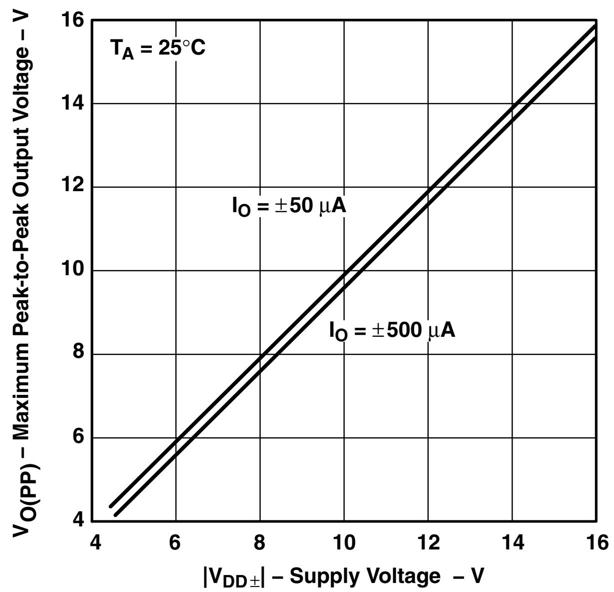
- **Qualified for Automotive Applications**
- **Output Swing Includes Both Supply Rails**
- **Low Noise . . . 9 nV/√Hz Typ at f = 1 kHz**
- **Low Input Bias Current . . . 1 pA Typ**
- **Fully Specified for Both Single-Supply and Split-Supply Operation**
- **Common-Mode Input Voltage Range Includes Negative Rail**
- **High-Gain Bandwidth . . . 2.2 MHz Typ**
- **High Slew Rate . . . 3.6 V/µs Typ**
- **Low Input Offset Voltage**
  **950 µV Max at $T_A$ = 25°C**
- **Macromodel Included**
- **Performance Upgrades for the TS272, TS274, TLC272, and TLC274**

## description

The TLC2272 and TLC2274 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 TLC227x family offers 2 MHz of bandwidth and 3 V/µs of slew rate for higher speed applications. These devices offer comparable ac performance while having better noise, input offset voltage, and power dissipation than existing CMOS operational amplifiers. The TLC227x has a noise voltage of 9 nV/√Hz, two times lower than competitive solutions.

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




The TLC227x, exhibiting high input impedance and low noise, is excellent for small-signal conditioning for high-impedance sources, such as piezoelectric transducers. Because of the micro-power 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 TLC227xA family is available with a maximum input offset voltage of 950 µV. This family is fully characterized at 5 V and ±5 V.

The TLC2272/4 also makes great upgrades to the TLC272/4 or TS272/4 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 range, see the TLV2432 and TLV2442 devices.

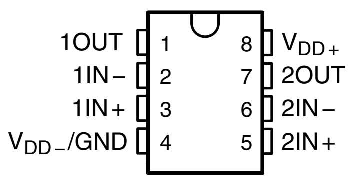
**AVAILABLE OPTIONS†**

| $T_A$ | $V_{IO}$max At 25°C | PACKAGED DEVICES‡ | |
|---|---|---|---|
| | | SMALL OUTLINE (D) | TSSOP (PW) |
| −40°C to 125°C | 950 μV<br>2.5 mV | TLC2272AQDRQ1<br>TLC2272QDRQ1 | TLC2272AQPWRQ1<br>TLC2272QPWRQ1 |
| −40°C to 125°C | 950 μV<br>2.5 mV | TLC2274AQDRQ1<br>TLC2274QDRQ1 | TLC2274AQPWRQ1<br>TLC2274QPWRQ1 |

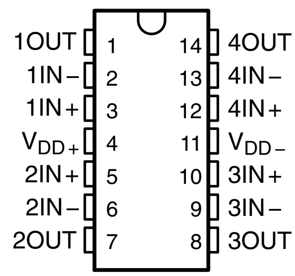
† For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI web site at http://www.ti.com.

‡ Package drawings, thermal data, and symbolization are available at http://www.ti.com/packaging.

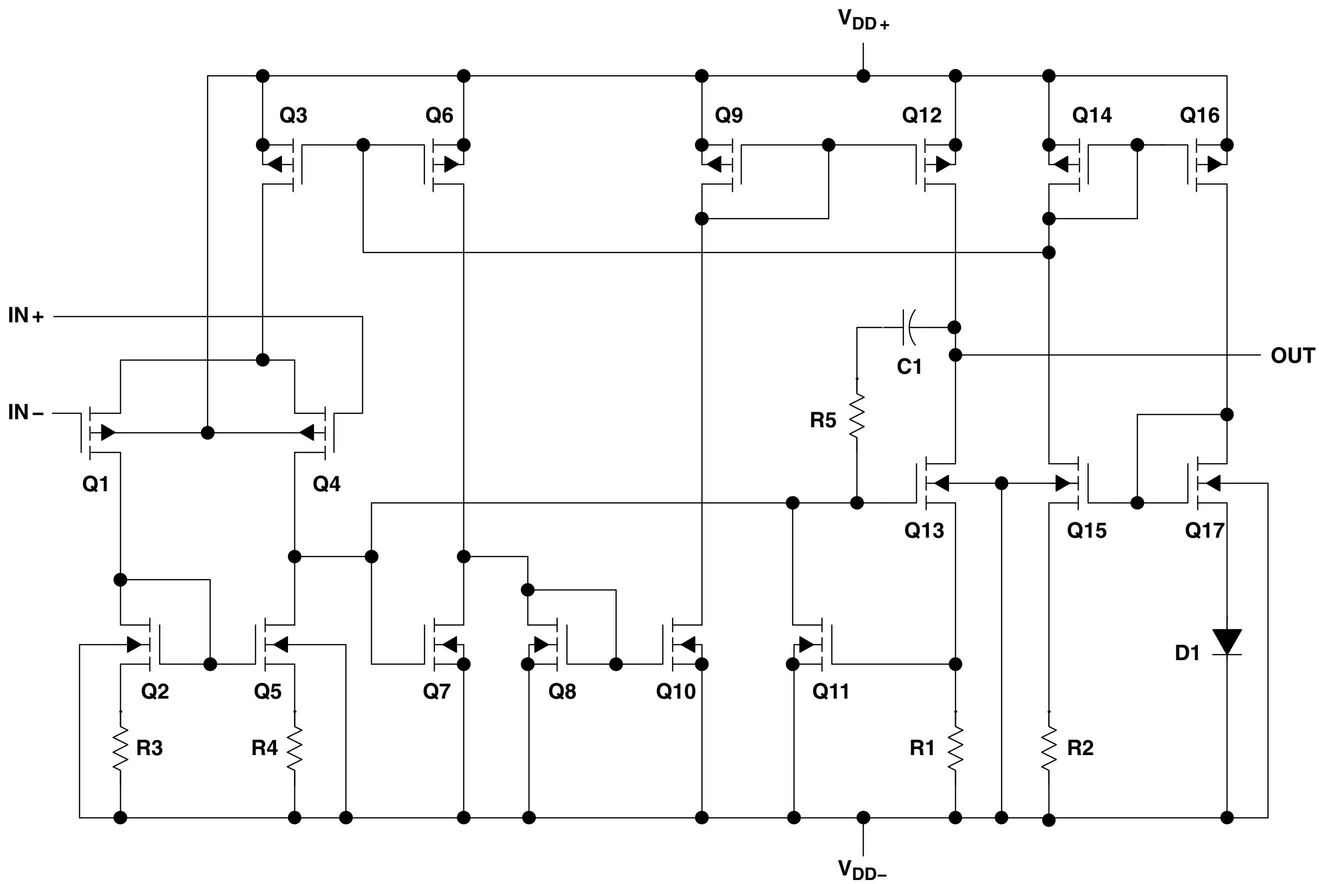
**TLC2272**
**D OR PW PACKAGE**
**(TOP VIEW)**




