2254I | | | TLC2254AI | | | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | MIN | TYP | MAX | MIN | TYP | MAX | |
| $V_{IO}$ | Input offset voltage | $V_{IC}$ = 0, $V_O$ = 0, $R_S$ = 50 Ω | | 25°C | | 200 | 1500 | | 200 | 850 | μV |
| | | | | Full range | | | 1750 | | | 1000 | |
| $\alpha_{VIO}$ | Temperature coefficient of input offset voltage | | | 25°C to 125°C | | 0.5 | | | 0.5 | | μV/°C |
| | Input offset voltage long-term drift (see Note 4) | | | 25°C | | 0.003 | | | 0.003 | | μV/mo |
| $I_{IO}$ | Input offset current | | | 25°C | | 0.5 | | | 0.5 | | pA |
| | | | | Full range | | | 1000 | | | 1000 | |
| $I_{IB}$ | Input bias current | | | 25°C | | 1 | | | 1 | | pA |
| | | | | Full range | | | 1000 | | | 1000 | |
| $V_{ICR}$ | Common-mode input voltage range | $R_S$ = 50 Ω, $\|V_{IO}\| \le$ 5 mV | | 25°C | −5 to 4 | −5.3 to 4.2 | | −5 to 4 | −5.3 to 4.2 | | V |
| | | | | Full range | −5 to 3.5 | | | −5 to 3.5 | | | |
| $V_{OM+}$ | Maximum positive peak output voltage | $I_O$ = −20 μA | | 25°C | | 4.98 | | | 4.98 | | V |
| | | $I_O$ = −100 μA | | 25°C | 4.9 | 4.93 | | 4.9 | 4.93 | | |
| | | | | Full range | 4.7 | | | 4.7 | | | |
| | | $I_O$ = −200 μA | | 25°C | 4.8 | 4.86 | | 4.8 | 4.86 | | |
| $V_{OM-}$ | Maximum negative peak output voltage | $V_{IC}$ = 0, | $I_O$ = 50 μA | 25°C | | −4.99 | | | −4.99 | | V |
| | | $V_{IC}$ = 0, | $I_O$ = 500 μA | 25°C | −4.85 | −4.91 | | −4.85 | −4.91 | | |
| | | | | Full range | −4.85 | | | −4.85 | | | |
| | | $V_{IC}$ = 0, | $I_O$ = 4 mA | 25°C | −4 | −4.3 | | −4 | −4.3 | | |
| | | | | Full range | −3.8 | | | −3.8 | | | |
| $A_{VD}$ | Large-signal differential voltage amplification | $V_O$ = ±4 V | $R_L$ = 100 kΩ | 25°C | 40 | 150 | | 40 | 150 | | V/mV |
| | | | | Full range | 10 | | | 10 | | | |
| | | | $R_L$ = 1 MΩ | 25°C | | 3000 | | | 3000 | | |
| $r_{i(d)}$ | Differential input resistance | | | 25°C | | $10^{12}$ | | | $10^{12}$ | | Ω |
| $r_{i(c)}$ | Common-mode input resistance | | | 25°C | | $10^{12}$ | | | $10^{12}$ | | Ω |
| $c_{i(c)}$ | Common-mode input capacitance | f = 10 kHz, | N package | 25°C | | 8 | | | 8 | | pF |
| $z_o$ | Closed-loop output impedance | f = 25 kHz, | $A_V$ = 10 | 25°C | | 190 | | | 190 | | Ω |
| CMRR | Common-mode rejection ratio | $V_{IC}$ = −5 V to 2.7 V, $V_O$ = 0, $R_S$ = 50 Ω | | 25°C | 75 | 88 | | 75 | 88 | | dB |
| | | | | Full range | 75 | | | 75 | | | |
| $k_{SVR}$ | Supply-voltage rejection ratio ($\Delta V_{DD\pm}/\Delta V_{IO}$) | $V_{DD\pm}$ = ±2.2 V to ±8 V, $V_{IC}$ = $V_{DD}$/2, No load | | 25°C | 80 | 95 | | 80 | 95 | | dB |
| | | | | Full range | 80 | | | 80 | | | |
| $I_{DD}$ | Supply current (four amplifiers) | $V_O$ = 0, | No load | 25°C | | 160 | 250 | | 160 | 250 | μA |
| | | | | Full range | | | 300 | | | 300 | |

† Full range is – 40°C to 125°C.

NOTE 4: Typical values are based on the input offset voltage shift observed through 500 hours of operating life test at $T_A$ = 150°C extrapolated to $T_A$ = 25°C using the Arrhenius equation and assuming an activation energy of 0.96 eV.

## operating characteristics at specified free-air temperature, $V_{DD\pm}$ = ±5 V

| PARAMETER | | TEST CONDITIONS | | $T_A$† | TLC2254I | | | TLC2254AI | | | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | MIN | TYP | MAX | MIN | TYP | MAX | |
| SR | Slew rate at unity gain | $V_O$ = ±1.9 V, $C_L$ = 100 pF | $R_L$ = 100 kΩ, | 25°C | 0.07 | 0.12 | | 0.07 | 0.12 | | V/μs |
| | | | | Full range | 0.05 | | | 0.05 | | | |
| $V_n$ | Equivalent input noise voltage | f = 10 Hz | | 25°C | | 38 | | | 38 | | nV/√Hz |
| | | f = 1 kHz | | 25°C | | 19 | | | 19 | | |
| $V_{N(PP)}$ | Peak-to-peak equivalent input noise voltage | f = 0.1 Hz to 1 Hz | | 25°C | | 0.8 | | | 0.8 | | μV |
| | | f = 0.1 Hz to 10 Hz | | 25°C | | 1.1 | | | 1.1 | | |
| $I_n$ | Equivalent input noise current | | | 25°C | | 0.6 | | | 0.6 | | fA/√Hz |
| THD + N | Total harmonic distortion plus noise | $V_O$ = ±2.3 V, $R_L$ = 50 kΩ, f = 20 kHz | $A_V$ = 1 | 25°C | | 0.2% | | | 0.2% | | |
| | | | $A_V$ = 10 | | | 1% | | | 1% | | |
| | Gain-bandwidth product | f =10 kHz, $C_L$ = 100 pF | $R_L$ = 50 kΩ, | 25°C | | 0.21 | | | 0.21 | | MHz |
| $B_{OM}$ | Maximum output-swing bandwidth | $V_{O(PP)}$ = 4.6 V, $R_L$ = 50 kΩ, | $A_V$ = 1, $C_L$ = 100 pF | 25°C | | 14 | | | 14 | | kHz |
| $\phi_m$ | Phase margin at unity gain | $R_L$ = 50 kΩ, | $C_L$ = 100 pF | 25°C | | 63° | | | 63° | | |
| | Gain margin | | | 25°C | | 15 | | | 15 | | dB |

† Full range is –40°C to 125°C.

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

| PARAMETER | | TEST CONDITIONS | | $T_A$† | TLC2252Q TLC2252M | | | TLC2252AQ TLC2252AM | | | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | MIN | TYP | MAX | MIN | TYP | MAX | |
| $V_{IO}$ | Input offset voltage | $V_{DD\pm}$ = ±2.5 V, $V_O$ = 0, | $V_{IC}$ = 0, $R_S$ = 50 Ω | 25°C | | 200 | 1500 | | 200 | 850 | μV |
| | | | | Full range | | | 1750 | | | 1000 | |
| $\alpha_{VIO}$ | Temperature coefficient of input offset voltage | | | 25°C to 125°C | | 0.5 | | | 0.5 | | μV/°C |
| | Input offset voltage long-term drift (see Note 4) | | | 25°C | | 0.003 | | | 0.003 | | μV/mo |
| $I_{IO}$ | Input offset current | | | 25°C | | 0.5 | | | 0.5 | | pA |
| | | | | Full range | | | 500 | | | 500 | |
| $I_{IB}$ | Input bias current | | | 25°C | | 1 | | | 1 | | pA |
| | | | | Full range | | | 500 | | | 500 | |
| $V_{ICR}$ | Common-mode input voltage range | $R_S$ = 50 Ω, | $\lvert V_{IO}\rvert \le$ 5 mV | 25°C | 0 to 4 | −0.3 to 4.2 | | 0 to 4 | −0.3 to 4.2 | | V |
| | | | | Full range | 0 to 3.5 | | | 0 to 3.5 | | | |
| $V_{OH}$ | High-level output voltage | $I_{OH}$ = −20 μA | | 25°C | | 4.98 | | | 4.98 | | V |
| | | $I_{OH}$ = −75 μA | | 25°C | 4.9 | 4.94 | | 4.9 | 4.94 | | |
| | | | | Full range | 4.8 | | | 4.8 | | | |
| | | $I_{OH}$ = −150 μA | | 25°C | 4.8 | 4.88 | | 4.8 | 4.88 | | |
| $V_{OL}$ | Low-level output voltage | $V_{IC}$ = 2.5 V, | $I_{OL}$ = 50 μA | 25°C | | 0.01 | | | 0.01 | | V |
| | | $V_{IC}$ = 2.5 V, | $I_{OL}$ = 500 μA | 25°C | | 0.09 | 0.15 | | 0.09 | 0.15 | |
| | | | | Full range | | | 0.15 | | | 0.15 | |
| | | $V_{IC}$ = 2.5 V, | $I_{OL}$ = 4 mA | 25°C | | 0.8 | 1 | | 0.7 | 1 | |
| | | | | Full range | | | 1.2 | | | 1.2 | |
| $A_{VD}$ | Large-signal differential voltage amplification | $V_{IC}$ = 2.5 V, $V_O$ = 1 V to 4 V | $R_L$ = 100 kΩ‡ | 25°C | 100 | 350 | | 100 | 350 | | V/mV |
| | | | | Full range | 10 | | | 10 | | | |
| | | | $R_L$ = 1 MΩ‡ | 25°C | | 1700 | | | 1700 | | |
| $r_{id}$ | Differential input resistance | | | 25°C | | $10^{12}$ | | | $10^{12}$ | | Ω |
| $r_{ic}$ | Common-mode input resistance | | | 25°C | | $10^{12}$ | | | $10^{12}$ | | Ω |
| $c_{ic}$ | Common-mode input capacitance | f = 10 kHz, | f = 10 kHz, | 25°C | | 8 | | | 8 | | pF |
| $z_o$ | Closed-loop output impedance | f = 25 kHz, | $A_V$ = 10 | 25°C | | 200 | | | 200 | | Ω |
| CMRR | Common-mode rejection ratio | $V_{IC}$ = 0 to 2.7 V, $R_S$ = 50 Ω | $V_O$ = 2.5 V, | 25°C | 70 | 83 | | 70 | 83 | | dB |
| | | | | Full range | 70 | | | 70 | | | |
| $k_{SVR}$ | Supply-voltage rejection ratio ($\Delta V_{DD}/\Delta V_{IO}$) | $V_{DD}$ = 4.4 V to 16 V, $V_{IC}$ = $V_{DD}$/2, | No load | 25°C | 80 | 95 | | 80 | 95 | | dB |
| | | | | Full range | 80 | | | 80 | | | |
| $I_{DD}$ | Supply current | $V_O$ = 2.5 V, | No load | 25°C | | 70 | 125 | | 70 | 125 | μA |
| | | | | Full range | | | 150 | | | 150 | |

† Full range is – 40°C to 125°C for Q suffix, – 55°C to 125°C for M suffix.
‡ Referenced to 2.5 V
NOTE 4: Typical values are based on the input offset voltage shift observed through 500 hours of operating life test at $T_A$ = 150°C extrapolated to $T_A$ = 25°C using the Arrhenius equation and assuming an activation energy of 0.96 eV.

## operating characteristics at specified free-air temperature, $V_{DD}$ = 5 V

| PARAMETER | | TEST CONDITIONS | | $T_A$† | TLC2252Q TLC2252M | | | TLC2252AQ TLC2252AM | | | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | MIN | TYP | MAX | MIN | TYP | MAX | |
| SR | Slew rate at unity gain | $V_O$ = 0.5 V to 3.5 V, $R_L$ = 100 kΩ‡, | $C_L$ = 100 pF‡ | 25°C | 0.07 | 0.12 | | 0.07 | 0.12 | | V/μs |
| | | | | Full range | 0.05 | | | 0.05 | | | |
| $V_n$ | Equivalent input noise voltage | f = 10 Hz | | 25°C | | 36 | | | 36 | | nV/√Hz |
| | | f = 1 kHz | | 25°C | | 19 | | | 19 | | |
| $V_{N(PP)}$ | Peak-to-peak equivalent input noise voltage | f = 0.1 Hz to 1 Hz | | 25°C | | 0.7 | | | 0.7 | | μV |
| | | f = 0.1 Hz to 10 Hz | | 25°C | | 1.1 | | | 1.1 | | |
| $I_n$ | Equivalent input noise current | | | 25°C | | 0.6 | | | 0.6 | | fA√Hz |
| THD + N | Total harmonic distortion plus noise | $V_O$ = 0.5 V to 2.5 V, f = 10 kHz, $R_L$ = 50 kΩ‡ | $A_V$ = 1 | 25°C | | 0.2% | | | 0.2% | | |
| | | | $A_V$ = 10 | | | 1% | | | 1% | | |
| | Gain-bandwidth product | f = 50 kHz, $C_L$ = 100 pF‡ | $R_L$ = 50 kΩ‡, | 25°C | | 0.2 | | | 0.2 | | MHz |
| $B_{OM}$ | Maximum output-swing bandwidth | $V_{O(PP)}$ = 2 V, $R_L$ = 50 kΩ‡, | $A_V$ = 1, $C_L$ = 100 pF‡ | 25°C | | 30 | | | 30 | | kHz |
| $\phi_m$ | Phase margin at unity gain | $R_L$ = 50 kΩ‡, | $C_L$ = 100 pF‡ | 25°C | | 63° | | | 63° | | |
| | Gain margin | | | 25°C | | 15 | | | 15 | | dB |

† Full range is – 40°C to 125°C for Q suffix, – 55°C to 125°C for M suffix.
‡ Referenced to 2.5 V

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

| PARAMETER | | TEST CONDITIONS | | $T_A$† | TLC2252Q TLC2252M | | | TLC2252AQ TLC2252AM | | | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | MIN | TYP | MAX | MIN | TYP | MAX | |
| $V_{IO}$ | Input offset voltage | $V_{IC}$ = 0, $R_S$ = 50 Ω | $V_O$ = 0, | 25°C | | 200 | 1500 | | 200 | 850 | µV |
| | | | | Full range | | | 1750 | | | 1000 | |
| $\alpha_{VIO}$ | Temperature coefficient of input offset voltage | | | 25°C to 125°C | | 0.5 | | | 0.5 | | µV/°C |
| | Input offset voltage long-term drift (see Note 4) | | | 25°C | | 0.003 | | | 0.003 | | µV/mo |
| $I_{IO}$ | Input offset current | | | 25°C | | 0.5 | | | 0.5 | | pA |
| | | | | Full range | | | 500 | | | 500 | |
| $I_{IB}$ | Input bias current | | | 25°C | | 1 | | | 1 | | pA |
| | | | | Full range | | | 500 | | | 500 | |
| $V_{ICR}$ | Common-mode input voltage range | $R_S$ = 50 Ω, | $\|V_{IO}\| \le$5 mV | 25°C | −5 to 4 | −5.3 to 4.2 | | −5 to 4 | −5.3 to 4.2 | | V |
| | | | | Full range | −5 to 3.5 | | | −5 to 3.5 | | | |
| $V_{OM+}$ | Maximum positive peak output voltage | $I_O$ = −20 µA | | 25°C | | 4.98 | | | 4.98 | | V |
| | | $I_O$ = −100 µA | | 25°C | 4.9 | 4.93 | | 4.9 | 4.93 | | |
| | | | | Full range | 4.7 | | | 4.7 | | | |
| | | $I_O$ = −200 µA | | 25°C | 4.8 | 4.86 | | 4.8 | 4.86 | | |
| $V_{OM-}$ | Maximum negative peak output voltage | $V_{IC}$ = 0, | $I_O$ = 50 µA | 25°C | | −4.99 | | | −4.99 | | V |
| | | $V_{IC}$ = 0, | $I_O$ = 500 µA | 25°C | −4.85 | −4.91 | | −4.85 | −4.91 | | |
| | | | | Full range | −4.85 | | | −4.85 | | | |
| | | $V_{IC}$ = 0, | $I_O$ = 4 mA | 25°C | −4 | −4.3 | | −4 | −4.3 | | |
| | | | | Full range | −3.8 | | | −3.8 | | | |
| $A_{VD}$ | Large-signal differential voltage amplification | $V_O$ = ±4 V | $R_L$ = 100 kΩ | 25°C | 40 | 150 | | 40 | 150 | | V/mV |
| | | | | Full range | 10 | | | 10 | | | |
| | | | $R_L$ = 1 MΩ | 25°C | | 3000 | | | 3000 | | |
| $r_{id}$ | Differential input resistance | | | 25°C | | $10^{12}$ | | | $10^{12}$ | | Ω |
| $r_{ic}$ | Common-mode input resistance | | | 25°C | | $10^{12}$ | | | $10^{12}$ | | Ω |
| $c_{ic}$ | Common-mode input capacitance | f = 10 kHz, | P package | 25°C | | 8 | | | 8 | | pF |
| $z_o$ | Closed-loop output impedance | f = 25 kHz, | $A_V$ = 10 | 25°C | | 190 | | | 190 | | Ω |
| CMRR | Common-mode rejection ratio | $V_{IC}$ = −5 V to 2.7 V, $V_O$ = 0, | $R_S$ = 50 Ω | 25°C | 75 | 88 | | 75 | 88 | | dB |
| | | | | Full range | 75 | | | 75 | | | |
| $k_{SVR}$ | Supply-voltage rejection ratio ($\Delta V_{DD\pm}/\Delta V_{IO}$) | $V_{DD}$ = ±2.2 V to ±8 V, $V_{IC}$ = 0, | No load | 25°C | 80 | 95 | | 80 | 95 | | dB |
| | | | | Full range | 80 | | | 80 | | | |
| $I_{DD}$ | Supply current | $V_O$ = 2.5 V, | No load | 25°C | | 80 | 125 | | 80 | 125 | µA |
| | | | | Full range | | | 150 | | | 150 | |

† Full range is – 40°C to 125°C for Q suffix, – 55°C to 125°C for M suffix.

NOTE 4: Typical values are based on the input offset voltage shift observed through 500 hours of operating life test at $T_A$ = 150°C extrapolated to $T_A$ = 25°C using the Arrhenius equation and assuming an activation energy of 0.96 eV.