**TLC2274**
**D OR PW PACKAGE**
**(TOP VIEW)**



### equivalent schematic (each amplifier)




| ACTUAL DEVICE COMPONENT COUNT† | | |
|---|---|---|
| **COMPONENT** | **TLC2272** | **TLC2274** |
| Transistors | 38 | 76 |
| Resistors | 26 | 52 |
| 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 range, $V_I$ (any input, see Note 1) . . . . . $V_{DD-}$ – 0.3 V to $V_{DD+}$
Input current, $I_I$ (any 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, $T_A$ . . . . . −40°C to 125°C
Storage temperature range . . . . . −65°C to 150°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds: D or PW package . . . . . 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 will flow if 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 | 725 mW | 5.8 mW/°C | 464 mW | 337 mW | 145 mW |
| D-14 | 950 mW | 7.6 mW/°C | 608 mW | 494 mW | 190 mW |
| PW-8 | 525 mW | 4.2 mW/°C | 336 mW | 273 mW | 105 mW |
| PW-14 | 700 mW | 5.6 mW/°C | 448 mW | 364 mW | — |

**ELECTROSTATIC DISCHARGE RATING TABLE**

| | | | | RATING |
|---|---|---|---|---|
| ESD | Electrostatic discharge rating | TLC2272 | Human-Body Model (HBM) | 2000 V |
| | | | Machine Model (MM) | 100 V |
| | | | Charged-Device Model (CDM) | 1500 V |
| | | TLC2274 | Human-Body Model (HBM) | 500 V |
| | | | Machine Model (MM) | 100 V |
| | | | Charged-Device Model (CDM) | 1000 V |

## recommended operating conditions

| | | MIN | MAX | UNIT |
|---|---|---|---|---|
| $V_{DD\pm}$ | Supply voltage | ±2.2 | ±8 | V |
| $V_I$ | Input voltage | $V_{DD-}$ | $V_{DD+}-1.5$ | V |
| $V_{IC}$ | Common-mode input voltage | $V_{DD-}$ | $V_{DD+}-1.5$ | V |
| $T_A$ | Operating free-air temperature | −40 | 125 | °C |

## TLC2272Q electrical characteristics at specified free-air temperature, $V_{DD}$ = 5 V (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | | $T_A$† | TLC2272Q | | | TLC2272AQ | | | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | MIN | TYP | MAX | MIN | TYP | MAX | |
| $V_{IO}$ | Input offset voltage | $V_{IC}$ = 0 V, $V_O$ = 0 V, | $V_{DD\pm}$ = ±2.5 V, $R_S$ = 50 Ω | 25°C | | 300 | 2500 | | 300 | 950 | µV |
| | | | | Full range | | | 3000 | | | 1500 | |
| $\alpha_{VIO}$ | Temperature coefficient of input offset voltage | | | 25°C to 125°C | | 2 | | | 2 | | µV/°C |
| | Input offset voltage long-term drift (see Note 4) | | | 25°C | | 0.002 | | | 0.002 | | µV/mo |
| $I_{IO}$ | Input offset current | | | 25°C | | 0.5 | 60 | | 0.5 | 60 | pA |
| | | | | Full range | | | 800 | | | 800 | |
| $I_{IB}$ | Input bias current | | | 25°C | | 1 | 60 | | 1 | 60 | pA |
| | | | | Full range | | | 800 | | | 800 | |
| $V_{ICR}$ | Common-mode input voltage | $R_S$ = 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 | | 4.99 | | | 4.99 | | V |
| | | $I_{OH}$ = −200 µA | | 25°C | 4.85 | 4.93 | | 4.85 | 4.93 | | |
| | | | | Full range | 4.85 | | | 4.85 | | | |
| | | $I_{OH}$ = −1 mA | | 25°C | 4.25 | 4.65 | | 4.25 | 4.65 | | |
| | | | | Full range | 4.25 | | | 4.25 | | | |
| $V_{OL}$ | 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, | $I_{OL}$ = 5 mA | 25°C | | 0.9 | 1.5 | | 0.9 | 1.5 | |
| | | | | Full range | | | 1.5 | | | 1.5 | |
| $A_{VD}$ | Large-signal differential voltage amplification | $V_{IC}$ = 2.5 V, $V_O$ = 1 V to 4 V | $R_L$ = 10 kΩ‡ | 25°C | 10 | 35 | | 10 | 35 | | V/mV |
| | | | | Full range | 10 | | | 10 | | | |
| | | | $R_L$ = 1 mΩ‡ | 25°C | | 175 | | | 175 | | |
| $r_{id}$ | Differential input resistance | | | 25°C | | $10^{12}$ | | | $10^{12}$ | | Ω |
| $r_i$ | Common-mode input resistance | | | 25°C | | $10^{12}$ | | | $10^{12}$ | | Ω |
| $c_i$ | Common-mode input capacitance | f = 10 kHz, | P package | 25°C | | 8 | | | 8 | | pF |
| $z_o$ | Closed-loop output impedance | f = 1 MHz, | $A_V$ = 10 | 25°C | | 140 | | | 140 | | Ω |
| CMRR | Common-mode rejection ratio | $V_{IC}$ = 0 V to 2.7 V, $V_O$ = 2.5 V, | $R_S$ = 50 Ω | 25°C | 70 | 75 | | 70 | 75 | | 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 | | 2.2 | 3 | | 2.2 | 3 | mA |
| | | | | Full range | | | 3 | | | 3 | |

† Full range is −40°C to 125°C for Q level part.
‡ Referenced to 2.5 V
NOTE 4: Typical values are based on the input offset voltage shift observed through 168 hours of operating life test at $T_A$ = 150°C extrapolated to $T_A$ = 25°C using the Arrhenius equation and assuming an activation energy of 0.96 eV.

## TLC2272Q operating characteristics at specified free-air temperature, $V_{DD}$ = 5 V

| PARAMETER | | TEST CONDITIONS | | $T_A$† | TLC2272Q MIN | TLC2272Q TYP | TLC2272Q MAX | TLC2272AQ MIN | TLC2272AQ TYP | TLC2272AQ MAX | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|
| SR | Slew rate at unity gain | $V_O$ = 1.25 V to 2.75 V, $R_L$ = 10 kΩ‡, $C_L$ = 100 pF‡ | | 25°C | 2.3 | 3.6 | | 2.3 | 3.6 | | V/µs |
| | | | | Full range | 1.7 | | | 1.7 | | | |
| $V_n$ | Equivalent input noise voltage | f = 10 Hz | | 25°C | | 50 | | | 50 | | nV/√Hz |
| | | f = 1 kHz | | 25°C | | 9 | | | 9 | | |
| $V_{NPP}$ | Peak-to-peak equivalent input noise voltage | f = 0.1 Hz to 1 Hz | | 25°C | | 1 | | | 1 | | µV |
| | | f = 0.1 Hz to 10 Hz | | 25°C | | 1.4 | | | 1.4 | | |
| $I_n$ | 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, $R_L$ = 10 kΩ‡, | $A_V$ = 1 | 25°C | | 0.0013% | | | 0.0013% | | |
| | | | $A_V$ = 10 | | | 0.004% | | | 0.004% | | |
| | | | $A_V$ = 100 | | | 0.03% | | | 0.03% | | |
| | Gain-bandwidth product | f = 10 kHz, $R_L$ = 10 kΩ‡, $C_L$ = 100 pF‡ | | 25°C | | 2.18 | | | 2.18 | | MHz |
| $B_{OM}$ | Maximum output-swing bandwidth | $V_{O(PP)}$ = 2 V, $A_V$ = 1, $R_L$ = 10 kΩ‡, $C_L$ = 100 pF‡ | | 25°C | | 1 | | | 1 | | MHz |
| $t_s$ | Settling time | $A_V$ = –1, Step = 0.5 V to 2.5 V, $R_L$ = 10 kΩ‡, $C_L$ = 100 pF‡ | To 0.1% | 25°C | | 1.5 | | | 1.5 | | µs |
| | | | To 0.01% | | | 2.6 | | | 2.6 | | |
| $\phi_m$ | Phase margin at unity gain | $R_L$ = 10 kΩ‡, $C_L$ = 100 pF‡ | | 25°C | | 50° | | | 50° | | |
| | Gain margin | | | 25°C | | 10 | | | 10 | | dB |

† Full range is –40°C to 125°C for Q level part.
‡ Referenced to 2.5 V

## TLC2272Q electrical characteristics at specified free-air temperature, $V_{DD\pm} = \pm5$ V (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | | $T_A$† | TLC2272Q MIN | TLC2272Q TYP | TLC2272Q MAX | TLC2272AQ MIN | TLC2272AQ TYP | TLC2272AQ MAX | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $V_{IO}$ | Input offset voltage | $V_{IC}$ = 0 V, $V_O$ = 0 V, $R_S$ = 50 Ω | | 25°C | | 300 | 2500 | | 300 | 950 | μV |
| | | | | Full range | | | 3000 | | | 1500 | |
| $\alpha_{VIO}$ | Temperature coefficient of input offset voltage | | | 25°C to 125°C | | 2 | | | 2 | | μV/°C |
| | Input offset voltage long-term drift (see Note 4) | | | 25°C | | 0.002 | | | 0.002 | | μV/mo |
| $I_{IO}$ | Input offset current | | | 25°C | | 0.5 | 60 | | 0.5 | 60 | pA |
| | | | | Full range | | | 800 | | | 800 | |
| $I_{IB}$ | Input bias current | | | 25°C | | 1 | 60 | | 1 | 60 | pA |
| | | | | Full range | | | 800 | | | 800 | |
| $V_{ICR}$ | Common-mode input voltage | $R_S$ = 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 | | 4.99 | | | 4.99 | | V |
| | | $I_O$ = −200 μA | | 25°C | 4.85 | 4.93 | | 4.85 | 4.93 | | |
| | | | | Full range | 4.85 | | | 4.85 | | | |
| | | $I_O$ = −1 mA | | 25°C | 4.25 | 4.65 | | 4.25 | 4.65 | | |
| | | | | Full range | 4.25 | | | 4.25 | | | |
| $V_{OM-}$ | Maximum negative peak output voltage | $V_{IC}$ = 0 V, $I_O$ = 50 μA | | 25°C | | −4.99 | | | −4.99 | | V |
| | | $V_{IC}$ = 0 V, $I_O$ = 500 μA | | 25°C | −4.85 | −4.91 | | −4.85 | −4.91 | | |
| | | | | Full range | −4.85 | | | −4.85 | | | |
| | | $V_{IC}$ = 0 V, $I_O$ = 5 mA | | 25°C | −3.5 | −4.1 | | −3.5 | −4.1 | | |
| | | | | Full range | −3.5 | | | −3.5 | | | |
| $A_{VD}$ | Large-signal differential voltage amplification | $V_O$ = ±4 V | $R_L$ = 10 kΩ | 25°C | 20 | 50 | | 20 | 50 | | V/mV |
| | | | | Full range | 20 | | | 20 | | | |
| | | | $R_L$ = 1 mΩ | 25°C | | 300 | | | 300 | | |
| $r_{id}$ | Differential input resistance | | | 25°C | | $10^{12}$ | | | $10^{12}$ | | Ω |
| $r_i$ | Common-mode input resistance | | | 25°C | | $10^{12}$ | | | $10^{12}$ | | Ω |
| $c_i$ | Common-mode input capacitance | f = 10 kHz, P package | | 25°C | | 8 | | | 8 | | pF |
| $z_o$ | Closed-loop output impedance | f = 1 MHz, $A_V$ = 10 | | 25°C | | 130 | | | 130 | | Ω |
| CMRR | Common-mode rejection ratio | $V_{IC}$ = −5 V to 2.7 V, $V_O$ = 0 V, $R_S$ = 50 Ω | | 25°C | 75 | 80 | | 75 | 80 | | 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 V, 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 | | 2.4 | 3 | | 2.4 | 3 | mA |
| | | | | Full range | | | 3 | | | 3 | |

† Full range is −40°C to 125°C for Q level part.

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

## TLC2272Q operating characteristics at specified free-air temperature, $V_{DD\pm} = \pm 5$ V

| PARAMETER | | TEST CONDITIONS | | $T_A$† | TLC2272Q MIN | TLC2272Q TYP | TLC2272Q MAX | TLC2272AQ MIN | TLC2272AQ TYP | TLC2272AQ MAX | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|
| SR | Slew rate at unity gain | $V_O = \pm 1$ V, $C_L = 100$ pF | $R_L = 10$ kΩ, | 25°C | 2.3 | 3.6 | | 2.3 | 3.6 | | V/μs |
| | | | | Full range | 1.7 | | | 1.7 | | | |
| $V_n$ | Equivalent input noise voltage | f = 10 Hz | | 25°C | | 50 | | | 50 | | nV/√Hz |
| | | f = 1 kHz | | 25°C | | 9 | | | 9 | | |
| $V_{NPP}$ | Peak-to-peak equivalent input noise voltage | f = 0.1 Hz to 1 Hz | | 25°C | | 1 | | | 1 | | μV |
| | | f = 0.1 Hz to 10 Hz | | 25°C | | 1.4 | | | 1.4 | | |
| $I_n$ | Equivalent input noise current | | | 25°C | | 0.6 | | | 0.6 | | fA/√Hz |
| THD + N | Total harmonic distortion plus noise | $V_O = \pm 2.3$ V, $R_L = 10$ kΩ, f = 20 kHz | $A_V = 1$ | 25°C | | 0.0011% | | | 0.0011% | | |
| | | | $A_V = 10$ | | | 0.004% | | | 0.004% | | |
| | | | $A_V = 100$ | | | 0.03% | | | 0.03% | | |
| | Gain-bandwidth product | f = 10 kHz, $C_L = 100$ pF | $R_L = 10$ kΩ, | 25°C | | 2.25 | | | 2.25 | | MHz |
| $B_{OM}$ | Maximum output-swing bandwidth | $V_{O(PP)} = 4.6$ V, $R_L = 10$ kΩ, | $A_V = 1$, $C_L = 100$ pF | 25°C | | 0.54 | | | 0.54 | | MHz |
| $t_s$ | Settling time | $A_V = -1$, Step = −2.3 V to 2.3 V, $R_L = 10$ kΩ, $C_L = 100$ pF | To 0.1% | 25°C | | 1.5 | | | 1.5 | | μs |
| | | | To 0.01% | | | 3.2 | | | 3.2 | | |
| $\phi_m$ | Phase margin at unity gain | $R_L = 10$ kΩ, | $C_L = 100$ pF | 25°C | | 52° | | | 52° | | |
| | Gain margin | | | 25°C | | 10 | | | 10 | | dB |

† Full range is −40°C to 125°C for Q level part.

## TLC2274Q electrical characteristics at specified free-air temperature, $V_{DD}$ = 5 V (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | | $T_A$† | TLC2274Q MIN | TLC2274Q TYP | TLC2274Q MAX | TLC2274AQ MIN | TLC2274AQ TYP | TLC2274AQ MAX | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $V_{IO}$ | Input offset voltage | $V_{DD\pm} = \pm2.5$ V, $V_{IC}$ = 0 V, $V_O$ = 0 V, $R_S$ = 50 Ω | | 25°C | | 300 | 2500 | | 300 | 950 | μV |
| | | | | Full range | | | 3000 | | | 1500 | |
| $\alpha_{VIO}$ | Temperature coefficient of input offset voltage | | | 25°C to 125°C | | 2 | | | 2 | | μV/°C |
| | Input offset voltage long-term drift (see Note 4) | | | 25°C | | 0.002 | | | 0.002 | | μV/mo |
| $I_{IO}$ | Input offset current | | | 25°C | | 0.5 | 60 | | 0.5 | 60 | pA |
| | | | | Full range | | | 800 | | | 800 | |
| $I_{IB}$ | Input bias current | | | 25°C | | 1 | 60 | | 1 | 60 | pA |
| | | | | Full range | | | 800 | | | 800 | |
| $V_{ICR}$ | Common-mode input voltage | $R_S$ = 50 Ω, $\|V_{IO}\| \leq$ 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 | | 4.99 | | | 4.99 | | V |
| | | $I_{OH}$ = −200 μA | | 25°C | 4.85 | 4.93 | | 4.85 | 4.93 | | |
| | | | | Full range | 4.85 | | | 4.85 | | | |
| | | $I_{OH}$ = −1 mA | | 25°C | 4.25 | 4.65 | | 4.25 | 4.65 | | |
| | | | | Full range | 4.25 | | | 4.25 | | | |
| $V_{OL}$ | 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, $I_{OL}$ = 5 mA | | 25°C | | 0.9 | 1.5 | | 0.9 | 1.5 | |
| | | | | Full range | | | 1.5 | | | 1.5 | |
| $A_{VD}$ | Large-signal differential voltage amplification | $V_{IC}$ = 2.5 V, $V_O$ = 1 V to 4 V | $R_L$ = 10 kΩ‡ | 25°C | 10 | 35 | | 10 | 35 | | V/mV |
| | | | | Full range | 10 | | | 10 | | | |
| | | | $R_L$ = 1 MΩ‡ | 25°C | | 175 | | | 175 | | |
| $r_{id}$ | Differential input resistance | | | 25°C | | $10^{12}$ | | | $10^{12}$ | | Ω |
| $r_i$ | Common-mode input resistance | | | 25°C | | $10^{12}$ | | | $10^{12}$ | | Ω |
| $c_i$ | Common-mode input capacitance | f = 10 kHz, N package | | 25°C | | 8 | | | 8 | | pF |
| $z_o$ | Closed-loop output impedance | f = 1 MHz, $A_V$ = 10 | | 25°C | | 140 | | | 140 | | Ω |
| CMRR | Common-mode rejection ratio | $V_{IC}$ = 0 V to 2.7 V, $V_O$ = 2.5 V, $R_S$ = 50 Ω | | 25°C | 70 | 75 | | 70 | 75 | | 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 | | 4.4 | 6 | | 4.4 | 6 | mA |
| | | | | Full range | | | 6 | | | 6 | |