## operating characteristics at specified free-air temperature, $V_{DD\pm}$ = ±5 V

| PARAMETER | | TEST CONDITIONS | | $T_A$† | TLC2252Q TLC2252M | | | TLC2252AQ TLC2252AM | | | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | MIN | TYP | MAX | MIN | TYP | MAX | |
| SR | Slew rate at unity gain | $V_O$ = ±2 V, $C_L$ = 100 pF | $R_L$ = 100 kΩ, | 25°C | 0.07 | 0.12 | | 0.07 | 0.12 | | V/μs |
| | | | | Full range | 0.05 | | | 0.05 | | | |
| $V_n$ | Equivalent input noise voltage | f = 10 Hz | | 25°C | | 38 | | | 38 | | nV/√Hz |
| | | f = 1 kHz | | 25°C | | 19 | | | 19 | | |
| $V_{N(PP)}$ | Peak-to-peak equivalent input noise voltage | f = 0.1 Hz to 1 Hz | | 25°C | | 0.8 | | | 0.8 | | μV |
| | | f = 0.1 Hz to 10 Hz | | 25°C | | 1.1 | | | 1.1 | | |
| $I_n$ | Equivalent input noise current | | | 25°C | | 0.6 | | | 0.6 | | fA√Hz |
| THD + N | Total harmonic distortion plus noise | $V_O$ = ±2.3 V, $R_L$ = 50 kΩ, f = 10 kHz | $A_V$ = 1 | 25°C | | 0.2% | | | 0.2% | | |
| | | | $A_V$ = 10 | | | 1% | | | 1% | | |
| | Gain-bandwidth product | f =10 kHz, $C_L$ = 100 pF | $R_L$ = 50 kΩ, | 25°C | | 0.21 | | | 0.21 | | MHz |
| $B_{OM}$ | Maximum output-swing bandwidth | $V_{O(PP)}$ = 4.6 V, $R_L$ = 50 kΩ, | $A_V$ = 1, $C_L$ = 100 pF | 25°C | | 14 | | | 14 | | kHz |
| $\phi_m$ | Phase margin at unity gain | $R_L$ = 50 kΩ, | $C_L$ = 100 pF | 25°C | | 63° | | | 63° | | |
| | Gain margin | | | 25°C | | 15 | | | 15 | | dB |

† Full range is – 40°C to 125°C for Q suffix, – 55°C to 125°C for M suffix.

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

| PARAMETER | | TEST CONDITIONS | | $T_A$† | TLC2254Q TLC2254M | | | TLC2254AQ TLC2254AM | | | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | MIN | TYP | MAX | MIN | TYP | MAX | |
| $V_{IO}$ | Input offset voltage | $V_{DD\pm}$ = ±2.5 V, $V_O$ = 0, | $V_{IC}$ = 0, $R_S$ = 50 Ω | 25°C | | 200 | 1500 | | 200 | 850 | μV |
| | | | | Full range | | | 1750 | | | 1000 | |
| $\alpha_{VIO}$ | Temperature coefficient of input offset voltage | | | 25°C to 125°C | | 0.5 | | | 0.5 | | μV/°C |
| | Input offset voltage long-term drift (see Note 4) | | | 25°C | | 0.003 | | | 0.003 | | μV/mo |
| $I_{IO}$ | Input offset current | | | 25°C | | 0.5 | | | 0.5 | | pA |
| | | | | 125°C | | | 500 | | | 500 | |
| $I_{IB}$ | Input bias current | | | 25°C | | 1 | | | 1 | | pA |
| | | | | 125°C | | | 500 | | | 500 | |
| $V_{ICR}$ | Common-mode input voltage range | $R_S$ = 50 Ω, | $\lvert V_{IO}\rvert \le$5 mV | 25°C | 0 to 4 | −0.3 to 4.2 | | 0 to 4 | −0.3 to 4.2 | | V |
| | | | | Full range | 0 to 3.5 | | | 0 to 3.5 | | | |
| $V_{OH}$ | High-level output voltage | $I_{OH}$ = −20 μA | | 25°C | | 4.98 | | | 4.98 | | V |
| | | $I_{OH}$ = −75 μA | | 25°C | 4.9 | 4.94 | | 4.9 | 4.94 | | |
| | | | | Full range | 4.8 | | | 4.8 | | | |
| | | $I_{OH}$ = −150 μA | | 25°C | 4.8 | 4.88 | | 4.8 | 4.88 | | |
| $V_{OL}$ | Low-level output voltage | $V_{IC}$ = 2.5 V, | $I_{OL}$ = 50 μA | 25°C | | 0.01 | | | 0.01 | | V |
| | | $V_{IC}$ = 2.5 V, | $I_{OL}$ = 500 μA | 25°C | | 0.09 | 0.15 | | 0.09 | 0.15 | |
| | | | | Full range | | | 0.15 | | | 0.15 | |
| | | $V_{IC}$ = 2.5 V, | $I_{OL}$ = 4 mA | 25°C | | 0.8 | 1 | | 0.7 | 1 | |
| | | | | Full range | | | 1.2 | | | 1.2 | |
| $A_{VD}$ | Large-signal differential voltage amplification | $V_{IC}$ = 2.5 V, $V_O$ = 1 V to 4 V | $R_L$ = 100 kΩ‡ | 25°C | 100 | 350 | | 100 | 350 | | V/mV |
| | | | | Full range | 10 | | | 10 | | | |
| | | | $R_L$ = 1 MΩ‡ | 25°C | | 1700 | | | 1700 | | |
| $r_{i(d)}$ | Differential input resistance | | | 25°C | | $10^{12}$ | | | $10^{12}$ | | Ω |
| $r_{i(c)}$ | Common-mode input resistance | | | 25°C | | $10^{12}$ | | | $10^{12}$ | | Ω |
| $c_{i(c)}$ | Common-mode input capacitance | f = 10 kHz, | N package | 25°C | | 8 | | | 8 | | pF |
| $z_o$ | Closed-loop output impedance | f = 25 kHz, | $A_V$ = 10 | 25°C | | 200 | | | 200 | | Ω |
| CMRR | Common-mode rejection ratio | $V_{IC}$ = 0 to 2.7 V, $R_S$ = 50 Ω | $V_O$ = 2.5 V, | 25°C | 70 | 83 | | 70 | 83 | | dB |
| | | | | Full range | 70 | | | 70 | | | |
| $k_{SVR}$ | Supply-voltage rejection ratio ($\Delta V_{DD}/\Delta V_{IO}$) | $V_{DD}$ = 4.4 V to 16 V, $V_{IC}$ = $V_{DD}$/2, | No load | 25°C | 80 | 95 | | 80 | 95 | | dB |
| | | | | Full range | 80 | | | 80 | | | |
| $I_{DD}$ | Supply current (four amplifiers) | $V_O$ = 2.5 V, | No load | 25°C | | 140 | 250 | | 140 | 250 | μA |
| | | | | Full range | | | 300 | | | 300 | |

† Full range is – 40°C to 125°C for Q suffix, – 55°C to 125°C for M suffix.
‡ Referenced to 2.5 V
NOTE 4: Typical values are based on the input offset voltage shift observed through 500 hours of operating life test at $T_A$ = 150°C extrapolated to $T_A$ = 25°C using the Arrhenius equation and assuming an activation energy of 0.96 eV.

## operating characteristics at specified free-air temperature, $V_{DD}$ = 5 V

| PARAMETER | | TEST CONDITIONS | | $T_A$† | TLC2254Q TLC2254M | | | TLC2254AQ TLC2254AM | | | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | MIN | TYP | MAX | MIN | TYP | MAX | |
| SR | Slew rate at unity gain | $V_O$ = 0.5 V to 3.5 V, $R_L$ = 100 kΩ‡, $C_L$ = 100 pF‡ | | 25°C | 0.07 | 0.12 | | 0.07 | 0.12 | | V/μs |
| | | | | Full range | 0.05 | | | 0.05 | | | |
| $V_n$ | Equivalent input noise voltage | f = 10 Hz | | 25°C | | 36 | | | 36 | | nV/√Hz |
| | | f = 1 kHz | | 25°C | | 19 | | | 19 | | |
| $V_{N(PP)}$ | Peak-to-peak equivalent input noise voltage | f = 0.1 Hz to 1 Hz | | 25°C | | 0.7 | | | 0.7 | | μV |
| | | f = 0.1 Hz to 10 Hz | | 25°C | | 1.1 | | | 1.1 | | |
| $I_n$ | Equivalent input noise current | | | 25°C | | 0.6 | | | 0.6 | | fA/√Hz |
| THD + N | Total harmonic distortion plus noise | $V_O$ = 0.5 V to 2.5 V, f = 20 kHz, $R_L$ = 50 kΩ‡ | $A_V$ = 1 | 25°C | | 0.2% | | | 0.2% | | |
| | | | $A_V$ = 10 | | | 1% | | | 1% | | |
| | Gain-bandwidth product | f = 50 kHz, $C_L$ = 100 pF‡ | $R_L$ = 50 kΩ‡, | 25°C | | 0.2 | | | 0.2 | | MHz |
| $B_{OM}$ | Maximum output-swing bandwidth | $V_{O(PP)}$ = 2 V, $R_L$ = 50 kΩ‡, | $A_V$ = 1, $C_L$ = 100 pF‡ | 25°C | | 30 | | | 30 | | kHz |
| $\phi_m$ | Phase margin at unity gain | $R_L$ = 50 kΩ‡, | $C_L$ = 100 pF‡ | 25°C | | 63° | | | 63° | | |
| | Gain margin | | | 25°C | | 15 | | | 15 | | dB |

† Full range is – 40°C to 125°C for Q suffix, – 55°C to 125°C for M suffix.
‡ Referenced to 2.5 V

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

| PARAMETER | | TEST CONDITIONS | | $T_A$† | TLC2254Q TLC2254M | | | TLC2254AQ TLC2254AM | | | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | MIN | TYP | MAX | MIN | TYP | MAX | |
| $V_{IO}$ | Input offset voltage | $V_{IC}$ = 0, $V_O$ = 0, $R_S$ = 50 Ω | | 25°C | | 200 | 1500 | | 200 | 850 | μV |
| | | | | Full range | | | 1750 | | | 1000 | |
| $\alpha_{VIO}$ | Temperature coefficient of input offset voltage | | | 25°C to 125°C | | 0.5 | | | 0.5 | | μV/°C |
| | Input offset voltage long-term drift (see Note 4) | | | 25°C | | 0.003 | | | 0.003 | | μV/mo |
| $I_{IO}$ | Input offset current | | | 25°C | | 0.5 | | | 0.5 | | pA |
| | | | | 125°C | | | 500 | | | 500 | |
| $I_{IB}$ | Input bias current | | | 25°C | | 1 | | | 1 | | pA |
| | | | | 125°C | | | 500 | | | 500 | |
| $V_{ICR}$ | Common-mode input voltage range | $R_S$ = 50 Ω, $\|V_{IO}\| \le$ 5 mV | | 25°C | −5 to 4 | −5.3 to 4.2 | | −5 to 4 | −5.3 to 4.2 | | V |
| | | | | Full range | −5 to 3.5 | | | −5 to 3.5 | | | |
| $V_{OM+}$ | Maximum positive peak output voltage | $I_O$ = −20 μA | | 25°C | | 4.98 | | | 4.98 | | V |
| | | $I_O$ = −100 μA | | 25°C | 4.9 | 4.93 | | 4.9 | 4.93 | | |
| | | | | Full range | 4.7 | | | 4.7 | | | |
| | | $I_O$ = −200 μA | | 25°C | 4.8 | 4.86 | | 4.8 | 4.86 | | |
| $V_{OM-}$ | Maximum negative peak output voltage | $V_{IC}$ = 0, | $I_O$ = 50 μA | 25°C | | −4.99 | | | −4.99 | | V |
| | | $V_{IC}$ = 0, | $I_O$ = 500 μA | 25°C | −4.85 | −4.91 | | −4.85 | −4.91 | | |
| | | | | Full range | −4.85 | | | −4.85 | | | |
| | | $V_{IC}$ = 0, | $I_O$ = 4 mA | 25°C | −4 | −4.3 | | −4 | −4.3 | | |
| | | | | Full range | −3.8 | | | −3.8 | | | |
| $A_{VD}$ | Large-signal differential voltage amplification | $V_O$ = ±4 V | $R_L$ = 100 kΩ | 25°C | 40 | 150 | | 40 | 150 | | V/mV |
| | | | | Full range | 10 | | | 10 | | | |
| | | | $R_L$ = 1 MΩ | 25°C | | 3000 | | | 3000 | | |
| $r_{i(d)}$ | Differential input resistance | | | 25°C | | $10^{12}$ | | | $10^{12}$ | | Ω |
| $r_{i(c)}$ | Common-mode input resistance | | | 25°C | | $10^{12}$ | | | $10^{12}$ | | Ω |
| $c_{i(c)}$ | Common-mode input capacitance | f = 10 kHz, | N package | 25°C | | 8 | | | 8 | | pF |
| $z_o$ | Closed-loop output impedance | f = 25 kHz, | $A_V$ = 10 | 25°C | | 190 | | | 190 | | Ω |
| CMRR | Common-mode rejection ratio | $V_{IC}$ = −5 V to 2.7 V, $V_O$ = 0, $R_S$ = 50 Ω | | 25°C | 75 | 88 | | 75 | 88 | | dB |
| | | | | Full range | 75 | | | 75 | | | |
| $k_{SVR}$ | Supply-voltage rejection ratio ($\Delta V_{DD\pm}/\Delta V_{IO}$) | $V_{DD\pm}$ = ±2.2 V to ±8 V, $V_{IC}$ = $V_{DD}$/2, No load | | 25°C | 80 | 95 | | 80 | 95 | | dB |
| | | | | Full range | 80 | | | 80 | | | |
| $I_{DD}$ | Supply current (four amplifiers) | $V_O$ = 0, | No load | 25°C | | 160 | 250 | | 160 | 250 | μA |
| | | | | Full range | | | 300 | | | 300 | |

† Full range is – 40°C to 125°C for Q suffix, – 55°C to 125°C for M suffix.

NOTE 4: Typical values are based on the input offset voltage shift observed through 500 hours of operating life test at $T_A$ = 150°C extrapolated to $T_A$ = 25°C using the Arrhenius equation and assuming an activation energy of 0.96 eV.

## operating characteristics at specified free-air temperature, $V_{DD\pm}$ = ±5 V

| PARAMETER | | TEST CONDITIONS | | $T_A$† | TLC2254Q TLC2254M | | | TLC2254AQ TLC2254AM | | | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | MIN | TYP | MAX | MIN | TYP | MAX | |
| SR | Slew rate at unity gain | $V_O$ = ±2 V, $C_L$ = 100 pF | $R_L$ = 100 kΩ, | 25°C | 0.07 | 0.12 | | 0.07 | 0.12 | | V/μs |
| | | | | Full range | 0.05 | | | 0.05 | | | |
| $V_n$ | Equivalent input noise voltage | f = 10 Hz | | 25°C | | 38 | | | 38 | | nV/√Hz |
| | | f = 1 kHz | | 25°C | | 19 | | | 19 | | |
| $V_{N(PP)}$ | Peak-to-peak equivalent input noise voltage | f = 0.1 Hz to 1 Hz | | 25°C | | 0.8 | | | 0.8 | | μV |
| | | f = 0.1 Hz to 10 Hz | | 25°C | | 1.1 | | | 1.1 | | |
| $I_n$ | Equivalent input noise current | | | 25°C | | 0.6 | | | 0.6 | | fA/√Hz |
| THD + N | Total harmonic distortion plus noise | $V_O$ = ±2.3 V, $R_L$ = 50 kΩ, f = 20 kHz | $A_V$ = 1 | 25°C | | 0.2% | | | 0.2% | | |
| | | | $A_V$ = 10 | | | 1% | | | 1% | | |
| | Gain-bandwidth product | f =10 kHz, $C_L$ = 100 pF | $R_L$ = 50 kΩ, | 25°C | | 0.21 | | | 0.21 | | MHz |
| $B_{OM}$ | Maximum output-swing bandwidth | $V_{O(PP)}$ = 4.6 V, $R_L$ = 50 kΩ, | $A_V$ = 1, $C_L$ = 100 pF | 25°C | | 14 | | | 14 | | kHz |
| $\phi_m$ | Phase margin at unity gain | $R_L$ = 50 kΩ, | $C_L$ = 100 pF | 25°C | | 63° | | | 63° | | |
| | Gain margin | | | 25°C | | 15 | | | 15 | | dB |

† Full range is – 40°C to 125°C for Q suffix, – 55°C to 125°C for M suffix.

## TYPICAL CHARACTERISTICS

### Table of Graphs

| | | | FIGURE |
|---|---|---|---|
| $V_{IO}$ | Input offset voltage | Distribution<br>vs Common-mode input voltage | 2 – 5<br>6, 7 |
| $\alpha_{VIO}$ | Input offset voltage temperature coefficient | Distribution | 8 – 11 |
| $I_{IB}/I_{IO}$ | Input bias and input offset currents | vs Free-air temperature | 12 |
| $V_I$ | Input voltage range | vs Supply voltage<br>vs Free-air temperature | 13<br>14 |
| $V_{OH}$ | High-level output voltage | vs High-level output current | 15 |
| $V_{OL}$ | Low-level output voltage | vs Low-level output current | 16, 17 |
| $V_{OM+}$ | Maximum positive peak output voltage | vs Output current | 18 |
| $V_{OM-}$ | Maximum negative peak output voltage | vs Output current | 19 |
| $V_{O(PP)}$ | Maximum peak-to-peak output voltage | vs Frequency | 20 |
| $I_{OS}$ | Short-circuit output current | vs Supply voltage<br>vs Free-air temperature | 21<br>22 |
| $V_O$ | Output voltage | vs Differential input voltage | 23, 24 |
| | Differential gain | vs Load resistance | 25 |
| $A_{VD}$ | Large-signal differential voltage amplification | vs Frequency<br>vs Free-air temperature | 26, 27<br>28, 29 |
| $z_o$ | Output impedance | vs Frequency | 30, 31 |
| CMRR | Common-mode rejection ratio | vs Frequency<br>vs Free-air temperature | 32<br>33 |
| $k_{SVR}$ | Supply-voltage rejection ratio | vs Frequency<br>vs Free-air temperature | 34, 35<br>36 |
| $I_{DD}$ | Supply current | vs Supply voltage<br>vs Free-air temperature | 37<br>38 |
| SR | Slew rate | vs Load capacitance<br>vs Free-air temperature | 39<br>40 |
| $V_O$ | Inverting large-signal pulse response | vs Time | 41, 42 |
| $V_O$ | Voltage-follower large-signal pulse response | vs Time | 43, 44 |
| $V_O$ | Inverting small-signal pulse response | vs Time | 45, 46 |
| $V_O$ | Voltage-follower small-signal pulse response | vs Time | 47, 48 |
| $V_n$ | Equivalent input noise voltage | vs Frequency | 49, 50 |
| | Noise voltage (referred to input) | Over a 10-second period | 51 |
| | Integrated noise voltage | vs Frequency | 52 |
| THD + N | Total harmonic distortion plus noise | vs Frequency | 53 |
| | Gain-bandwidth product | vs Free-air temperature<br>vs Supply voltage | 54<br>55 |
| $\phi_m$ | Phase margin | vs Frequency<br>vs Load capacitance | 26, 27<br>56 |
| $A_m$ | Gain margin | vs Load capacitance | 57 |
| $B_1$ | Unity-gain bandwidth | vs Load capacitance | 58 |
| | Overestimation of phase margin | vs Load capacitance | 59 |

## TYPICAL CHARACTERISTICS

**DISTRIBUTION OF TLC2252
INPUT OFFSET VOLTAGE**

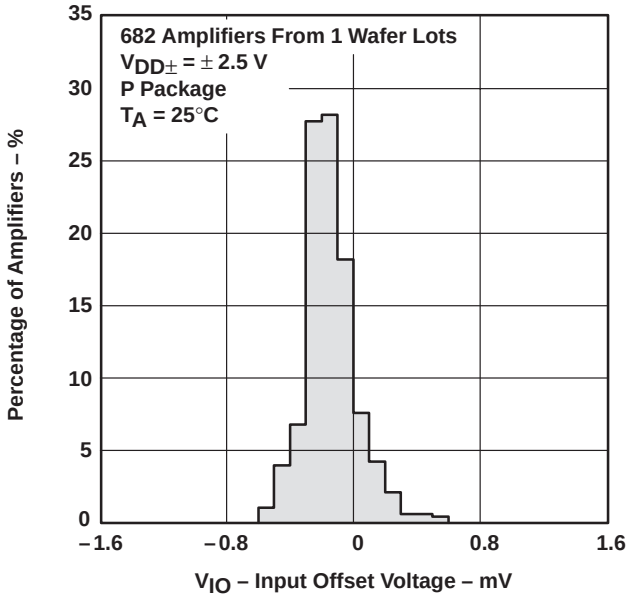



**Figure 2**

**DISTRIBUTION OF TLC2252
INPUT OFFSET VOLTAGE**

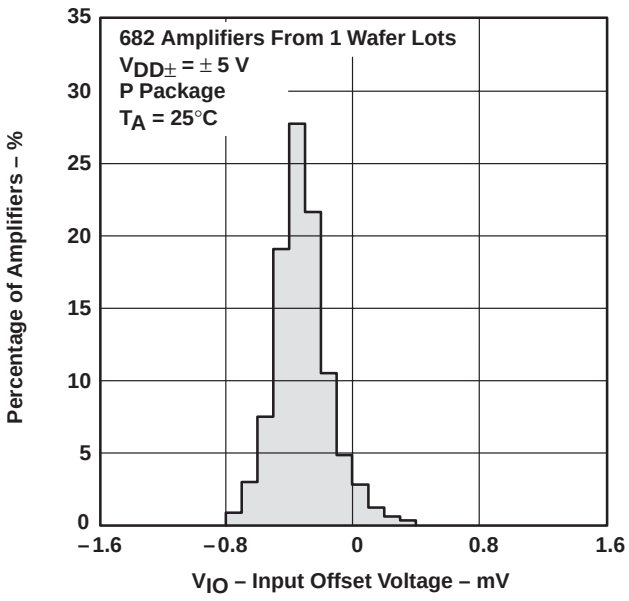



**Figure 3**

**DISTRIBUTION OF TLC2254
INPUT OFFSET VOLTAGE**

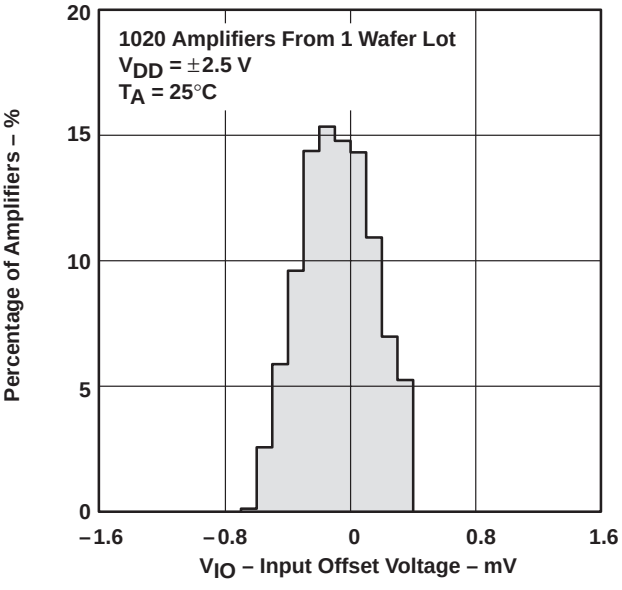



**Figure 4**

**DISTRIBUTION OF TLC2254
INPUT OFFSET VOLTAGE**

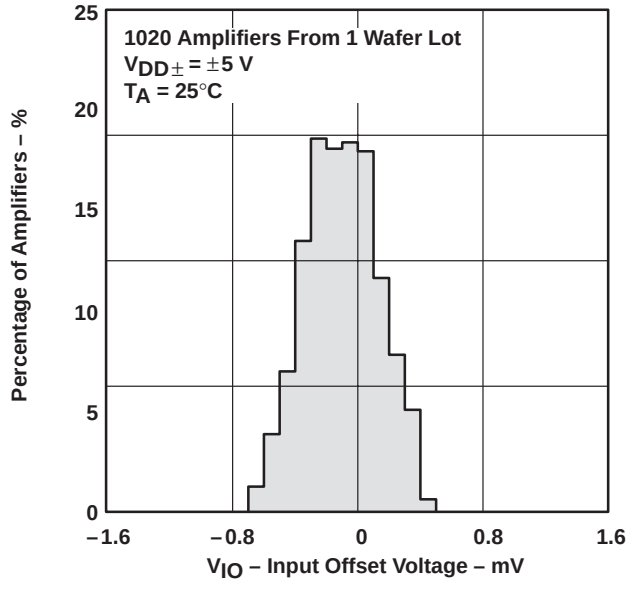



**Figure 5**

## TYPICAL CHARACTERISTICS

**INPUT OFFSET VOLTAGE† vs COMMON-MODE INPUT VOLTAGE**

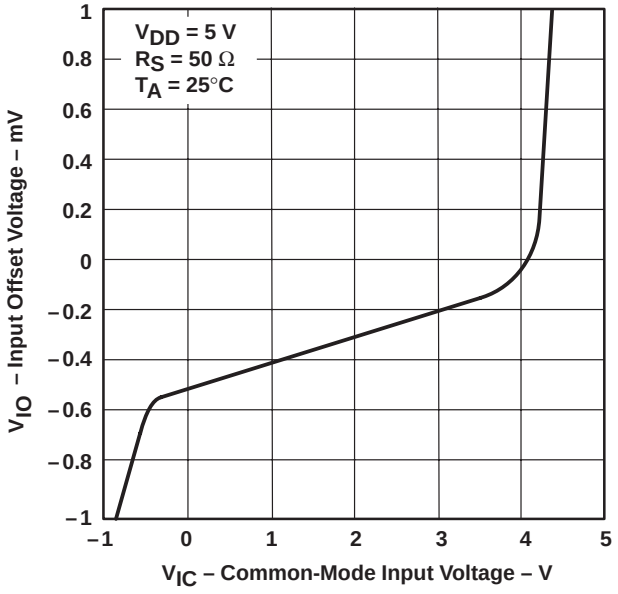



Figure 6

**INPUT OFFSET VOLTAGE vs COMMON-MODE INPUT VOLTAGE**

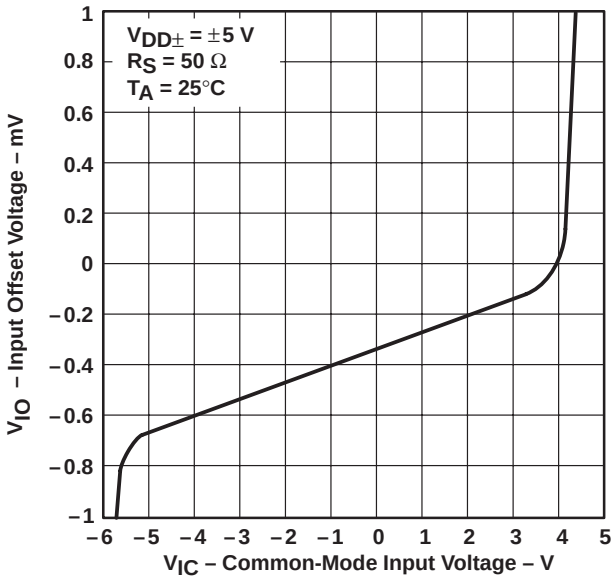



Figure 7

**DISTRIBUTION OF TLC2252 INPUT OFFSET VOLTAGE TEMPERATURE COEFFICIENT**

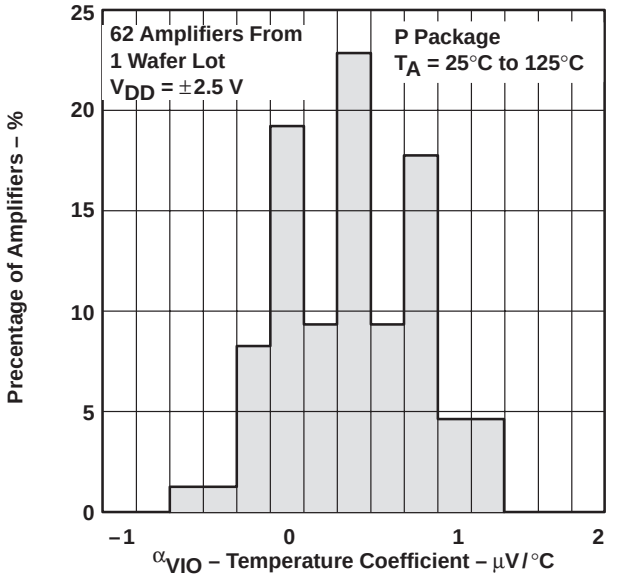



Figure 8

**DISTRIBUTION OF TLC2252 INPUT OFFSET VOLTAGE TEMPERATURE COEFFICIENT**

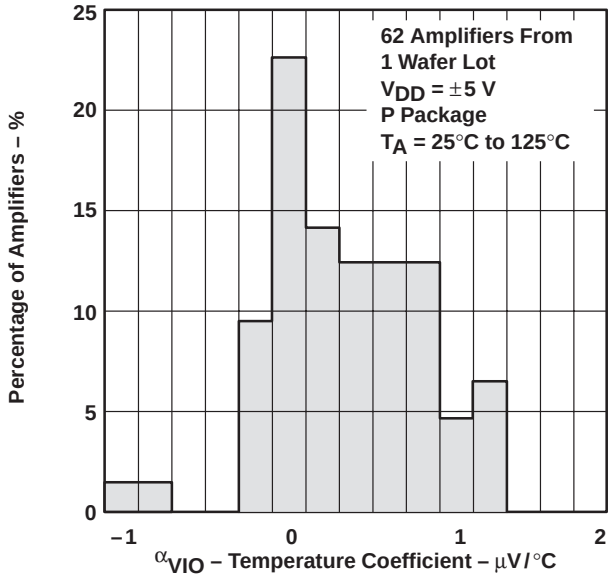



Figure 9

† For curves where $V_{DD}$ = 5 V, all loads are referenced to 2.5 V.

## TYPICAL CHARACTERISTICS

**DISTRIBUTION OF TLC2254 INPUT OFFSET VOLTAGE TEMPERATURE COEFFICIENT**

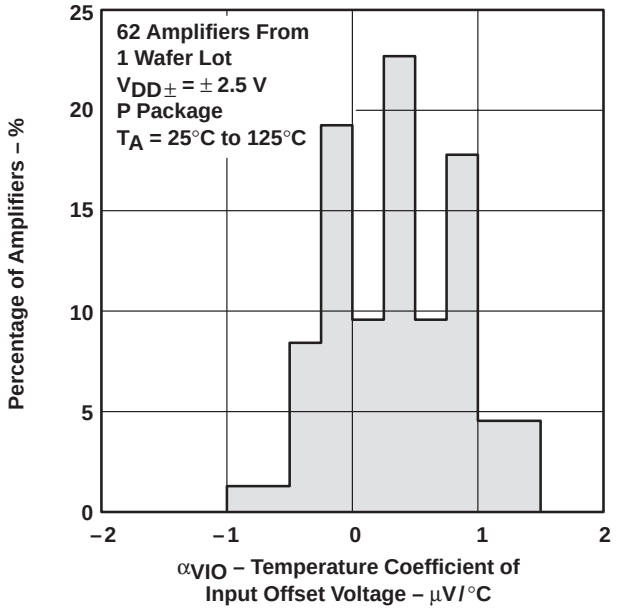



**Figure 10**

**DISTRIBUTION OF TLC2254 INPUT OFFSET VOLTAGE TEMPERATURE COEFFICIENT**

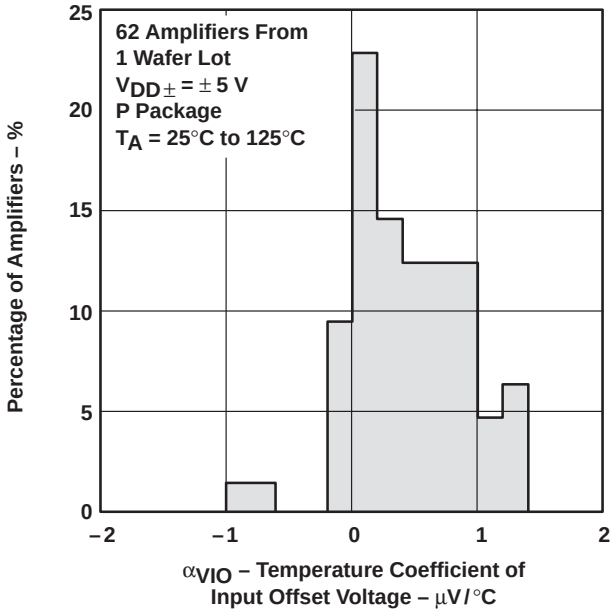



**Figure 11**

**INPUT BIAS AND INPUT OFFSET CURRENTS† vs FREE-AIR TEMPERATURE**

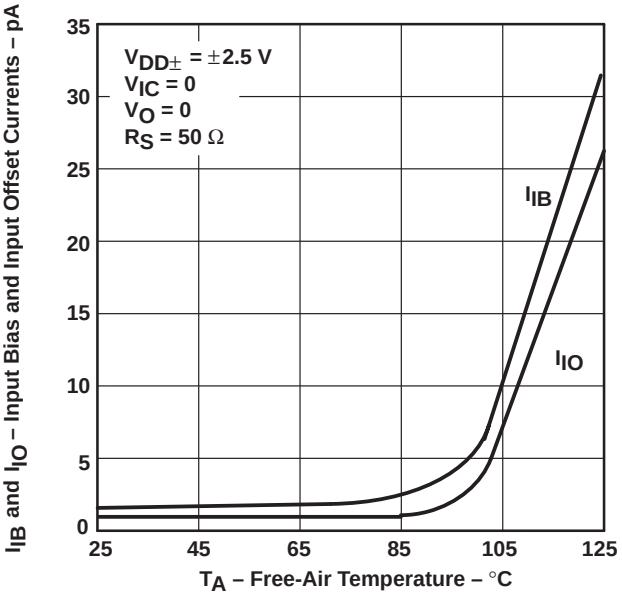



**Figure 12**

**INPUT VOLTAGE RANGE vs SUPPLY VOLTAGE**

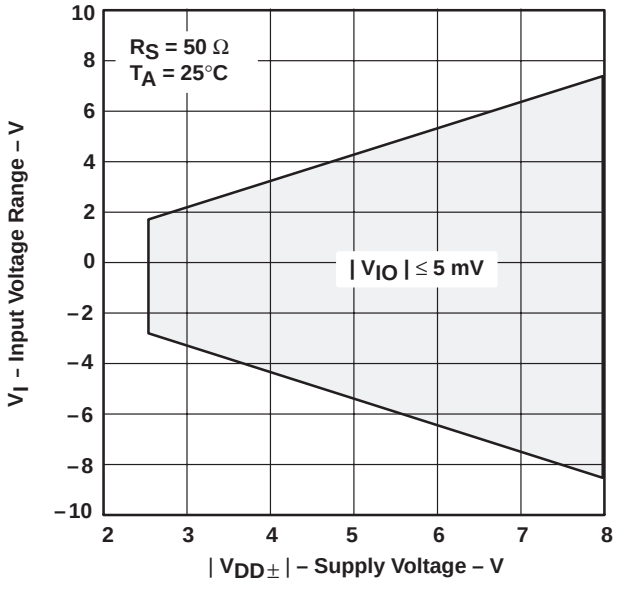



**Figure 13**

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

## TYPICAL CHARACTERISTICS

**INPUT VOLTAGE RANGE† vs FREE-AIR TEMPERATURE**

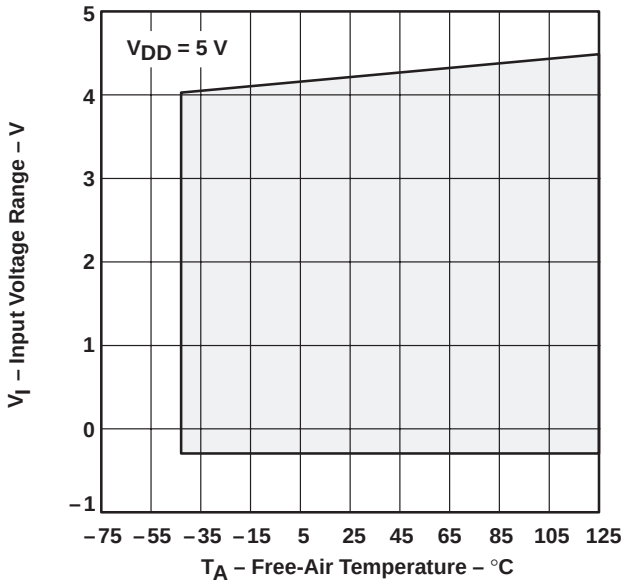



Figure 14

**HIGH-LEVEL OUTPUT VOLTAGE†‡ vs HIGH-LEVEL OUTPUT CURRENT**

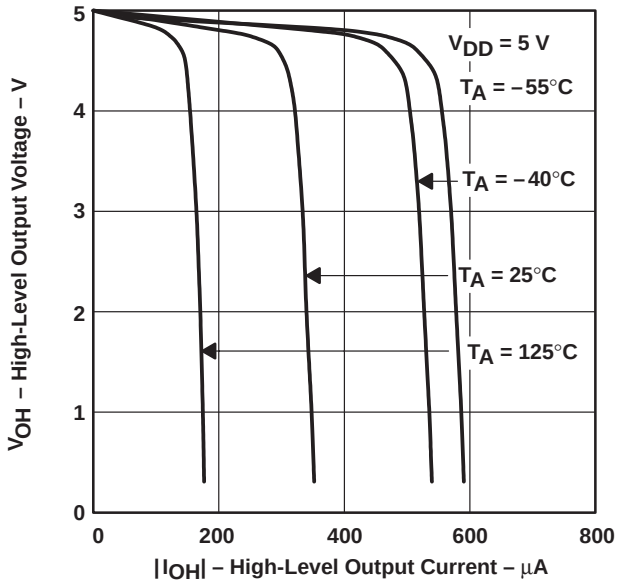



Figure 15

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

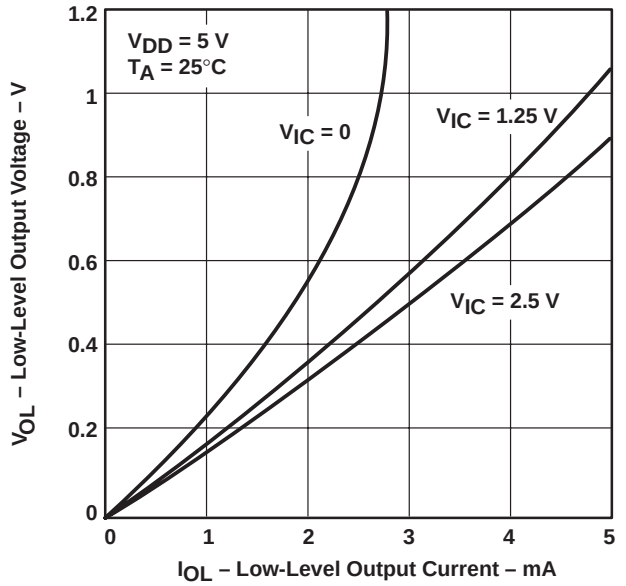



Figure 16

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

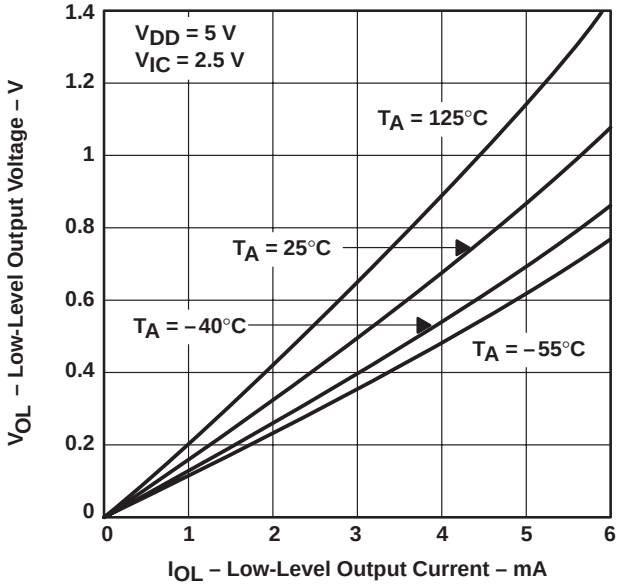



Figure 17

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.
‡ For curves where $V_{DD}$ = 5 V, all loads are referenced to 2.5 V.