† Full range is −40°C to 125°C for Q level part.
‡ Referenced to 2.5 V
NOTE 4: Typical values are based on the input offset voltage shift observed through 168 hours of operating life test at $T_A$ = 150°C extrapolated to $T_A$ = 25°C using the Arrhenius equation and assuming an activation energy of 0.96 eV.

## TLC2274Q operating characteristics at specified free-air temperature, $V_{DD}$ = 5 V

| PARAMETER | | TEST CONDITIONS | | $T_A$† | TLC2274Q MIN | TLC2274Q TYP | TLC2274Q MAX | TLC2274AQ MIN | TLC2274AQ TYP | TLC2274AQ MAX | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|
| SR | Slew rate at unity gain | $V_O$ = 0.5 V to 2.5 V, $R_L$ = 10 kΩ‡, | $C_L$ = 100 pF‡ | 25°C | 2.3 | 3.6 | | 2.3 | 3.6 | | V/μs |
| | | | | Full range | 1.7 | | | 1.7 | | | |
| $V_n$ | Equivalent input noise voltage | f = 10 Hz | | 25°C | | 50 | | | 50 | | nV/√Hz |
| | | f = 1 kHz | | 25°C | | 9 | | | 9 | | |
| $V_{N(PP)}$ | Peak-to-peak equivalent input noise voltage | f = 0.1 Hz to 1 Hz | | 25°C | | 1 | | | 1 | | μV |
| | | f = 0.1 Hz to 10 Hz | | 25°C | | 1.4 | | | 1.4 | | |
| $I_n$ | 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, $R_L$ = 10 kΩ‡ | $A_V$ = 1 | 25°C | | 0.0013% | | | 0.0013% | | |
| | | | $A_V$ = 10 | | | 0.004% | | | 0.004% | | |
| | | | $A_V$ = 100 | | | 0.03% | | | 0.03% | | |
| | Gain-bandwidth product | f = 10 kHz, $C_L$ = 100 pF‡ | $R_L$ = 10 kΩ‡, | 25°C | | 2.18 | | | 2.18 | | MHz |
| $B_{OM}$ | Maximum output-swing bandwidth | $V_{O(PP)}$ = 2 V, $R_L$ = 10 kΩ‡, | $A_V$ = 1, $C_L$ = 100 pF‡ | 25°C | | 1 | | | 1 | | MHz |
| $t_s$ | Settling time | $A_V$ = –1, Step = 0.5 V to 2.5 V, $R_L$ = 10 kΩ‡, $C_L$ = 100 pF‡ | To 0.1% | 25°C | | 1.5 | | | 1.5 | | μs |
| | | | To 0.01% | | | 2.6 | | | 2.6 | | |
| $\phi_m$ | Phase margin at unity gain | $R_L$ = 10 kΩ‡, | $C_L$ = 100 pF‡ | 25°C | | 50° | | | 50° | | |
| | Gain margin | | | 25°C | | 10 | | | 10 | | dB |

† Full range is –40°C to 125°C for Q level part.
‡ Referenced to 2.5 V

## TLC2274Q electrical characteristics at specified free-air temperature, $V_{DD\pm} = \pm 5$ V (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | | $T_A$† | TLC2274Q MIN | TLC2274Q TYP | TLC2274Q MAX | TLC2274AQ MIN | TLC2274AQ TYP | TLC2274AQ MAX | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $V_{IO}$ | Input offset voltage | $V_{IC}$ = 0 V, $V_O$ = 0 V, $R_S$ = 50 Ω | | 25°C | | 300 | 2500 | | 300 | 950 | μV |
| | | | | Full range | | | 3000 | | | 1500 | |
| $\alpha_{VIO}$ | Temperature coefficient of input offset voltage | | | 25°C to 125°C | | 2 | | | 2 | | μV/°C |
| | Input offset voltage long-term drift (see Note 4) | | | 25°C | | 0.002 | | | 0.002 | | μV/mo |
| $I_{IO}$ | Input offset current | | | 25°C | | 0.5 | 60 | | 0.5 | 60 | pA |
| | | | | Full range | | | 800 | | | 800 | |
| $I_{IB}$ | Input bias current | | | 25°C | | 1 | 60 | | 1 | 60 | pA |
| | | | | Full range | | | 800 | | | 800 | |
| $V_{ICR}$ | Common-mode input voltage | $R_S$ = 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 | | 4.99 | | | 4.99 | | V |
| | | $I_O$ = −200 μA | | 25°C | 4.85 | 4.93 | | 4.85 | 4.93 | | |
| | | | | Full range | 4.85 | | | 4.85 | | | |
| | | $I_O$ = −1 mA | | 25°C | 4.25 | 4.65 | | 4.25 | 4.65 | | |
| | | | | Full range | 4.25 | | | 4.25 | | | |
| $V_{OM-}$ | Maximum negative peak output voltage | $V_{IC}$ = 0 V, $I_O$ = 50 μA | | 25°C | | −4.99 | | | −4.99 | | V |
| | | $V_{IC}$ = 0 V, $I_O$ = 500 μA | | 25°C | −4.85 | −4.91 | | −4.85 | −4.91 | | |
| | | | | Full range | −4.85 | | | −4.85 | | | |
| | | $V_{IC}$ = 0 V, $I_O$ = 5 mA | | 25°C | −3.5 | −4.1 | | −3.5 | −4.1 | | |
| | | | | Full range | −3.5 | | | −3.5 | | | |
| $A_{VD}$ | Large-signal differential voltage amplification | $V_O$ = ±4 V | $R_L$ = 10 kΩ | 25°C | 20 | 50 | | 20 | 50 | | V/mV |
| | | | | Full range | 20 | | | 20 | | | |
| | | | $R_L$ = 1 MΩ | 25°C | | 300 | | | 300 | | |
| $r_{id}$ | Differential input resistance | | | 25°C | | $10^{12}$ | | | $10^{12}$ | | Ω |
| $r_i$ | Common-mode input resistance | | | 25°C | | $10^{12}$ | | | $10^{12}$ | | Ω |
| $c_i$ | Common-mode input capacitance | f = 10 kHz, N package | | 25°C | | 8 | | | 8 | | pF |
| $z_o$ | Closed-loop output impedance | f = 1 MHz, $A_V$ = 10 | | 25°C | | 130 | | | 130 | | Ω |
| CMRR | Common-mode rejection ratio | $V_{IC}$ = −5 V to 2.7 V, $V_O$ = 0 V, $R_S$ = 50 Ω | | 25°C | 75 | 80 | | 75 | 80 | | 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, $V_{IC}$ = 0 V, No load | | 25°C | 80 | 95 | | 80 | 95 | | dB |
| | | | | Full range | 80 | | | 80 | | | |
| $I_{DD}$ | Supply current | $V_O$ = 0 V, No load | | 25°C | | 4.8 | 6 | | 4.8 | 6 | mA |
| | | | | Full range | | | 6 | | | 6 | |

† Full range is −40°C to 125°C for Q level part.

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

## TLC2274Q operating characteristics at specified free-air temperature, $V_{DD\pm} = \pm 5$ V

| PARAMETER | | TEST CONDITIONS | | $T_A$† | TLC2274Q | | | TLC2274AQ | | | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | MIN | TYP | MAX | MIN | TYP | MAX | |
| SR | Slew rate at unity gain | $V_O = \pm 2.3$ V, $R_L = 10$ kΩ, $C_L = 100$ pF | | 25°C | 2.3 | 3.6 | | 2.3 | 3.6 | | V/µs |
| | | | | Full range | 1.7 | | | 1.7 | | | |
| $V_n$ | Equivalent input noise voltage | f = 10 Hz | | 25°C | | 50 | | | 50 | | nV/√Hz |
| | | f = 1 kHz | | 25°C | | 9 | | | 9 | | |
| $V_{N(PP)}$ | Peak-to-peak equivalent input noise voltage | f = 0.1 Hz to 1 Hz | | 25°C | | 1 | | | 1 | | µV |
| | | f = 0.1 Hz to 10 Hz | | 25°C | | 1.4 | | | 1.4 | | |
| $I_n$ | Equivalent input noise current | | | 25°C | | 0.6 | | | 0.6 | | fA/√Hz |
| THD + N | Total harmonic distortion plus noise | $V_O = \pm 2.3$ V, $R_L = 10$ kΩ, f = 20 kHz | $A_V = 1$ | 25°C | | 0.0011% | | | 0.0011% | | |
| | | | $A_V = 10$ | | | 0.004% | | | 0.004% | | |
| | | | $A_V = 100$ | | | 0.03% | | | 0.03% | | |
| | Gain-bandwidth product | f = 10 kHz, $R_L = 10$ kΩ, $C_L = 100$ pF | | 25°C | | 2.25 | | | 2.25 | | MHz |
| $B_{OM}$ | Maximum output-swing bandwidth | $V_{O(PP)} = 4.6$ V, $A_V = 1$, $R_L = 10$ kΩ, $C_L = 100$ pF | | 25°C | | 0.54 | | | 0.54 | | MHz |
| $t_s$ | Settling time | $A_V = -1$, Step = −2.3 V to 2.3 V, $R_L = 10$ kΩ, $C_L = 100$ pF | To 0.1% | 25°C | | 1.5 | | | 1.5 | | µs |
| | | | To 0.01% | | | 3.2 | | | 3.2 | | |
| $\phi_m$ | Phase margin at unit gain | $R_L = 10$ kΩ, $C_L = 100$ pF | | 25°C | | 52° | | | 52° | | |
| | Gain margin | | | 25°C | | 10 | | | 10 | | dB |

† Full range is −40°C to 125°C for Q level part.

## TYPICAL CHARACTERISTICS

### Table of Graphs

| | | | FIGURE |
|---|---|---|---|
| $V_{IO}$ | Input offset voltage | Distribution<br>vs Common-mode voltage | 1 – 4<br>5, 6 |
| $\alpha_{VIO}$ | Input offset voltage temperature coefficient | Distribution | 7 – 10 |
| $I_{IB}/I_{IO}$ | Input bias and input offset current | vs Free-air temperature | 11 |
| $V_I$ | Input voltage | vs Supply voltage<br>vs Free-air temperature | 12<br>13 |
| $V_{OH}$ | High-level output voltage | vs High-level output current | 14 |
| $V_{OL}$ | Low-level output voltage | vs Low-level output current | 15, 16 |
| $V_{OM+}$ | Maximum positive peak output voltage | vs Output current | 17 |
| $V_{OM-}$ | Maximum negative peak output voltage | vs Output current | 18 |
| $V_{O(PP)}$ | Maximum peak-to-peak output voltage | vs Frequency | 19 |
| $I_{OS}$ | Short-circuit output current | vs Supply voltage<br>vs Free-air temperature | 20<br>21 |
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| | Large-signal differential voltage amplification and phase margin | vs Frequency | 25, 26 |
| | Large-signal differential voltage amplification | vs Free-air temperature | 27, 28 |
| $z_o$ | Output impedance | vs Frequency | 29, 30 |
| CMRR | Common-mode rejection ratio | vs Frequency<br>vs Free-air temperature | 31<br>32 |
| $k_{SVR}$ | Supply-voltage rejection ratio | vs Frequency<br>vs Free-air temperature | 33, 34<br>35 |
| $I_{DD}$ | Supply current | vs Supply voltage<br>vs Free-air temperature | 36, 37<br>38, 39 |
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| $V_O$ | Inverting large-signal pulse response | | 42, 43 |
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| | Voltage-follower small-signal pulse response | | 48, 49 |
| $V_n$ | Equivalent input noise voltage | vs Frequency | 50, 51 |
| | Noise voltage over a 10-second period | | 52 |
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| THD + N | Total harmonic distortion plus noise | vs Frequency | 54 |
| | Gain-bandwidth product | vs Supply voltage<br>vs Free-air temperature | 55<br>56 |
| $\phi_m$ | Phase margin | vs Load capacitance | 57 |
| | Gain margin | vs Load capacitance | 58 |

NOTE: For all graphs where $V_{DD}$ = 5 V, all loads are referenced to 2.5 V.