## TYPICAL CHARACTERISTICS

**MAXIMUM POSITIVE PEAK OUTPUT VOLTAGE† vs OUTPUT CURRENT**

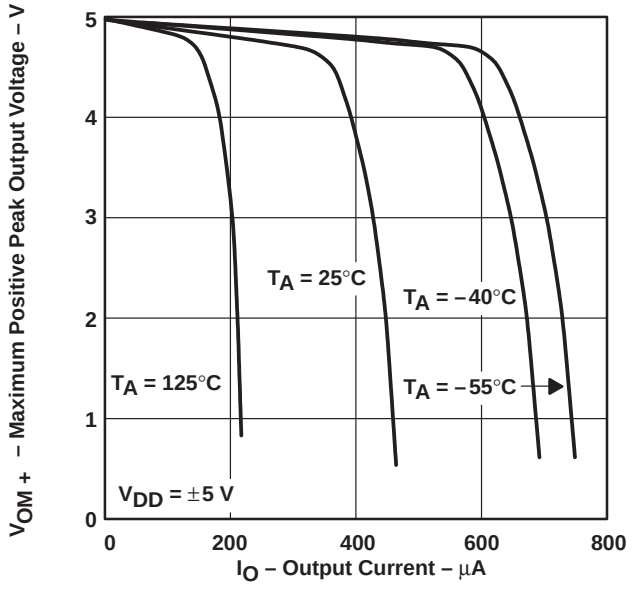



Figure 18

**MAXIMUM NEGATIVE PEAK OUTPUT VOLTAGE† vs OUTPUT CURRENT**

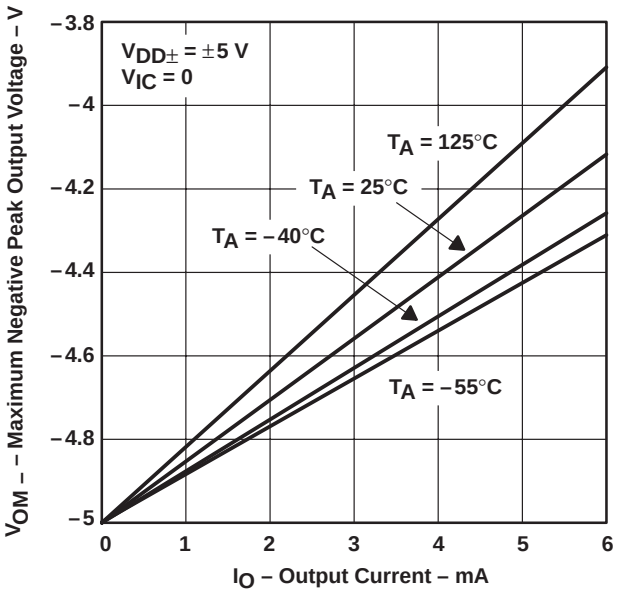



Figure 19

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

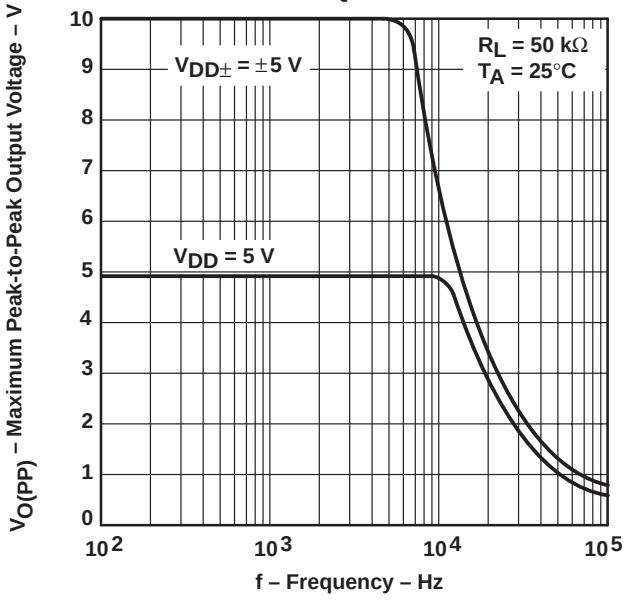



Figure 20

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

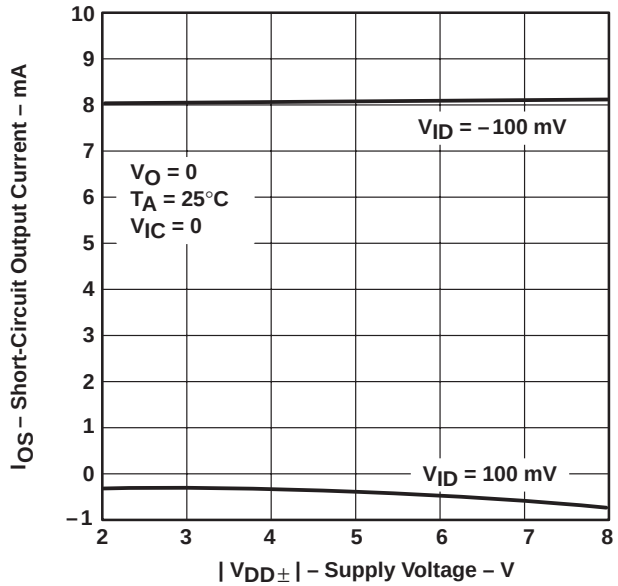



Figure 21

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.
‡ For curves where $V_{DD}$ = 5 V, all loads are referenced to 2.5 V.

## TYPICAL CHARACTERISTICS

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

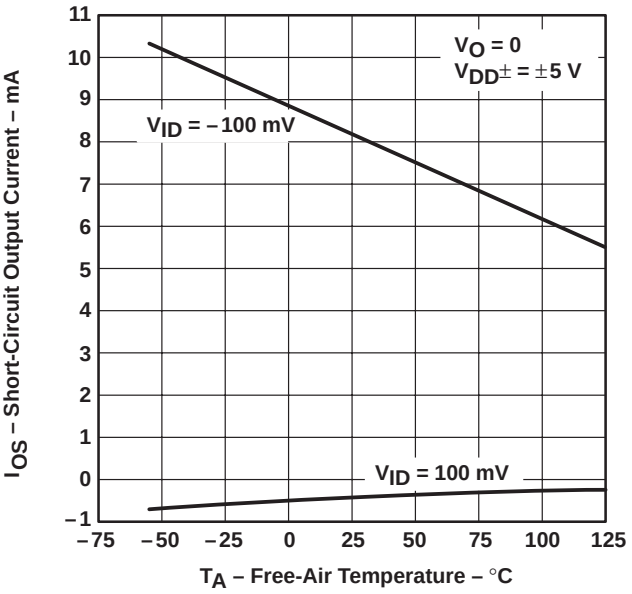



Figure 22

**OUTPUT VOLTAGE‡ vs DIFFERENTIAL INPUT VOLTAGE**

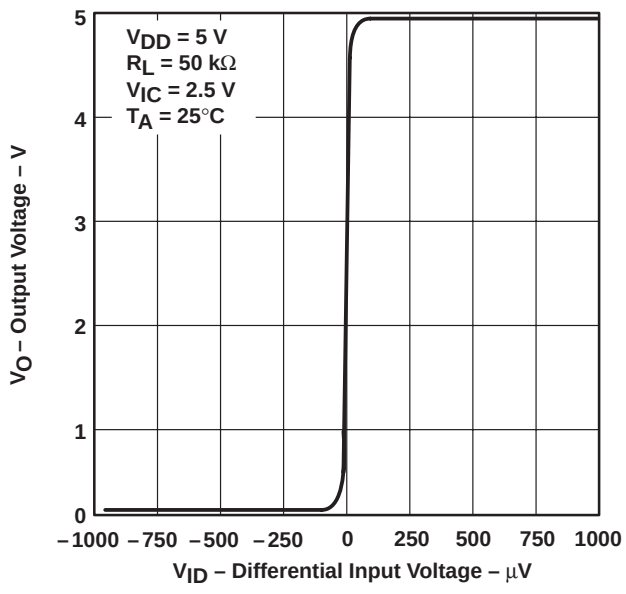



Figure 23

**OUTPUT VOLTAGE vs DIFFERENTIAL INPUT VOLTAGE**

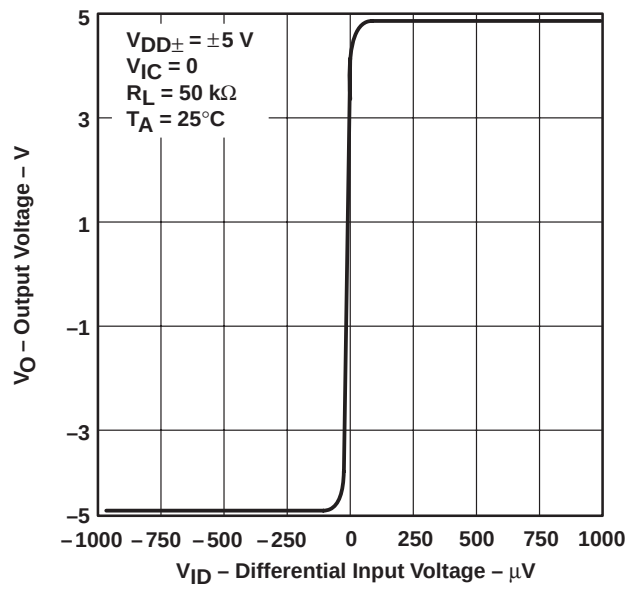



Figure 24

**DIFFERENTIAL GAIN‡ vs LOAD RESISTANCE**

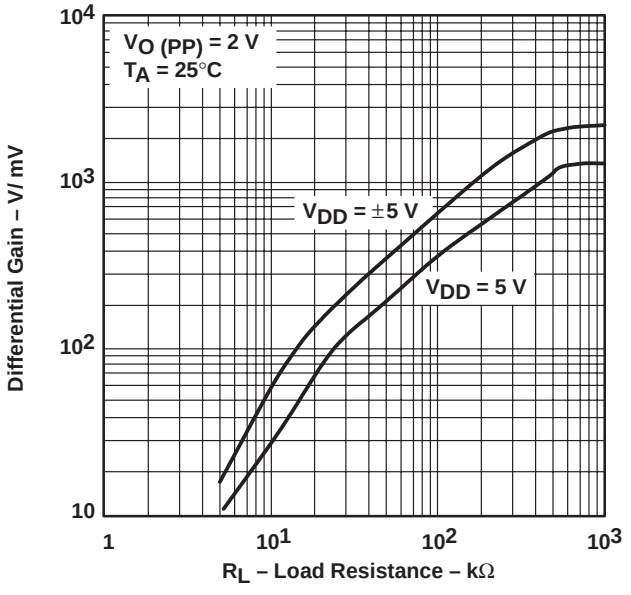



Figure 25

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.
‡ For curves where $V_{DD}$ = 5 V, all loads are referenced to 2.5 V.

## TYPICAL CHARACTERISTICS

**LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION AND PHASE MARGIN† vs FREQUENCY**

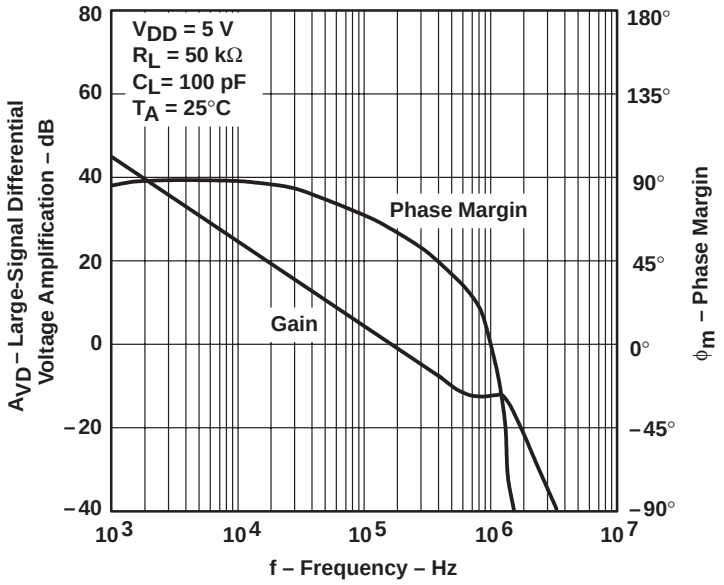



**Figure 26**

**LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION AND PHASE MARGIN vs FREQUENCY**

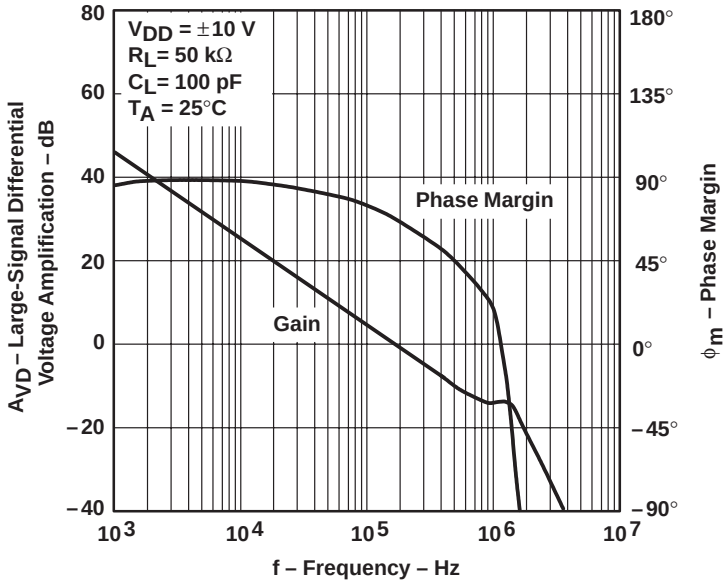



**Figure 27**

† For curves where $V_{DD}$ = 5 V, all loads are referenced to 2.5 V.

## TYPICAL CHARACTERISTICS

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

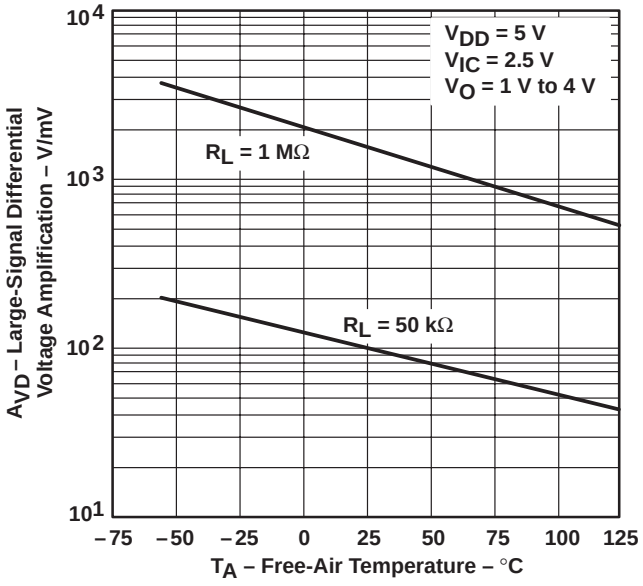



Figure 28

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

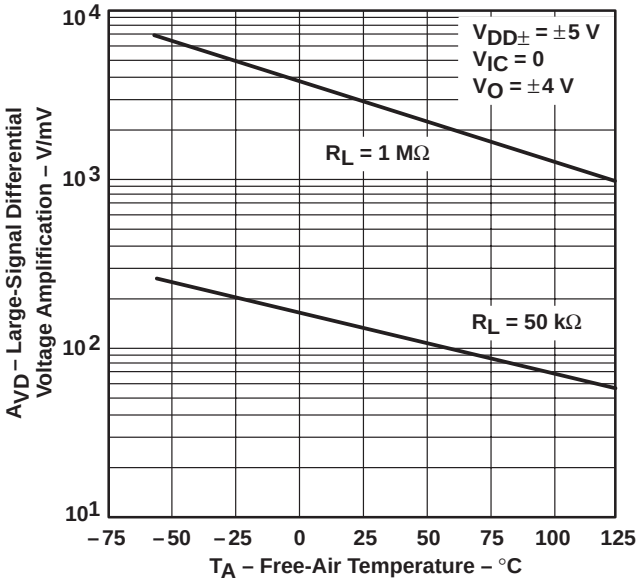



Figure 29

**OUTPUT IMPEDANCE‡ vs FREQUENCY**

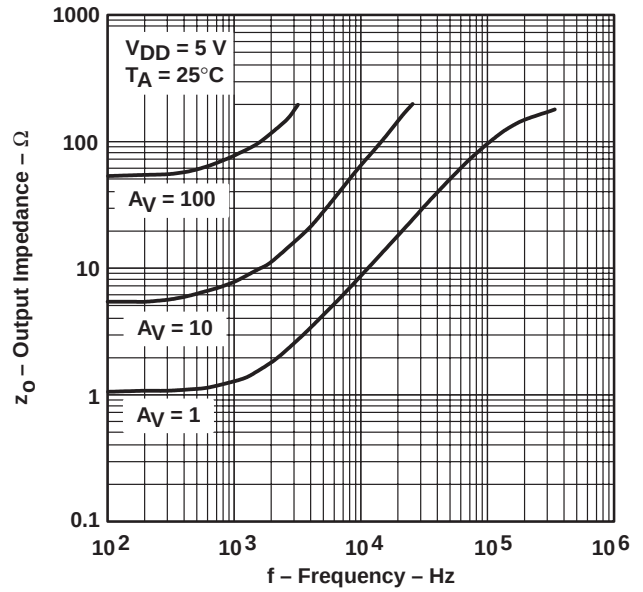



Figure 30

**OUTPUT IMPEDANCE vs FREQUENCY**

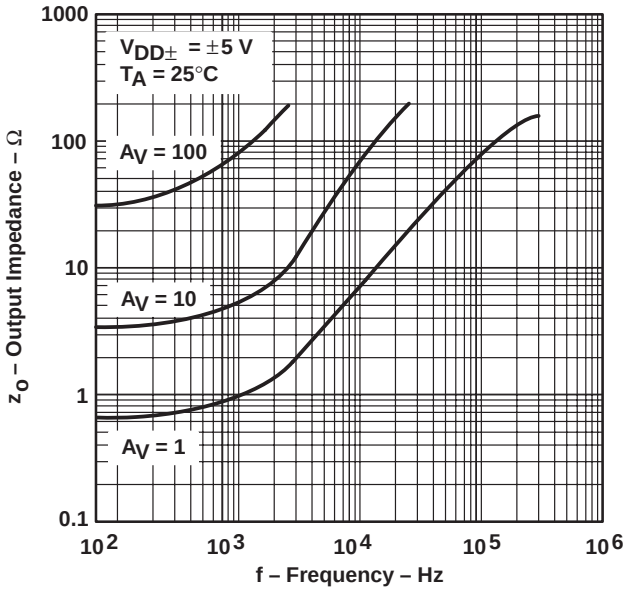



Figure 31

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.
‡ For curves where $V_{DD}$ = 5 V, all loads are referenced to 2.5 V.

## TYPICAL CHARACTERISTICS

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

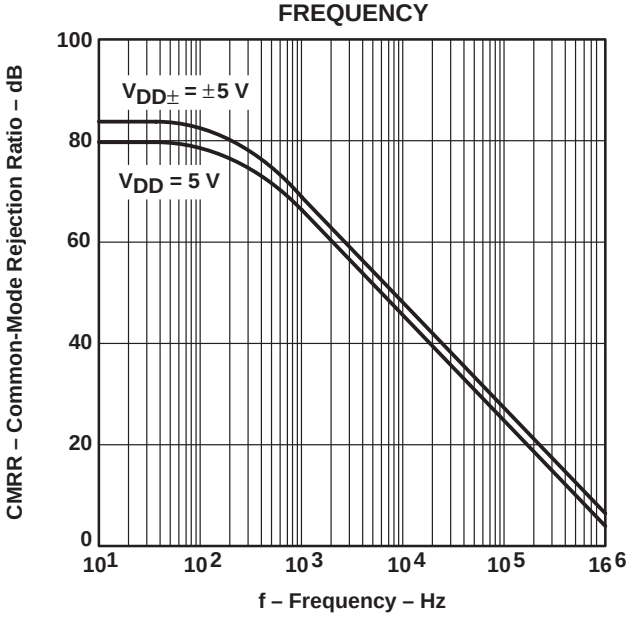



Figure 32

**COMMON-MODE REJECTION RATIO†‡ vs FREE-AIR TEMPERATURE**

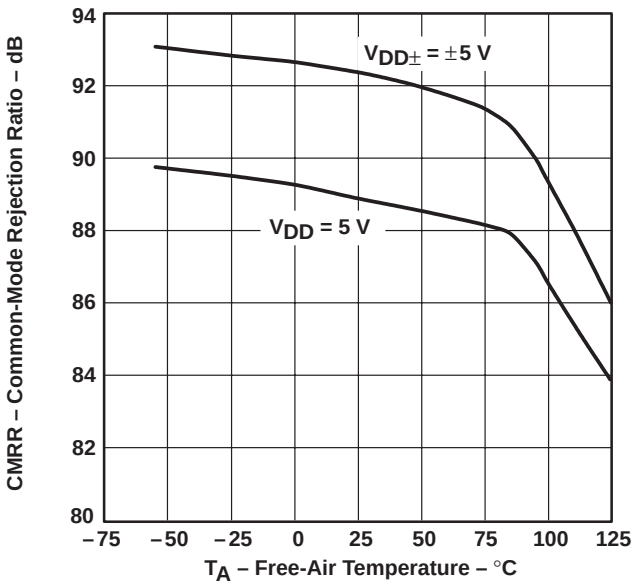



Figure 33

**SUPPLY-VOLTAGE REJECTION RATIO† vs FREQUENCY**

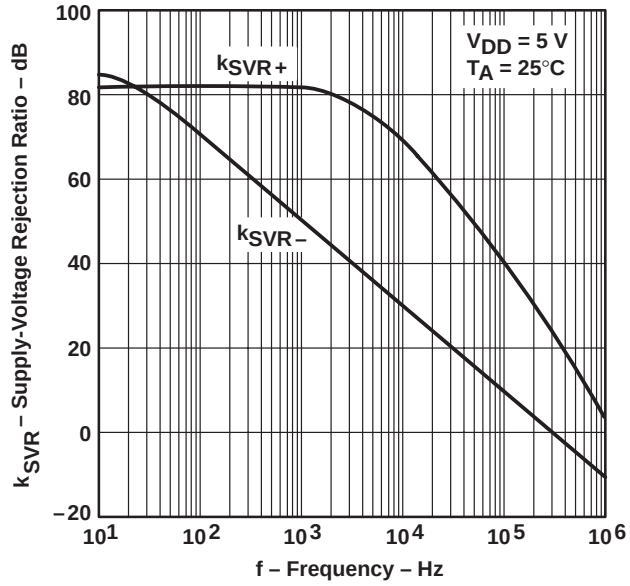



Figure 34

**SUPPLY-VOLTAGE REJECTION RATIO vs FREQUENCY**

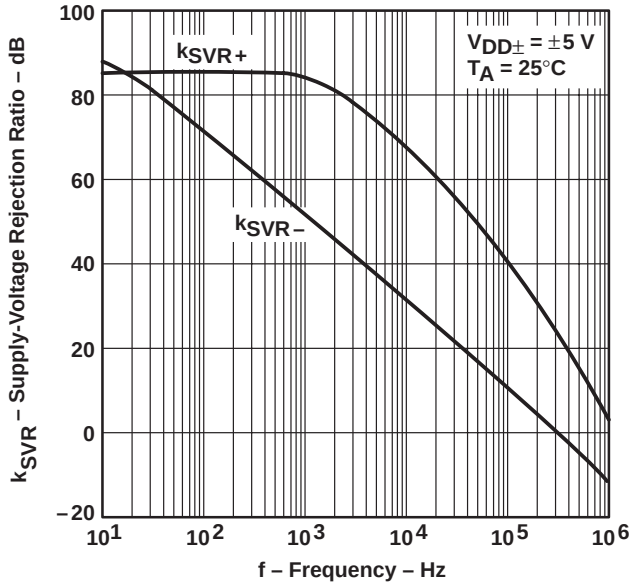



Figure 35

† For curves where $V_{DD}$ = 5 V, all loads are referenced to 2.5 V.
‡ Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

## TYPICAL CHARACTERISTICS

**SUPPLY-VOLTAGE REJECTION RATIO† vs FREE-AIR TEMPERATURE**

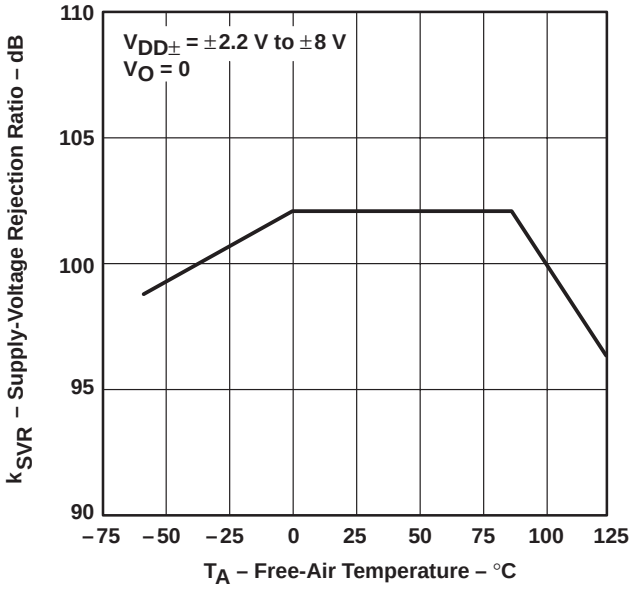



Figure 36

**SUPPLY CURRENT† vs SUPPLY VOLTAGE**

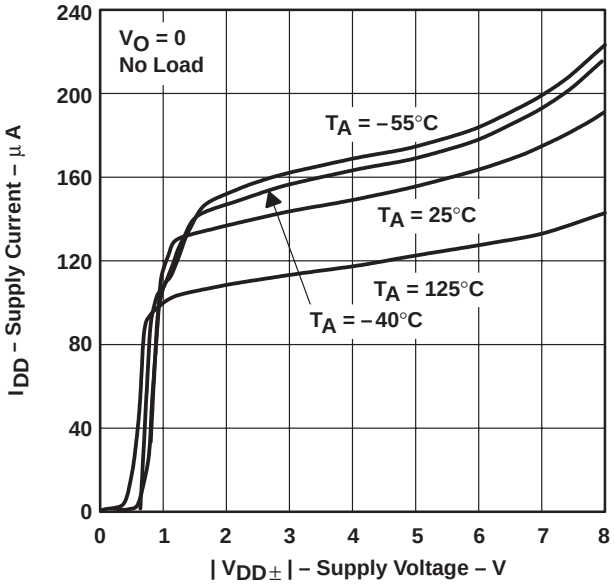



Figure 37

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

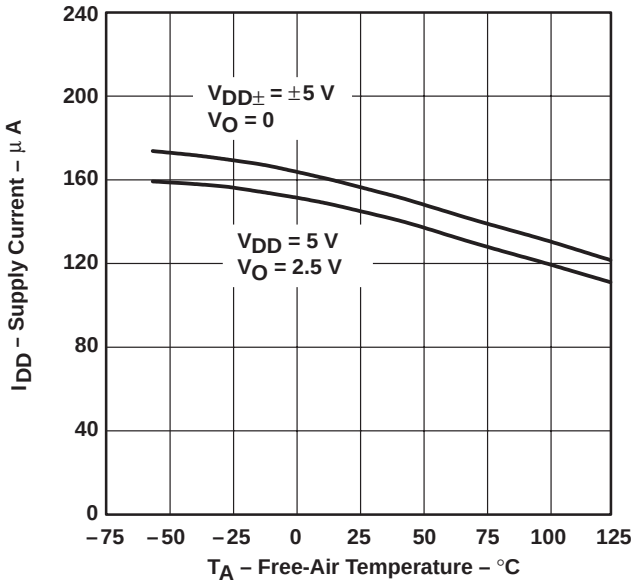



Figure 38

**SLEW RATE‡ vs LOAD CAPACITANCE**

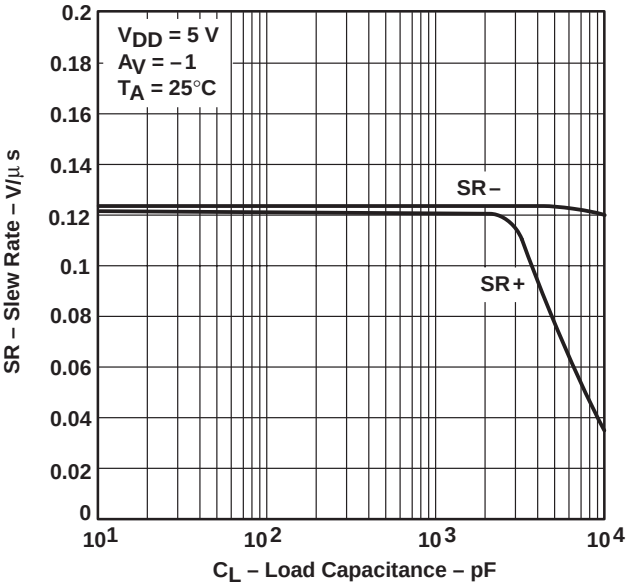



Figure 39

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.
‡ For curves where $V_{DD}$ = 5 V, all loads are referenced to 2.5 V.

## TYPICAL CHARACTERISTICS

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

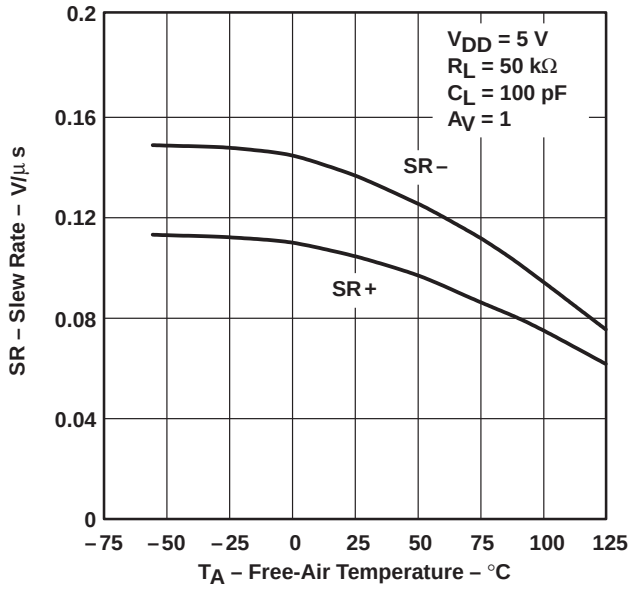



**Figure 40**

**INVERTING LARGE-SIGNAL PULSE RESPONSE‡**

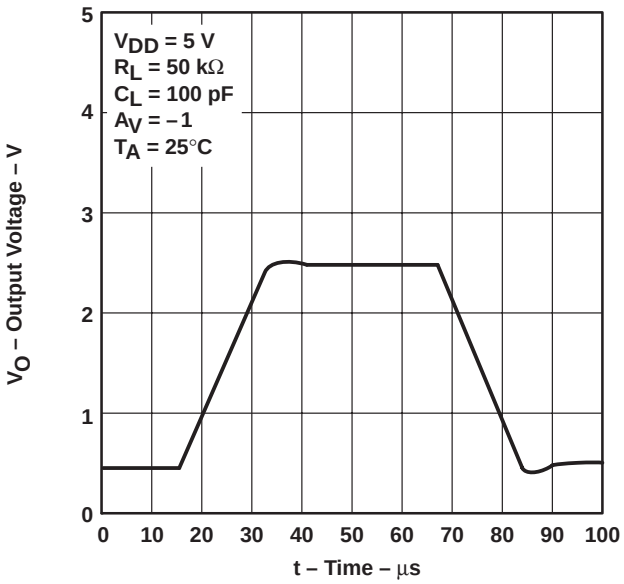



**Figure 41**

**INVERTING LARGE-SIGNAL PULSE RESPONSE**

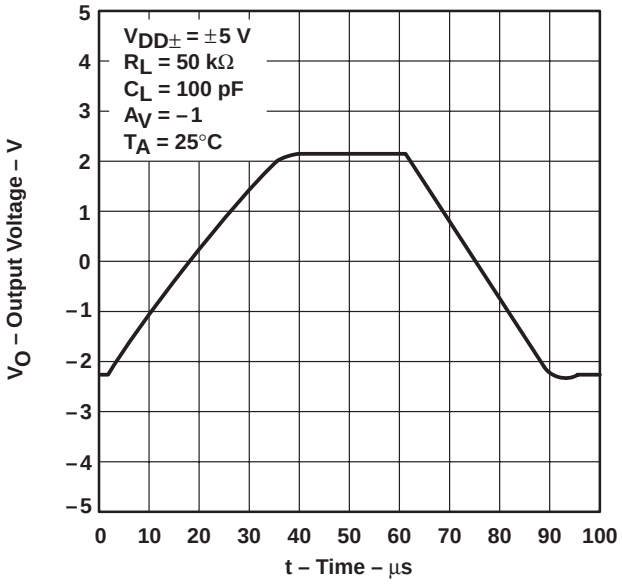



**Figure 42**

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

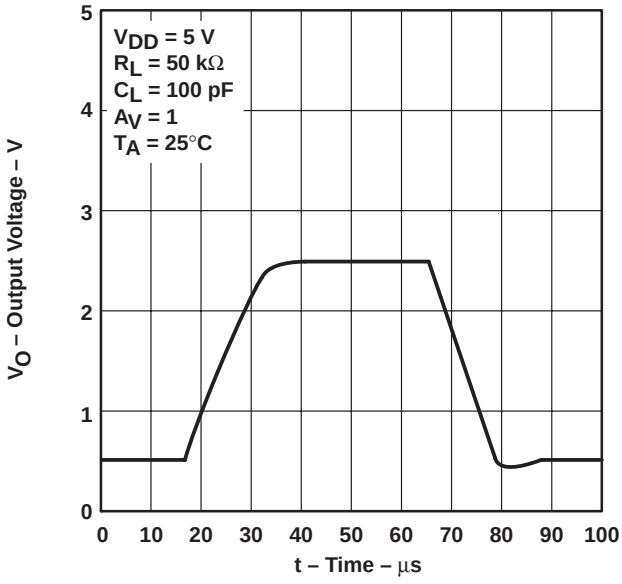



**Figure 43**

† Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.
‡ For curves where $V_{DD}$ = 5 V, all loads are referenced to 2.5 V.

## TYPICAL CHARACTERISTICS

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

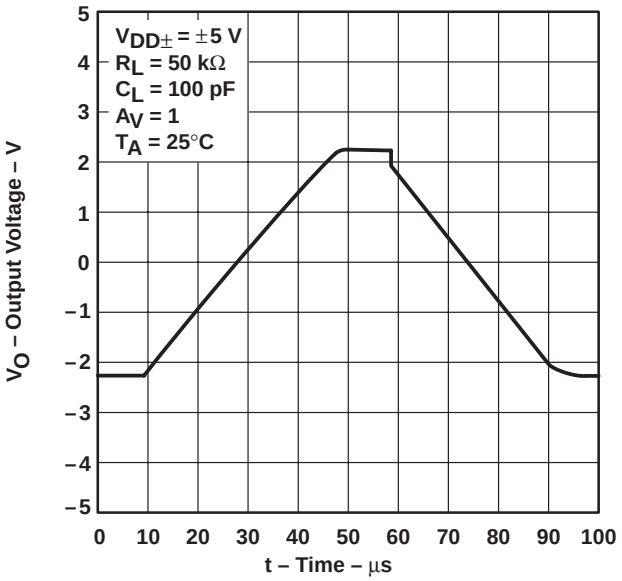



**Figure 44**

**INVERTING SMALL-SIGNAL PULSE RESPONSE†**

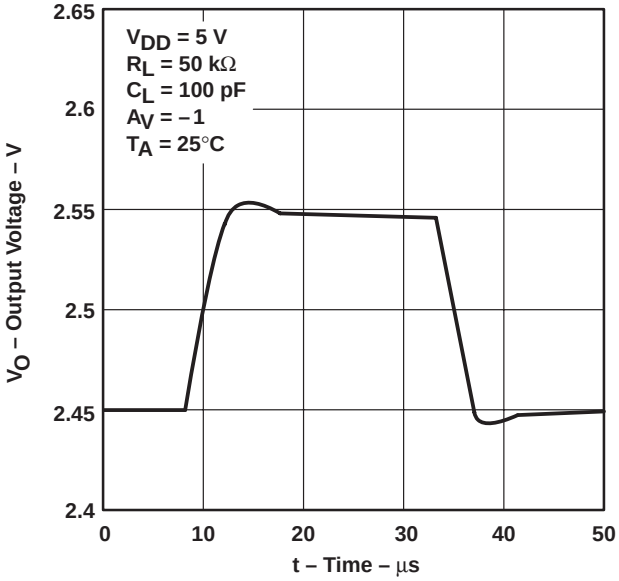



**Figure 45**

**INVERTING SMALL-SIGNAL PULSE RESPONSE**

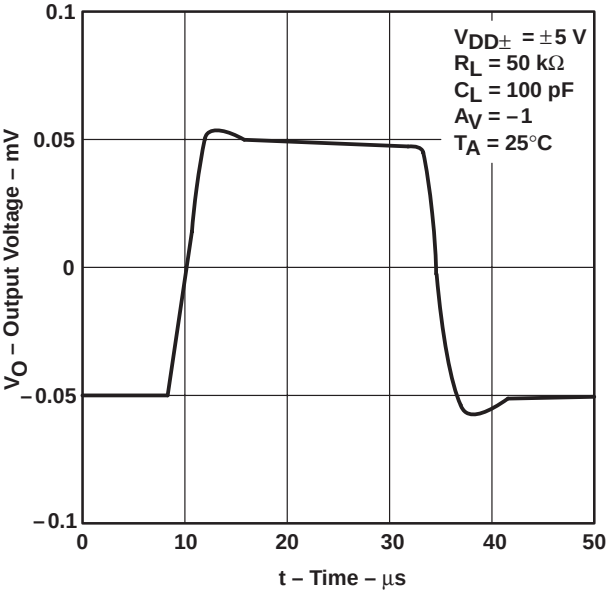



**Figure 46**

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

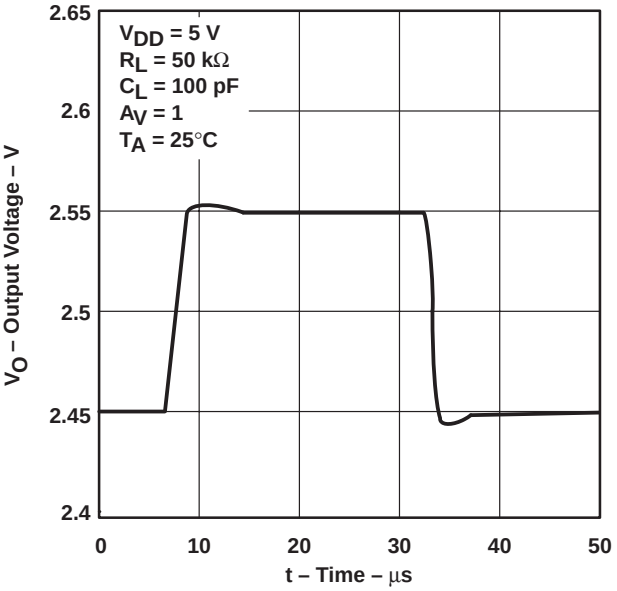



**Figure 47**

† For curves where $V_{DD}$ = 5 V, all loads are referenced to 2.5 V.