## TYPICAL CHARACTERISTICS

**DISTRIBUTION OF TLC2272 INPUT OFFSET VOLTAGE**

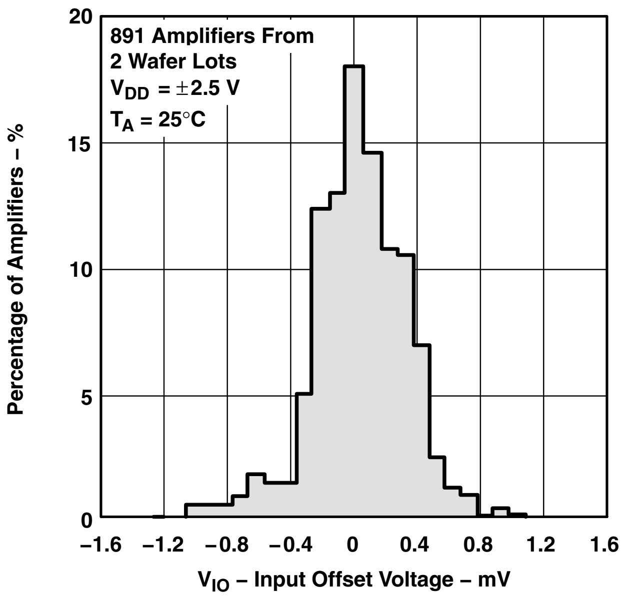



**Figure 1**

**DISTRIBUTION OF TLC2272 INPUT OFFSET VOLTAGE**

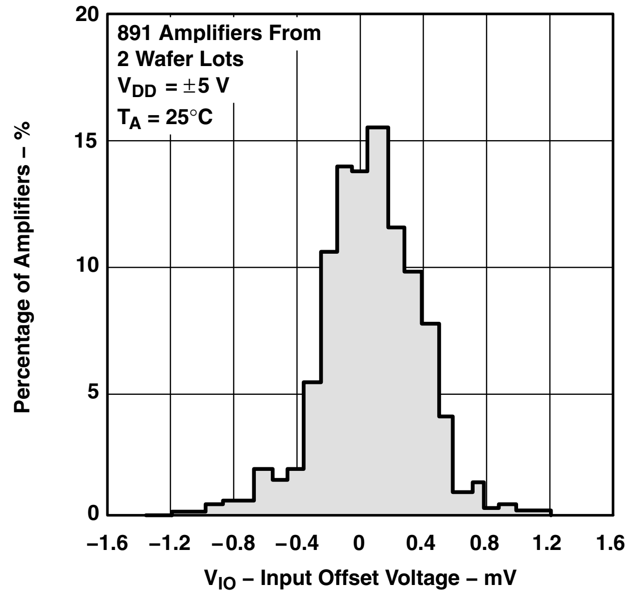



**Figure 2**

**DISTRIBUTION OF TLC2274 INPUT OFFSET VOLTAGE**

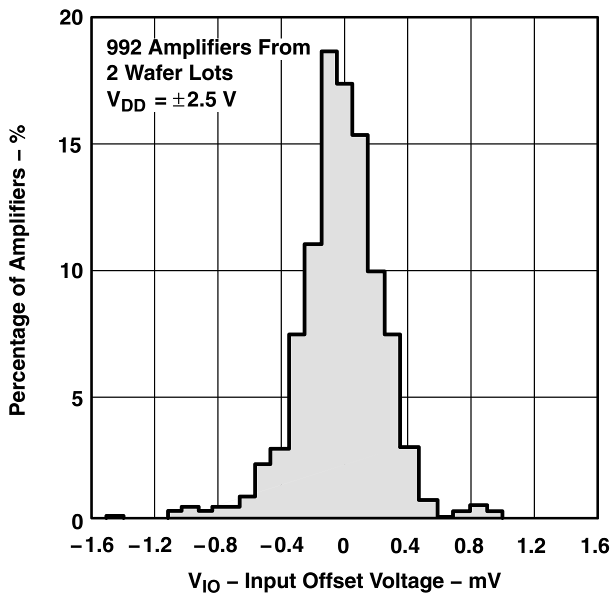



**Figure 3**

**DISTRIBUTION OF TLC2274 INPUT OFFSET VOLTAGE**

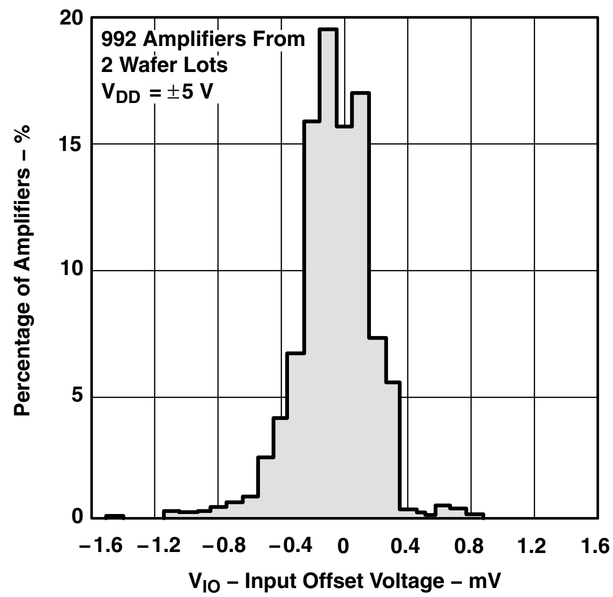



**Figure 4**

## TYPICAL CHARACTERISTICS

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

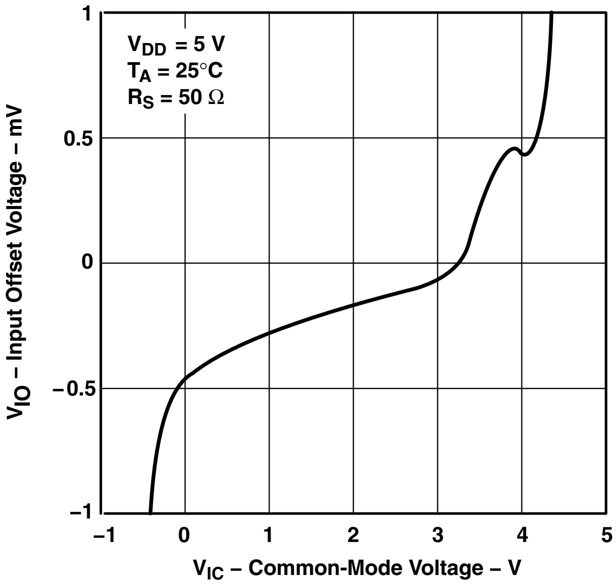



**Figure 5**

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

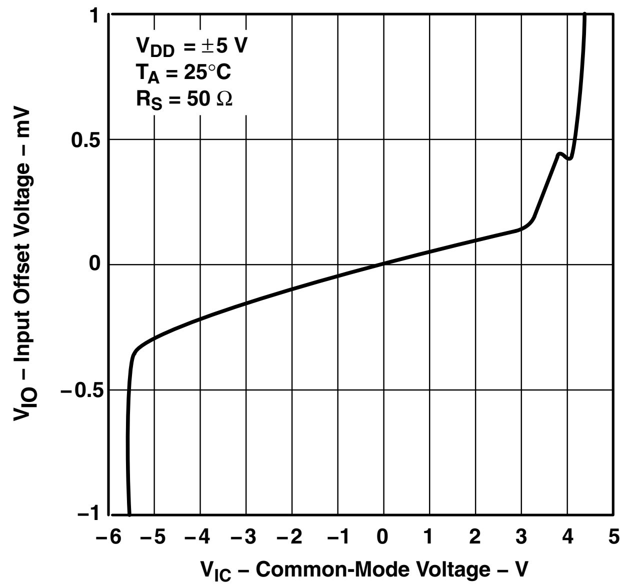