## TYPICAL CHARACTERISTICS

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

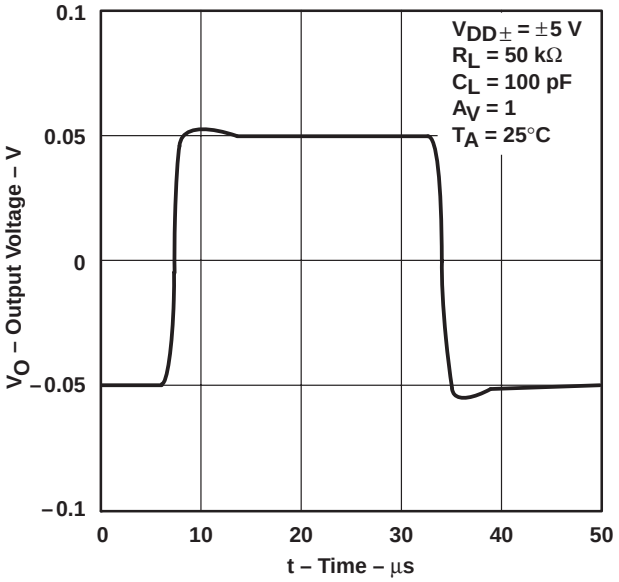



Figure 48

**EQUIVALENT INPUT NOISE VOLTAGE† vs FREQUENCY**

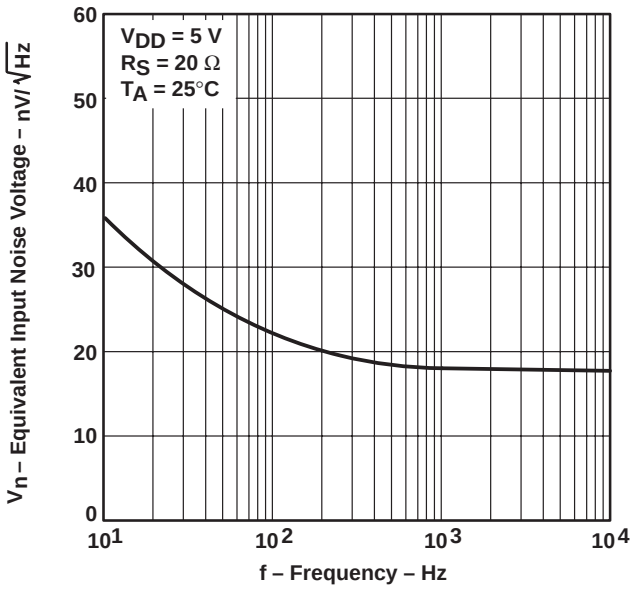



Figure 49

**EQUIVALENT INPUT NOISE VOLTAGE vs FREQUENCY**

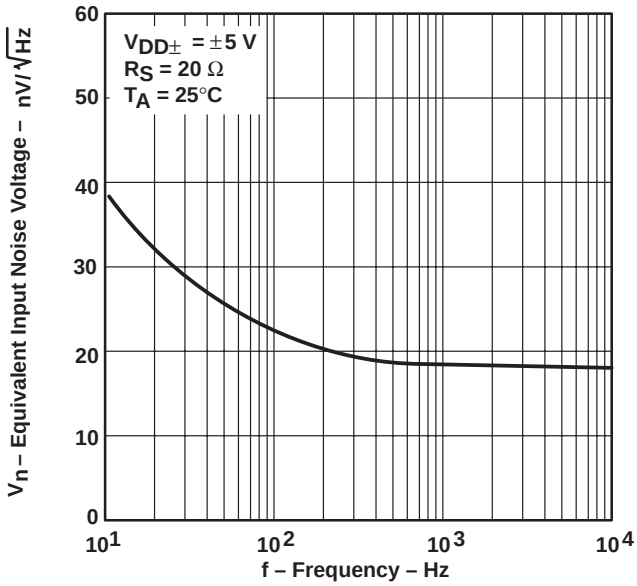



Figure 50

**EQUIVALENT INPUT NOISE VOLTAGE OVER A 10-SECOND PERIOD†**

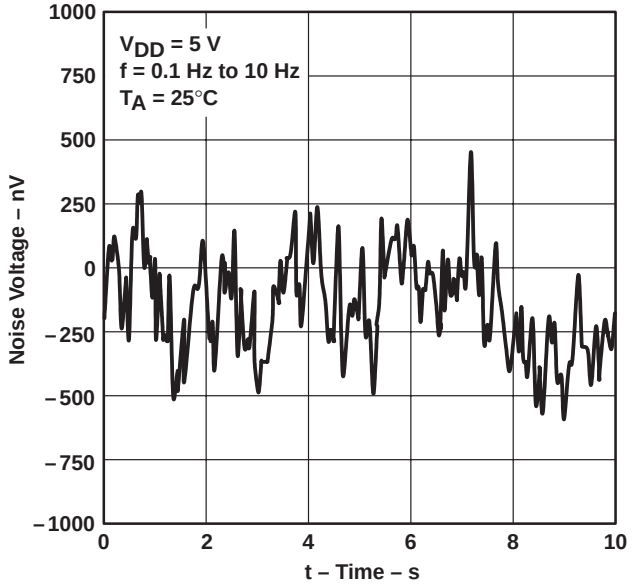



Figure 51

† For curves where $V_{DD}$ = 5 V, all loads are referenced to 2.5 V.

## TYPICAL CHARACTERISTICS

**INTEGRATED NOISE VOLTAGE vs FREQUENCY**

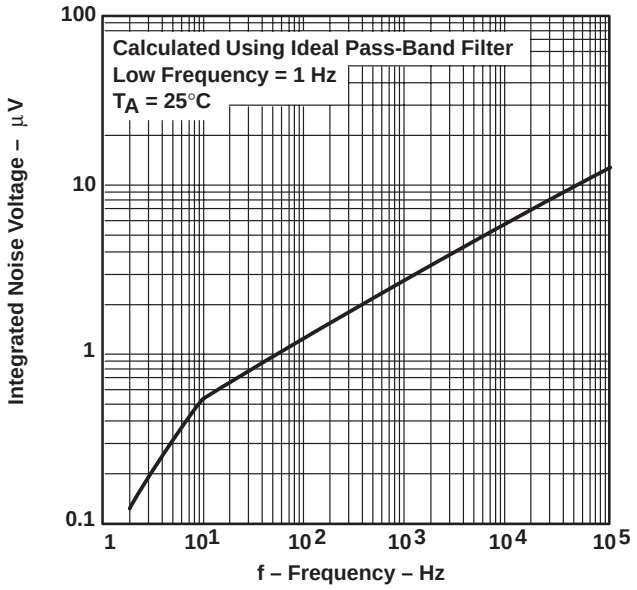



Figure 52

**TOTAL HARMONIC DISTORTION PLUS NOISE† vs FREQUENCY**

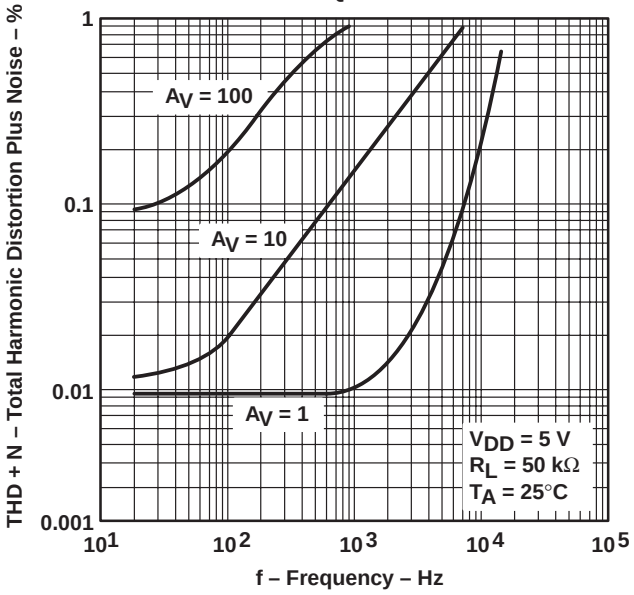



Figure 53

**GAIN-BANDWIDTH PRODUCT†‡ vs FREE-AIR TEMPERATURE**

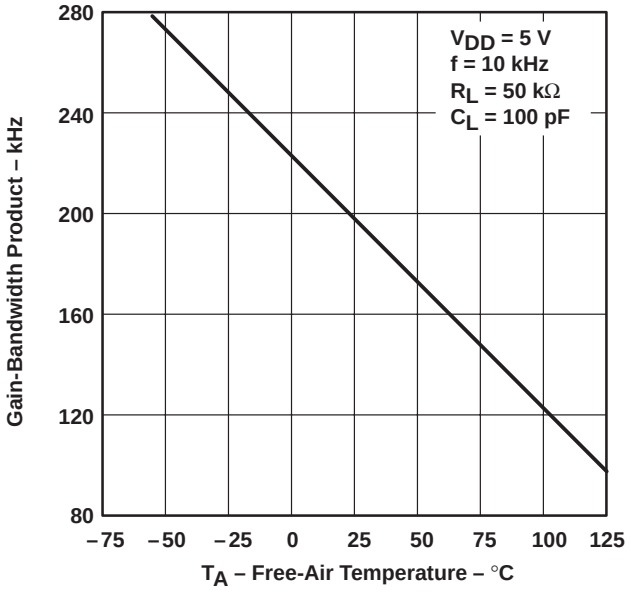



Figure 54

**GAIN-BANDWIDTH PRODUCT vs SUPPLY VOLTAGE**

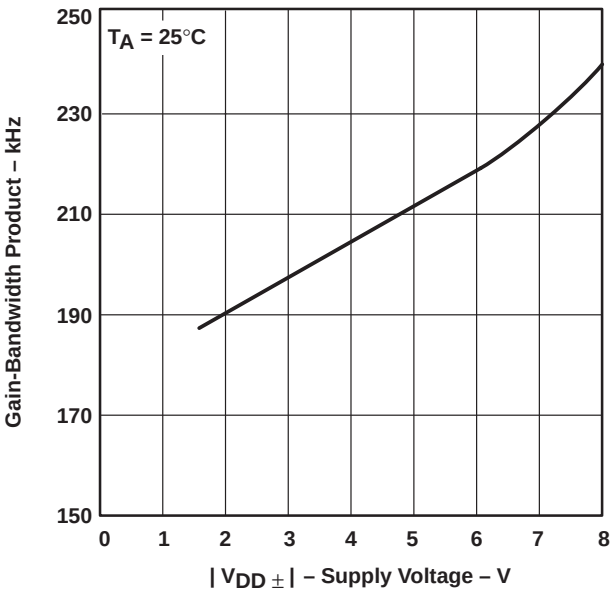



Figure 55

† For curves where $V_{DD}$ = 5 V, all loads are referenced to 2.5 V.
‡ Data at high and low temperatures are applicable only within the rated operating free-air temperature ranges of the various devices.

## TYPICAL CHARACTERISTICS

**PHASE MARGIN vs LOAD CAPACITANCE**

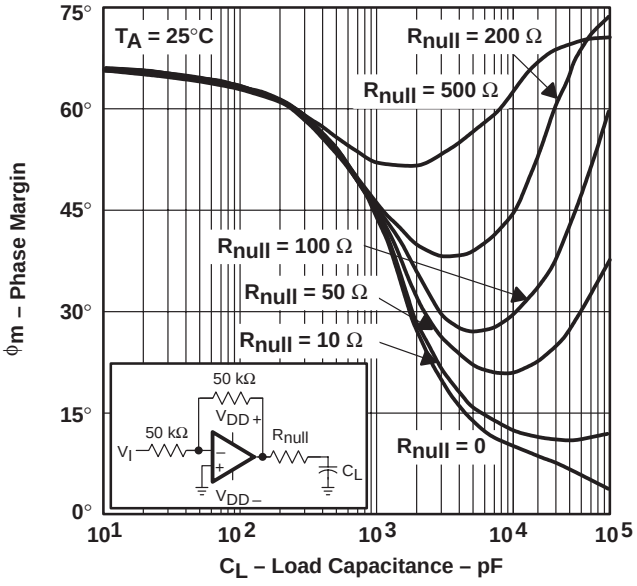



Figure 56

**GAIN MARGIN vs LOAD CAPACITANCE**

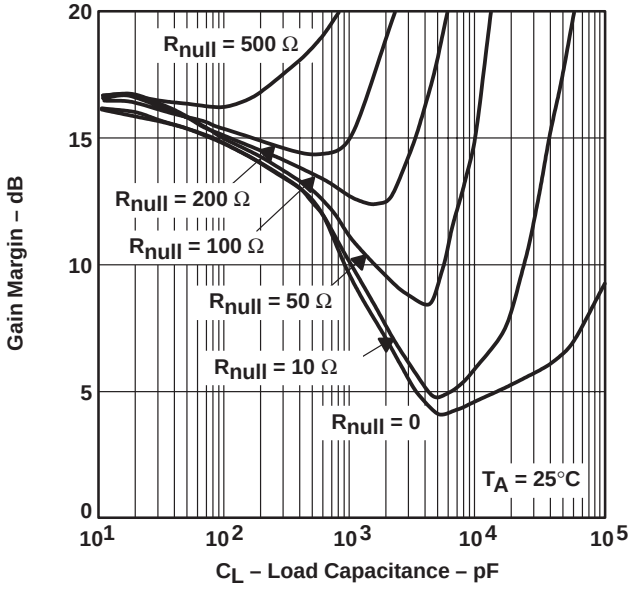



Figure 57

**UNITY-GAIN BANDWIDTH† vs LOAD CAPACITANCE**

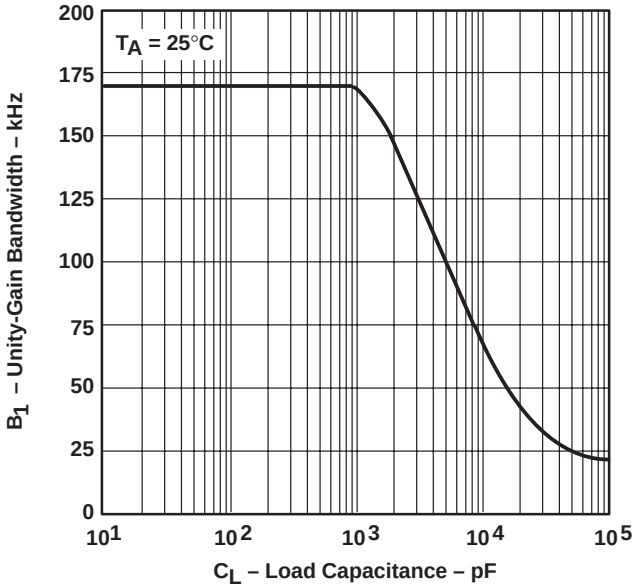



Figure 58

**OVERESTIMATION OF PHASE MARGIN† vs LOAD CAPACITANCE**

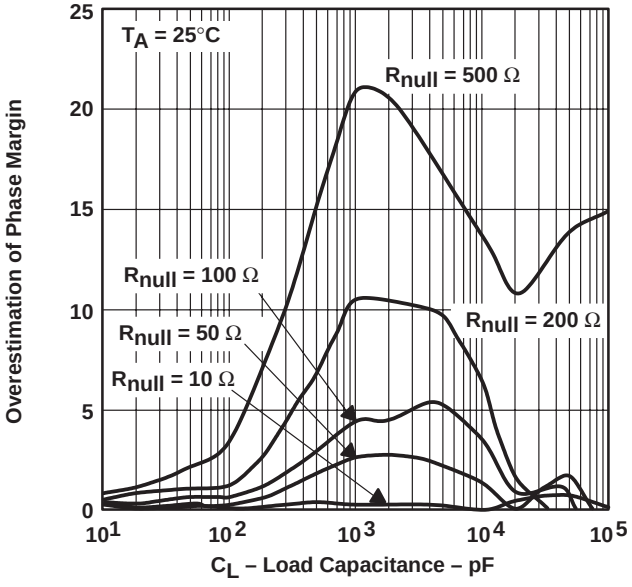



Figure 59

† See application information

## APPLICATION INFORMATION

### driving large capacitive loads

The TLC225x is designed to drive larger capacitive loads than most CMOS operational amplifiers. Figure 56 and Figure 57 illustrate its ability to drive loads up to 1000 pF while maintaining good gain and phase margins ($R_{null}$ = 0).

A smaller series resistor ($R_{null}$) at the output of the device (see Figure 60) improves the gain and phase margins when driving large capacitive loads. Figure 56 and Figure 57 show the effects of adding series resistances of 10 Ω, 50 Ω, 100 Ω, 200 Ω, and 500 Ω. The addition of this series resistor has two effects: the first is that it adds a zero to the transfer function and the second is that it reduces the frequency of the pole associated with the output load in the transfer function.

The zero introduced to the transfer function is equal to the series resistance times the load capacitance. To calculate the improvement in phase margin, equation 1 can be used.

$$\Delta\phi_{m1} = \tan^{-1}\left(2 \times \pi \times \text{UGBW} \times R_{null} \times C_L\right) \quad (1)$$

where :

$\Delta\phi_{m1}$ = improvement in phase margin
UGBW = unity-gain bandwidth frequency
$R_{null}$ = output series resistance
$C_L$ = load capacitance

The unity-gain bandwidth (UGBW) frequency decreases as the capacitive load increases (see Figure 58). To use equation 1, UGBW must be approximated from Figure 58.

Using equation 1 alone overestimates the improvement in phase margin, as illustrated in Figure 59. The overestimation is caused by the decrease in the frequency of the pole associated with the load, thus providing additional phase shift and reducing the overall improvement in phase margin.

Using Figure 60, with equation 1 enables the designer to choose the appropriate output series resistance to optimize the design of circuits driving large capacitance loads.