**Figure 6**

**DISTRIBUTION OF TLC2272 vs INPUT OFFSET VOLTAGE TEMPERATURE COEFFICIENT†**

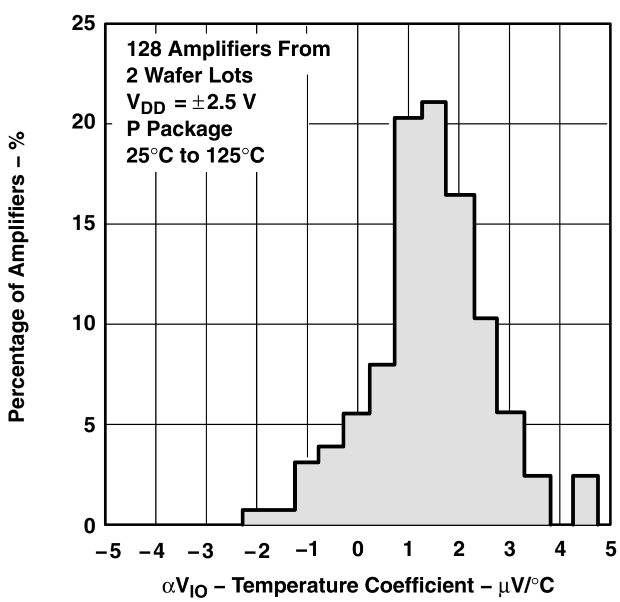



**Figure 7**

**DISTRIBUTION OF TLC2272 vs INPUT OFFSET VOLTAGE TEMPERATURE COEFFICIENT†**

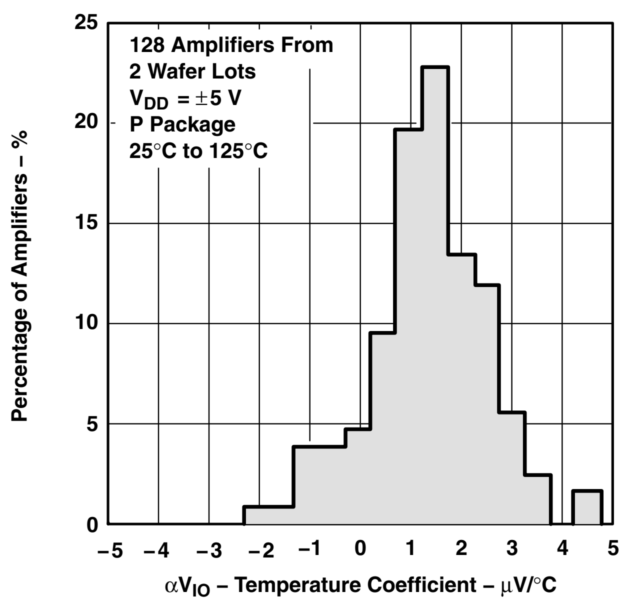



**Figure 8**

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

## TYPICAL CHARACTERISTICS

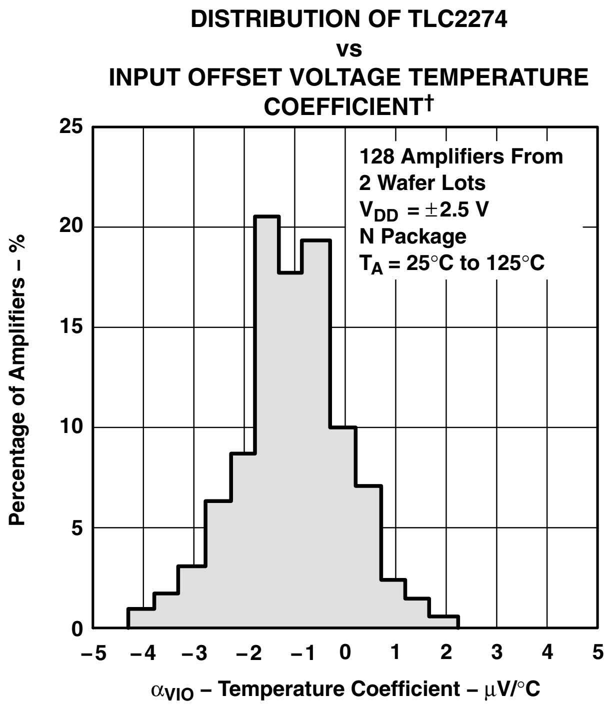



Figure 9

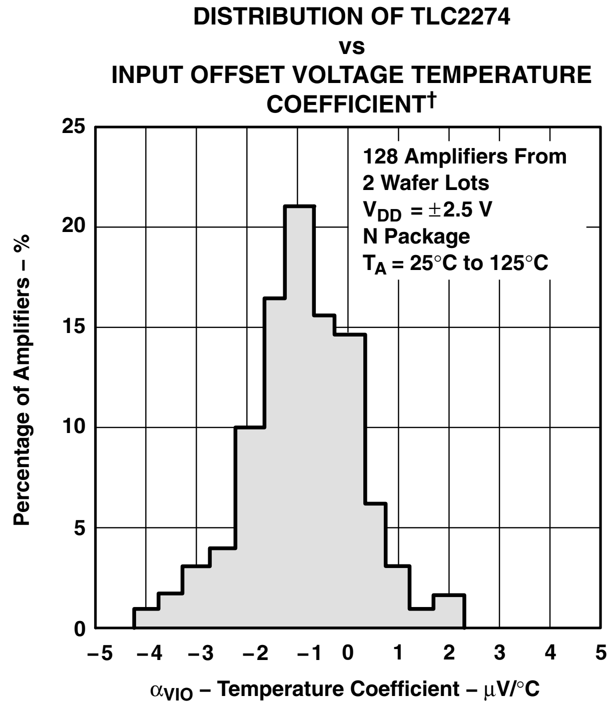



Figure 10

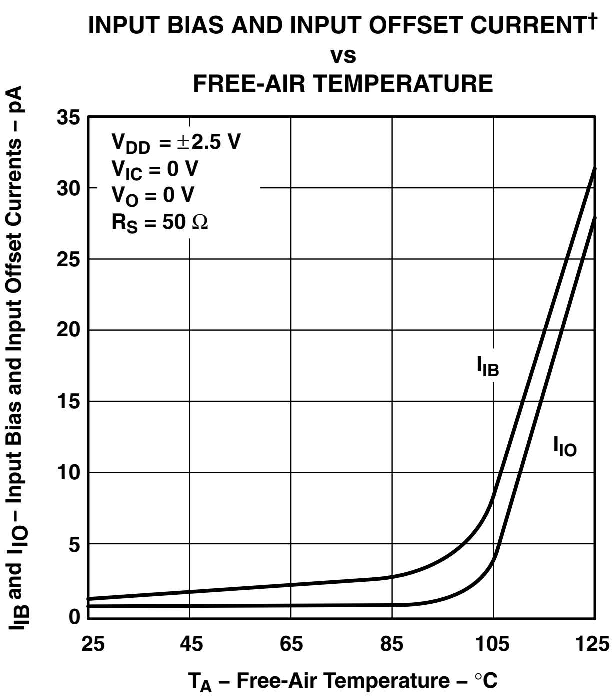



Figure 11

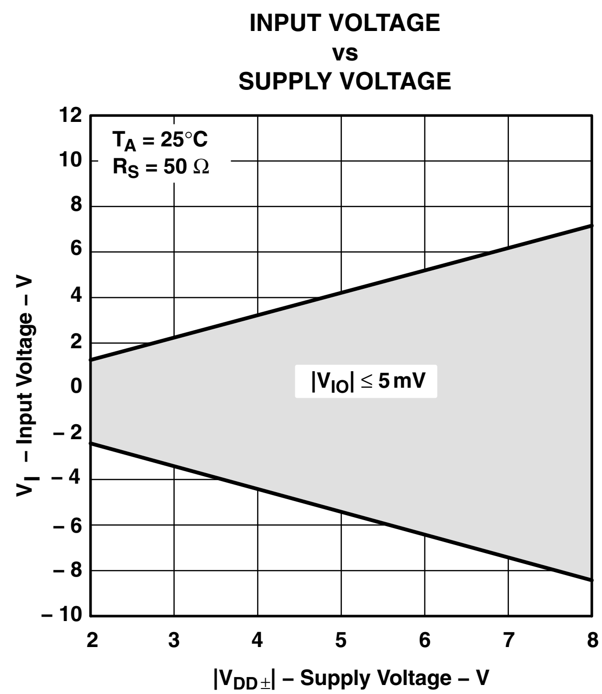



Figure 12

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

## TYPICAL CHARACTERISTICS

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

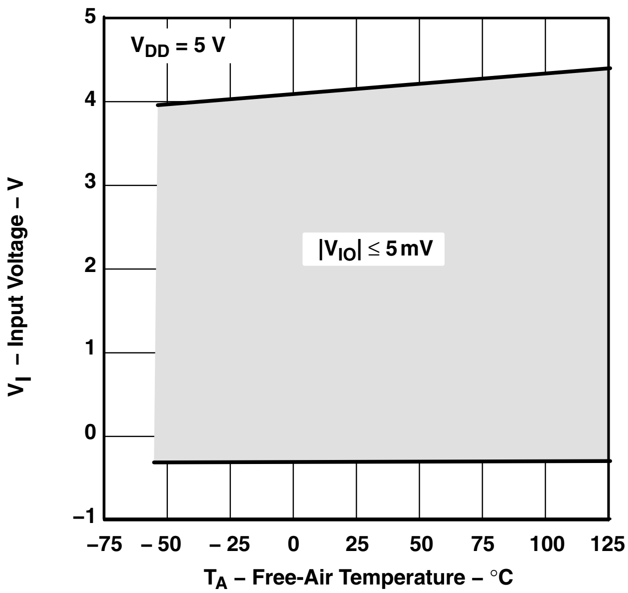



**Figure 13**

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