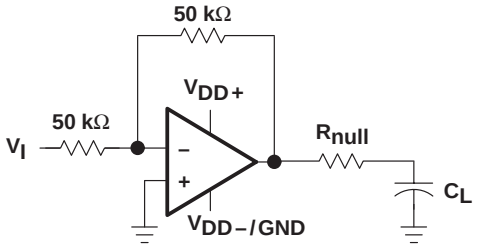



**Figure 60. Series-Resistance Circuit**

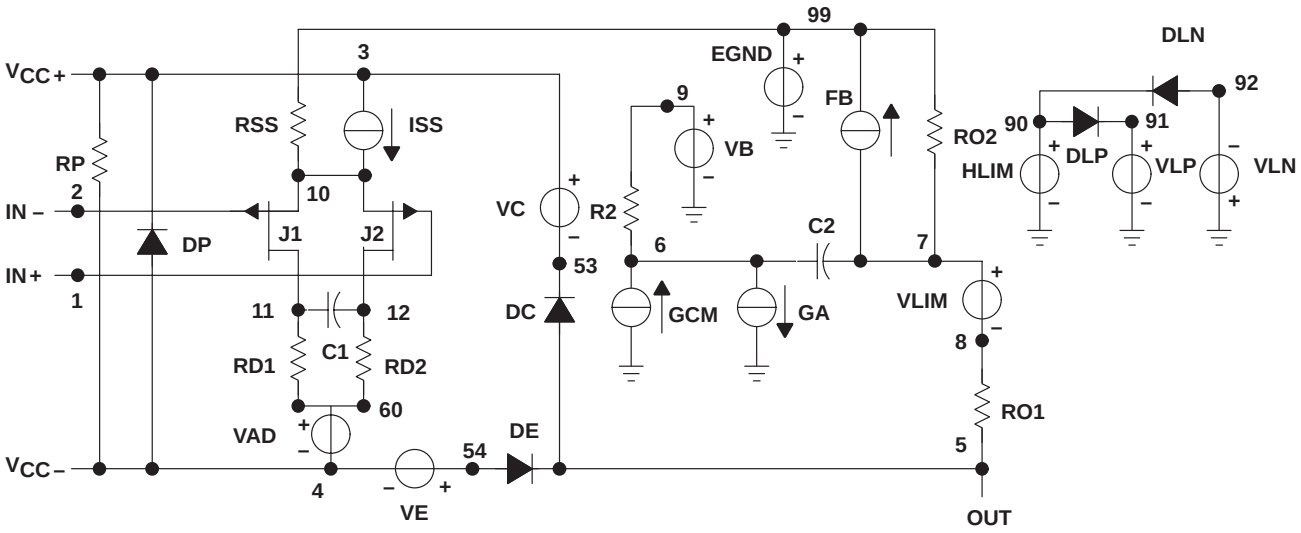
## APPLICATION INFORMATION

### 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 61 are generated using the TLC225x typical electrical and operating characteristics at $T_A$ = 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).




```
.SUBCKT TLC225x 1 2 3 4 5
C1      11      12      6.369E–12
C2      6       7       25.00E–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 57.62E6 –60E6 60E6 60E6 –60E6
GA      6       0       11      12 26.86E–6
GCM     0       6       10      99 2.686E–9
ISS     3       10      DC 3.1E–6
HLIM    90      0       VLIM 1K
J1      11      2       10 JX
J2      12      1       10 JX
R2      6       9       100.0E3
RD1     60      11      37.23E3
RD2     60      12      37.23E3
R01     8       5       84
R02     7       99      84
RP      3       4       71.43E3
RSS     10      99      64.52E6
VAD     60      4       –.5
VB      9       0       DC 0
VC      3       53      DC .605
VE      54      4       DC .605
VLIM    7       8       DC 0
VLP     91      0       DC –.235
VLN     0       92      DC 7.5
.MODEL DX D (IS=800.0E–18)
.MODEL JX PJF (IS=500.0E–15 BETA=139E–6
+ VTO=–.05)
.ENDS
```

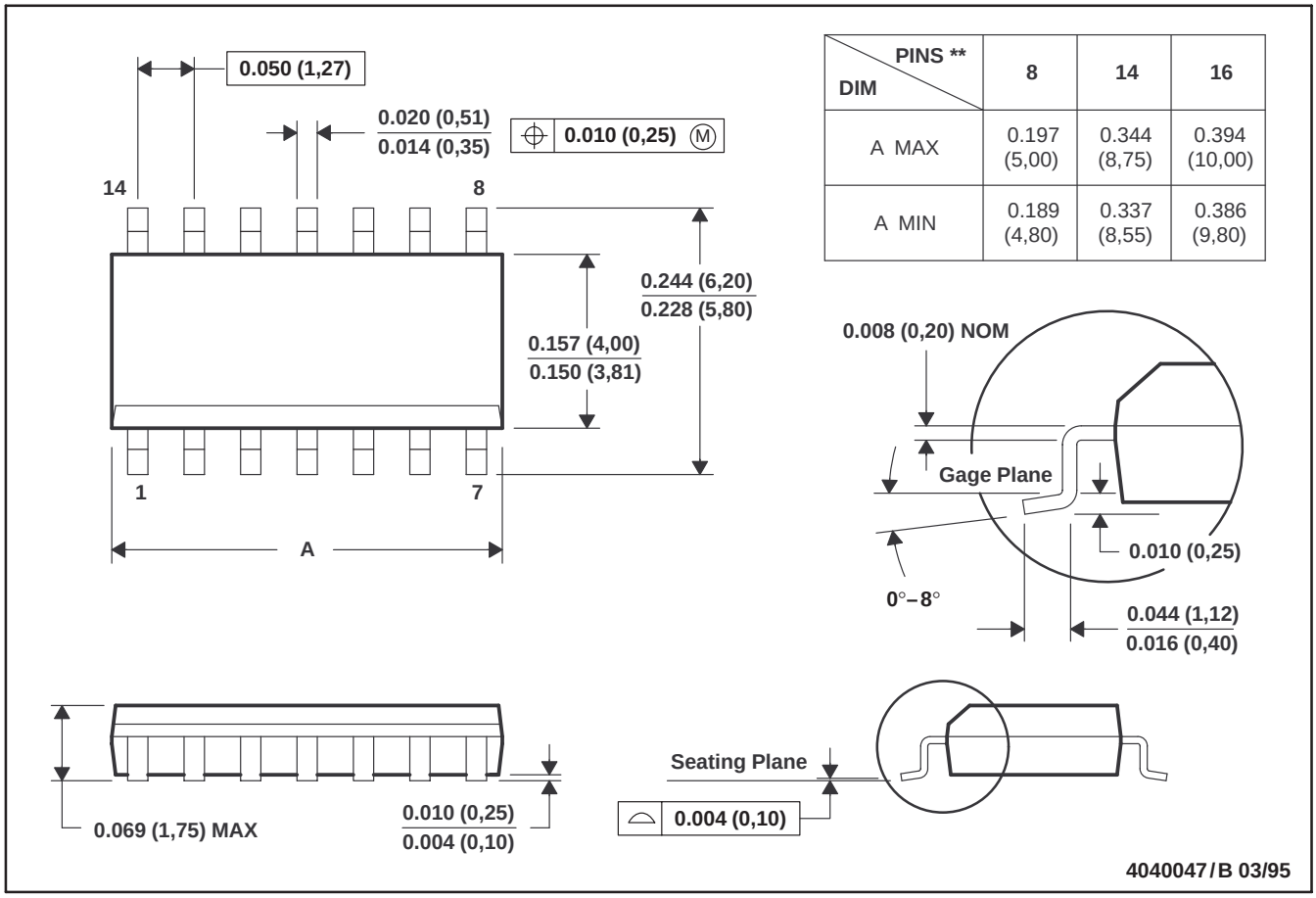
**Figure 61. Boyle Macromodel and Subcircuit**

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

## MECHANICAL INFORMATION

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

**14 PIN SHOWN**



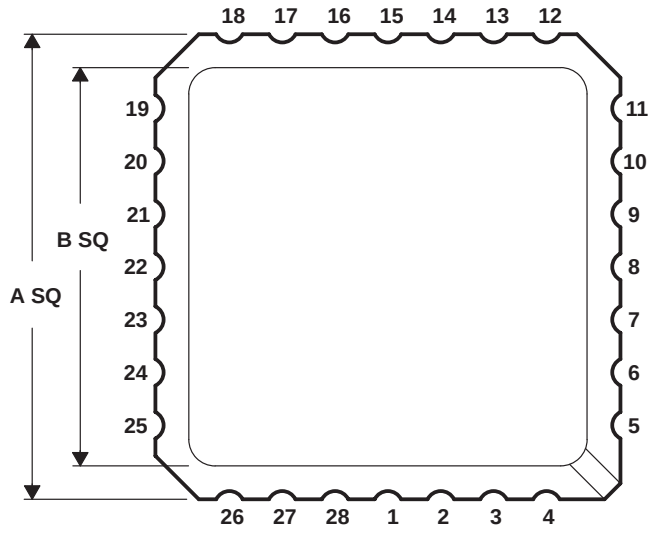

| DIM \ PINS ** | 8 | 14 | 16 |
|---|---|---|---|
| A MAX | 0.197 (5,00) | 0.344 (8,75) | 0.394 (10,00) |
| A MIN | 0.189 (4,80) | 0.337 (8,55) | 0.386 (9,80) |

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. Four center pins are connected to die mount pad.
E. Falls within JEDEC MS-012

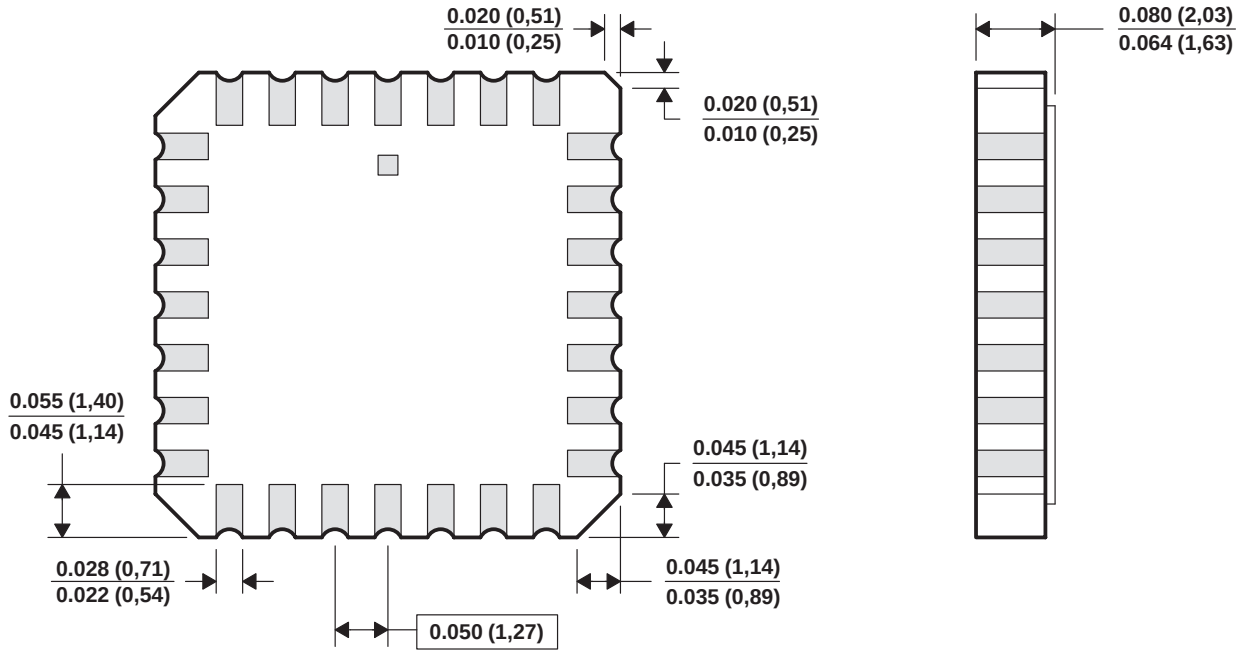
## MECHANICAL INFORMATION

**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 | 0.740 (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) |



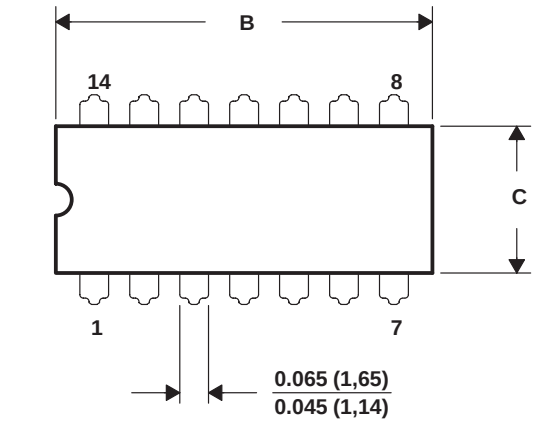

4040140/C 11/95

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

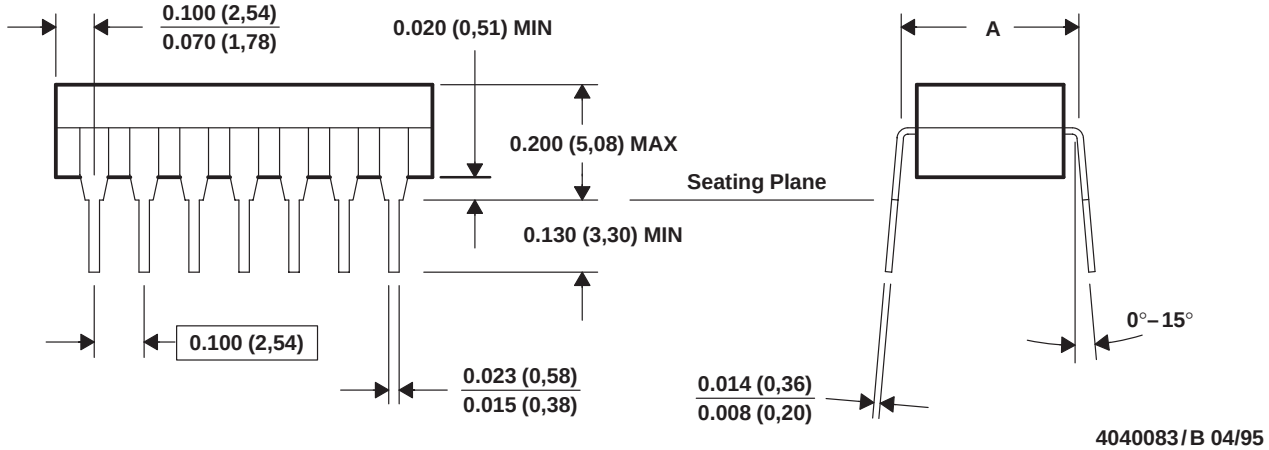
## MECHANICAL INFORMATION

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

**14 PIN SHOWN**




| DIM \ PINS ** | 14 | 16 | 18 | 20 | 22 |
|---|---|---|---|---|---|
| A MAX | 0.310 (7,87) | 0.310 (7,87) | 0.310 (7,87) | 0.310 (7,87) | 0.410 (10,41) |
| A MIN | 0.290 (7,37) | 0.290 (7,37) | 0.290 (7,37) | 0.290 (7,37) | 0.390 (9,91) |
| B MAX | 0.785 (19,94) | 0.785 (19,94) | 0.910 (23,10) | 0.975 (24,77) | 1.100 (28,00) |
| B MIN | 0.755 (19,18) | 0.755 (19,18) | — | 0.930 (23,62) | — |
| C MAX | 0.280 (7,11) | 0.300 (7,62) | 0.300 (7,62) | 0.300 (7,62) | 0.388 (9,65) |
| C MIN | 0.245 (6,22) | 0.245 (6,22) | 0.245 (6,22) | 0.245 (6,22) | — |

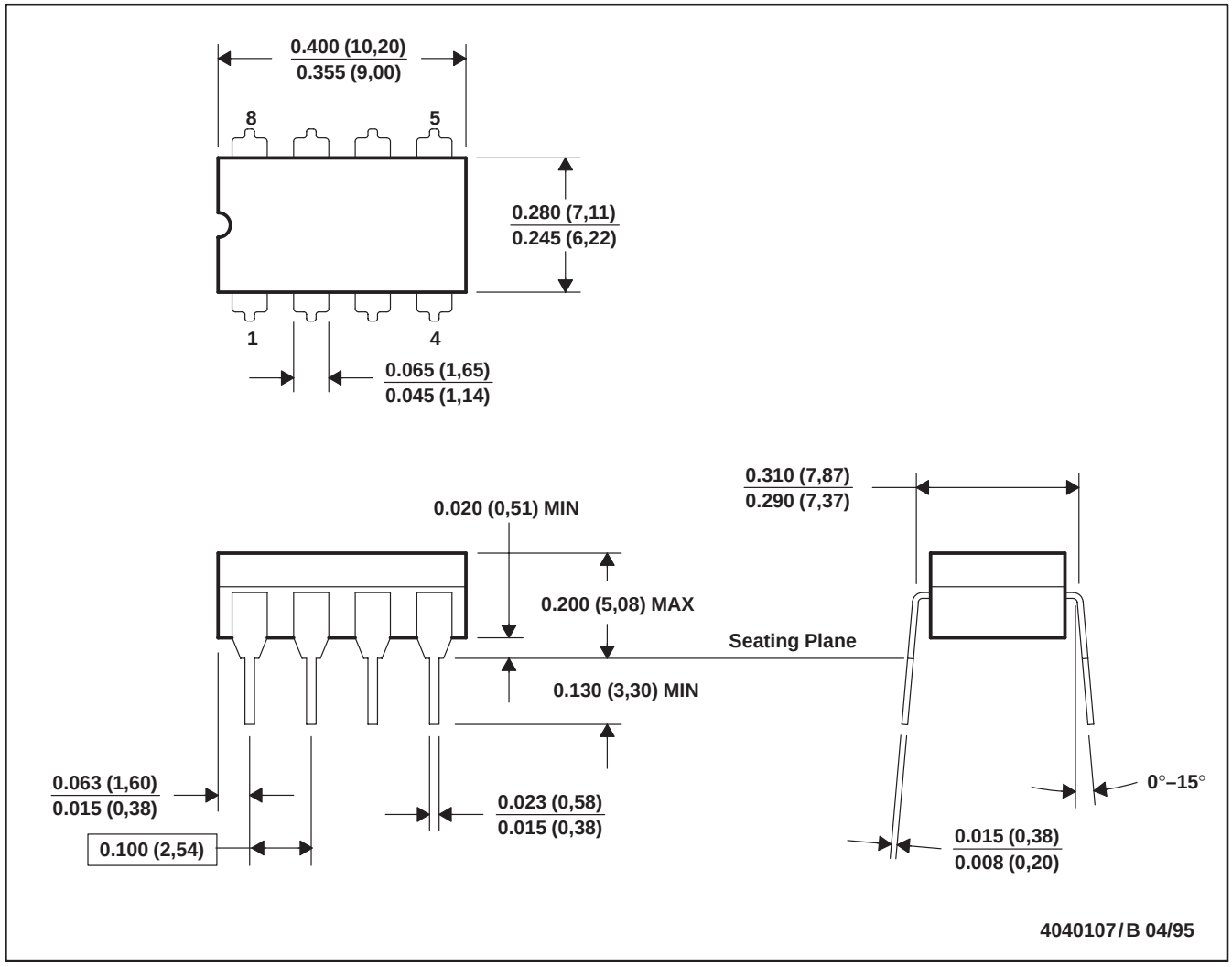



4040083/B 04/95

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 only on press ceramic glass frit seal only.
E. Falls within MIL-STD-1835 GDIP1-T14, GDIP1-T16, GDIP1-T18, GDIP1-T20, and GDIP1-T22

## MECHANICAL INFORMATION

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



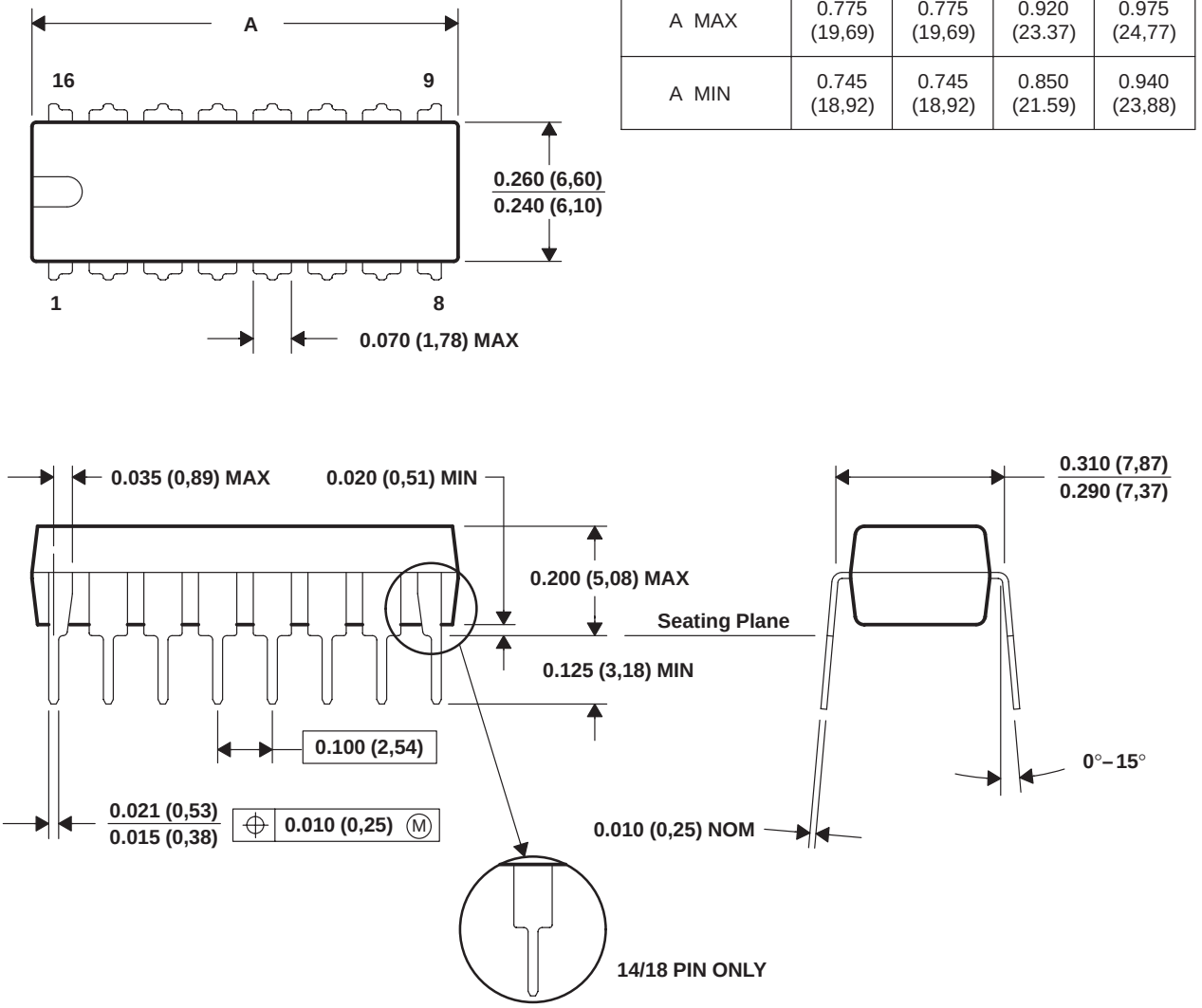

NOTES: A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. This package can be hermetically sealed with a ceramic lid using glass frit.
D. Index point is provided on cap for terminal identification only on press ceramic glass frit seal only
E.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

## MECHANICAL INFORMATION

**N (R-PDIP-T**)** **PLASTIC DUAL-IN-LINE PACKAGE**

**16 PIN SHOWN**

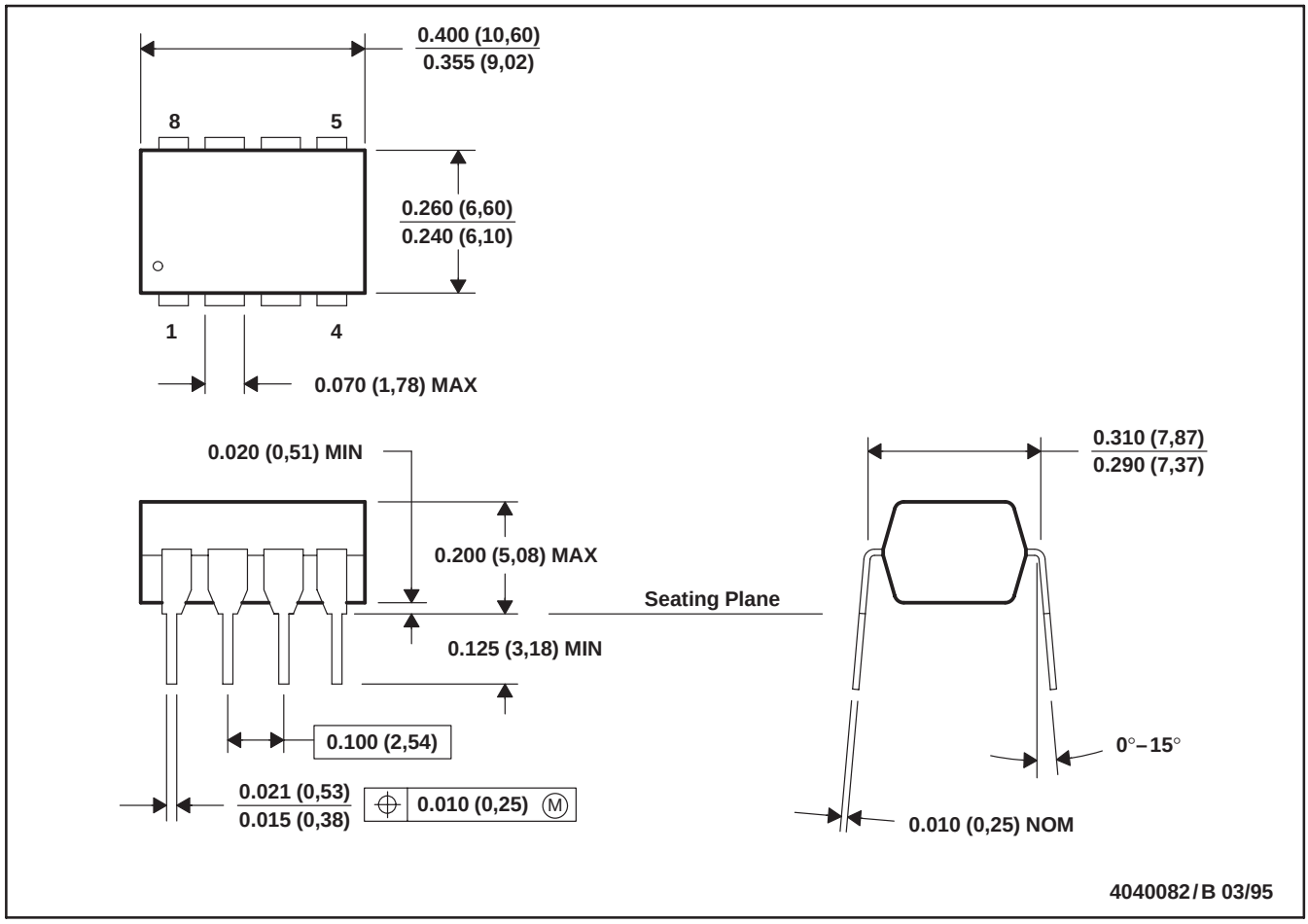
| DIM \ PINS ** | 14 | 16 | 18 | 20 |
|---|---|---|---|---|
| A MAX | 0.775 (19,69) | 0.775 (19,69) | 0.920 (23.37) | 0.975 (24,77) |
| A MIN | 0.745 (18,92) | 0.745 (18,92) | 0.850 (21.59) | 0.940 (23,88) |




NOTES: A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Falls within JEDEC MS-001 (20 pin package is shorter then MS-001.)

## MECHANICAL INFORMATION

**P (R-PDIP-T8)** **PLASTIC DUAL-IN-LINE PACKAGE**

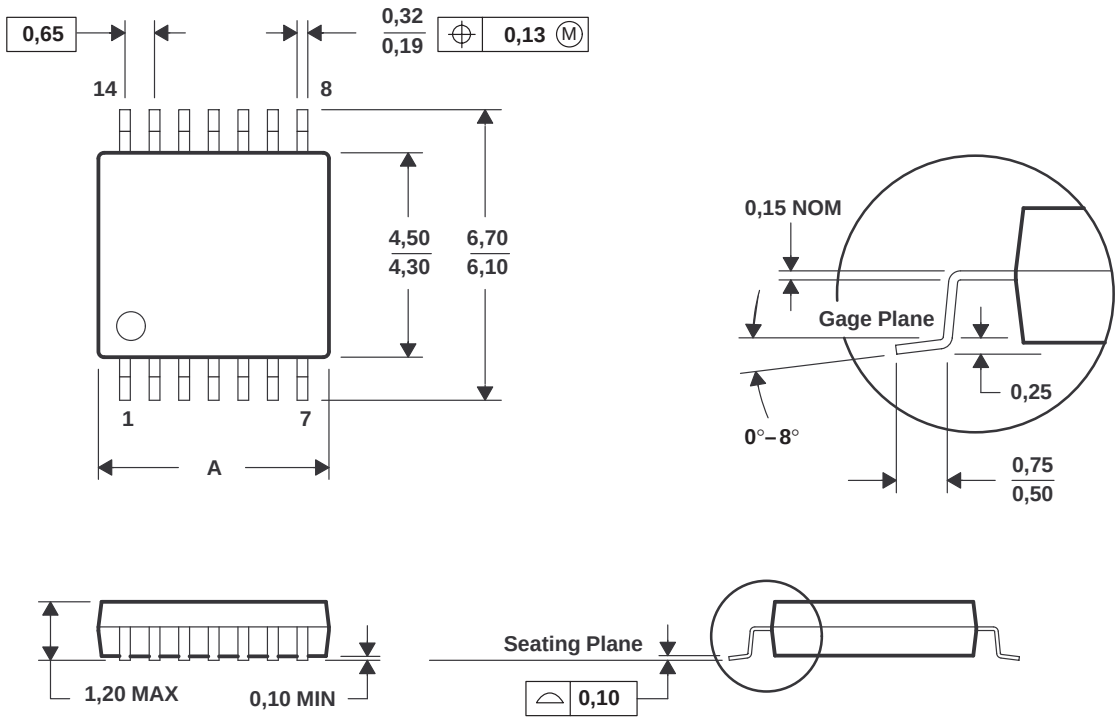



NOTES: A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Falls within JEDEC MS-001

## MECHANICAL INFORMATION

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

**14 PIN SHOWN**



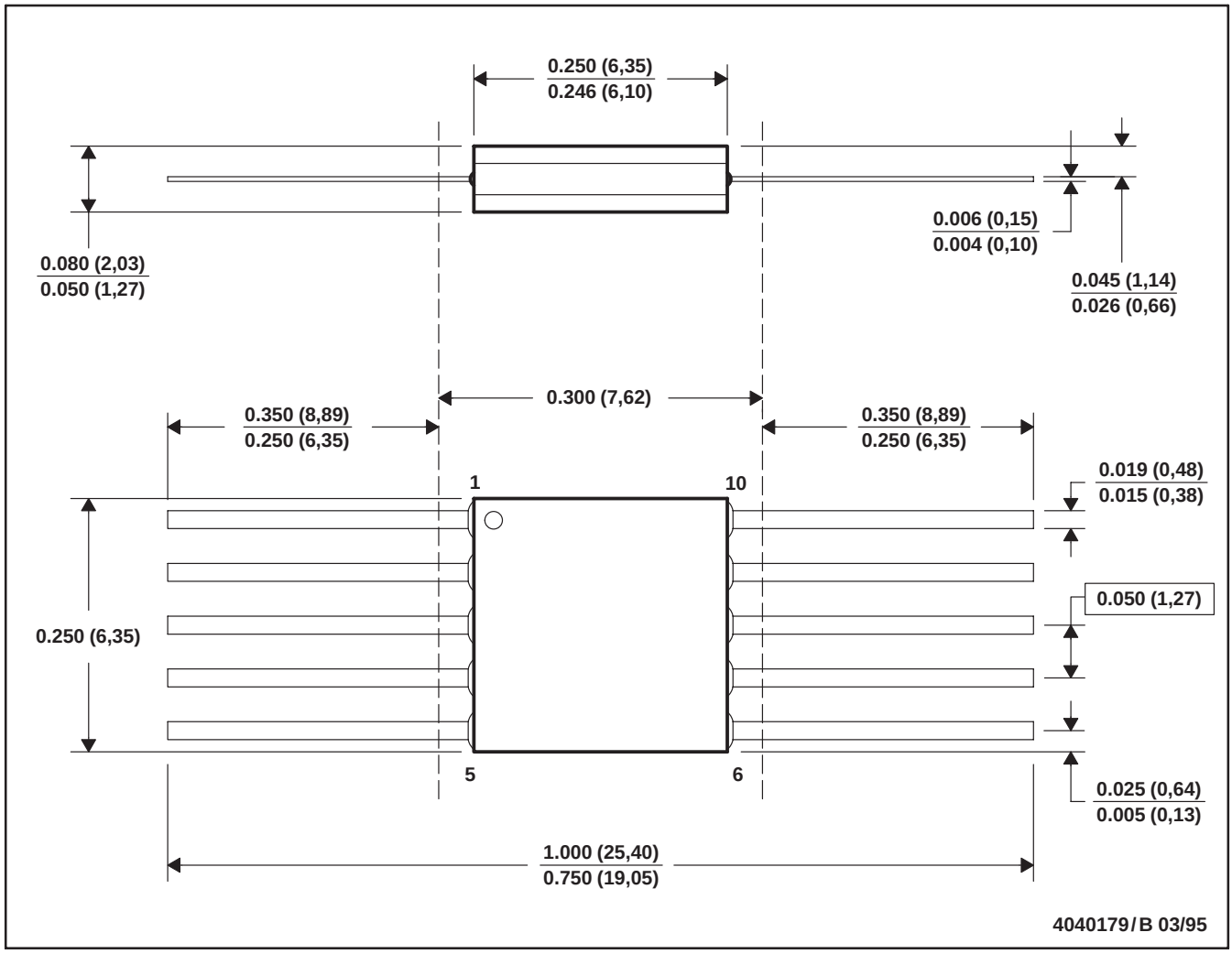

| DIM \ PINS ** | 8 | 14 | 16 | 20 | 24 | 28 |
|---|---|---|---|---|---|---|
| A MAX | 3,10 | 5,10 | 5,10 | 6,60 | 7,90 | 9,80 |
| A MIN | 2,90 | 4,90 | 4,90 | 6,40 | 7,70 | 9,60 |

**4040064/D 10/95**

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

## MECHANICAL INFORMATION

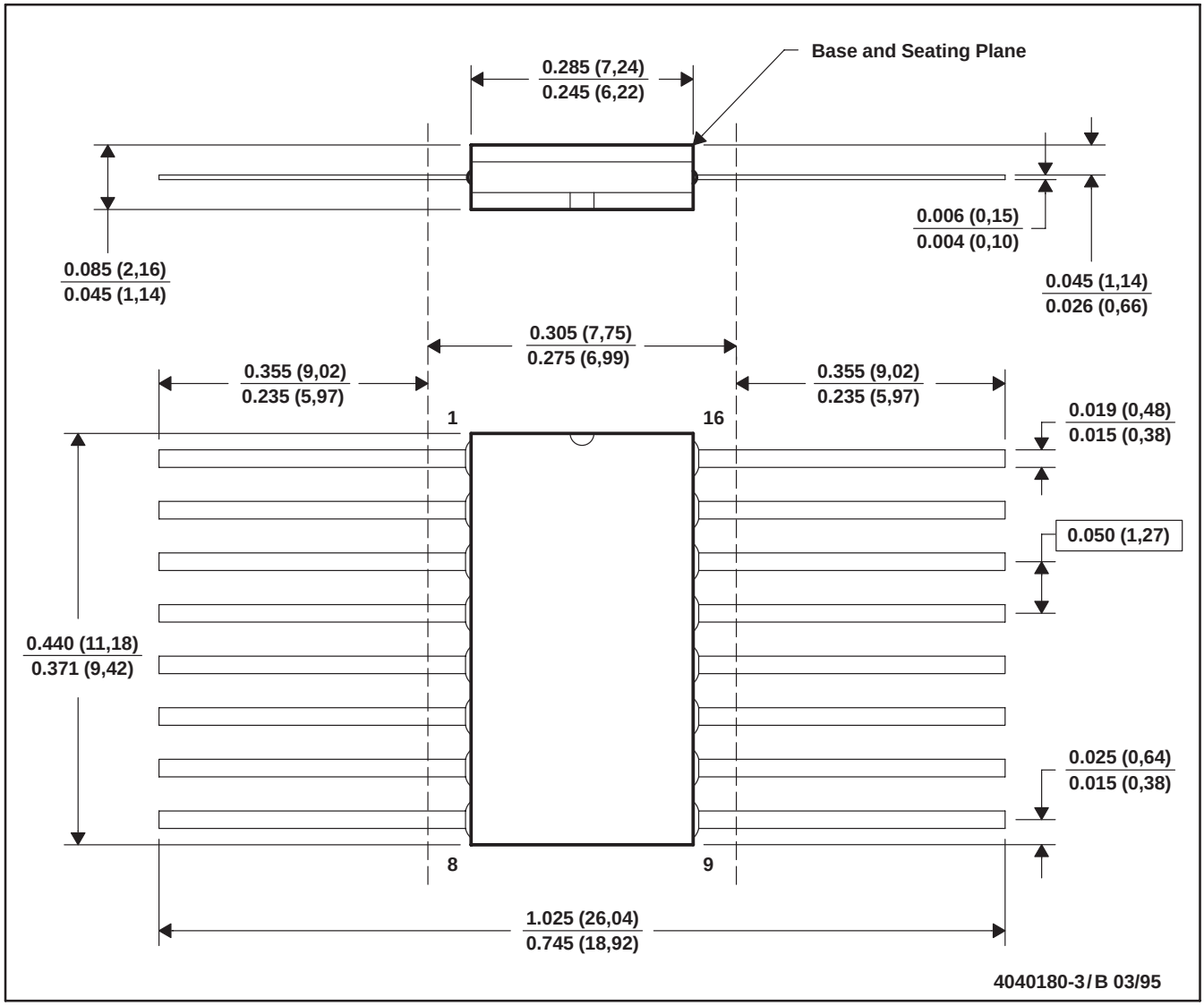
**U (S-GDFP-F10)** **CERAMIC DUAL FLATPACK**




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 only.
E. Falls within MIL STD 1835 GDFP1-F10 and JEDEC MO-092AA

## MECHANICAL INFORMATION

**W (R-GDFP-F16)** **CERAMIC DUAL FLATPACK**




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 only.
E. Falls within MIL-STD-1835 GDFP1-F16 and JEDEC MO-092AC

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