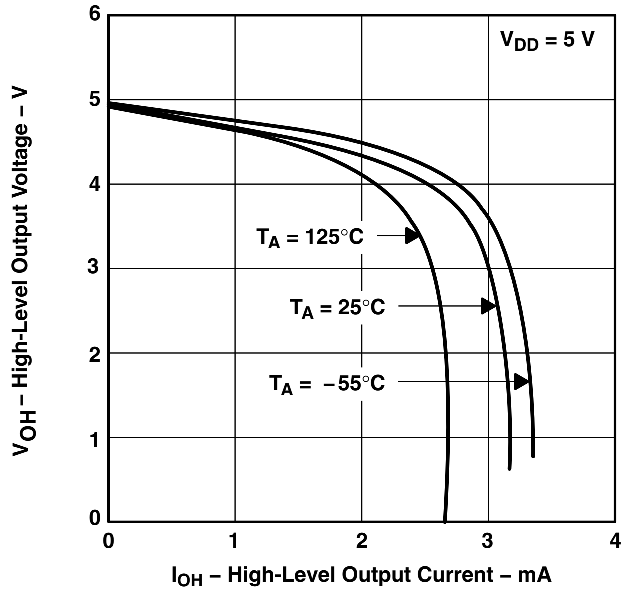



**Figure 14**

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

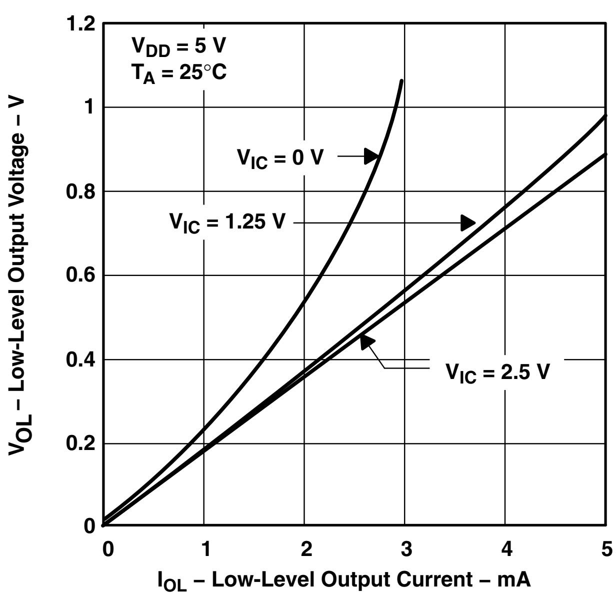



**Figure 15**

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

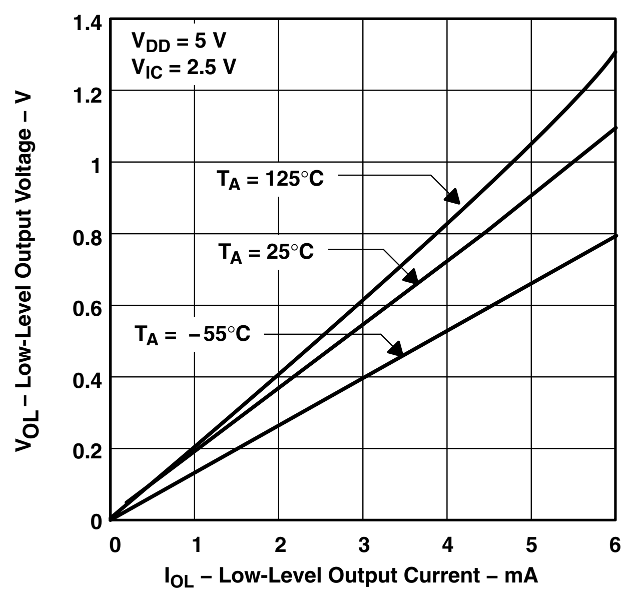



**Figure 16**

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

## TYPICAL CHARACTERISTICS

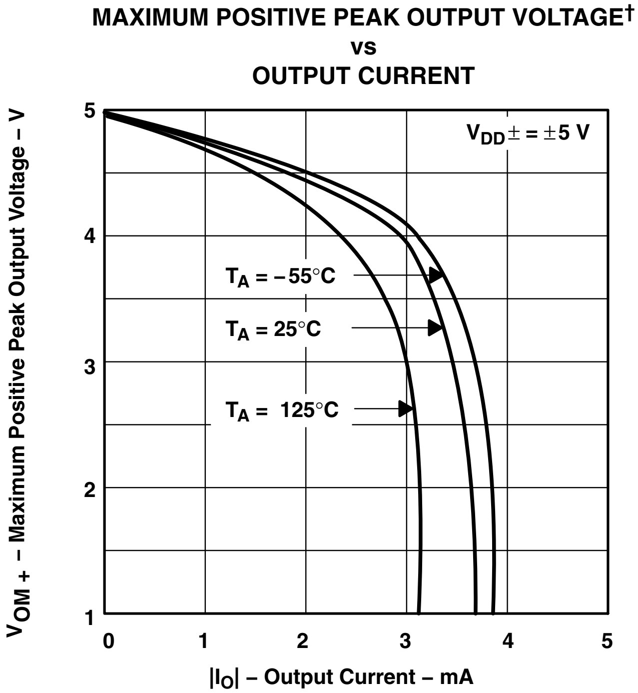



Figure 17

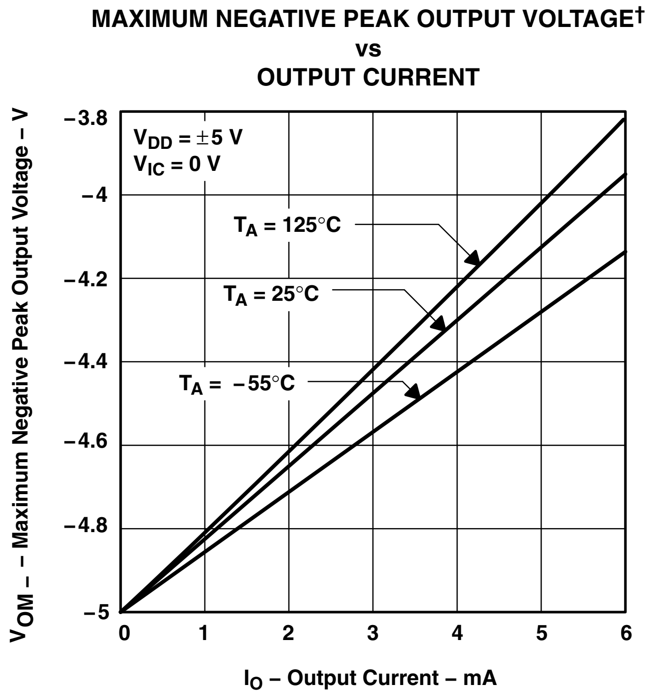



Figure 18

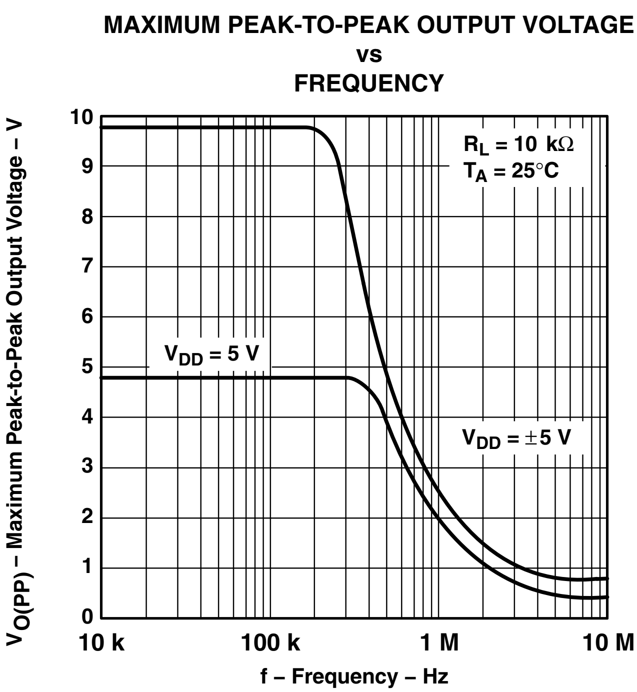



Figure 19

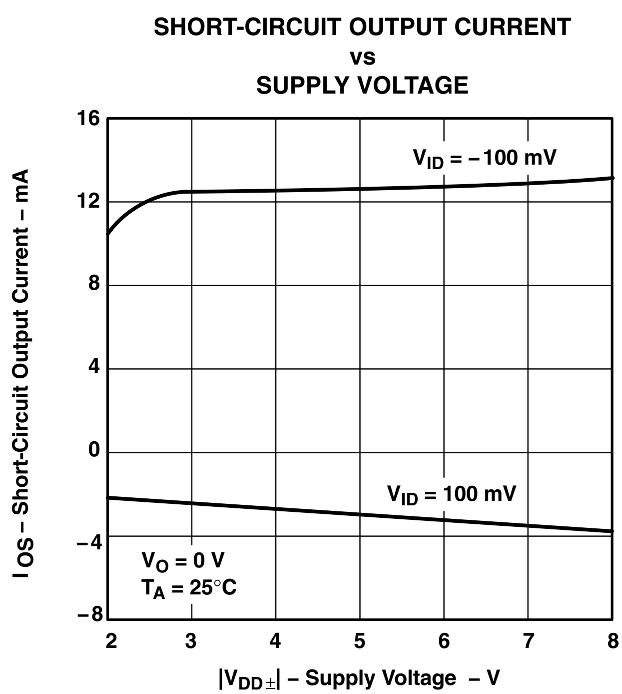



Figure 20

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

## TYPICAL CHARACTERISTICS

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

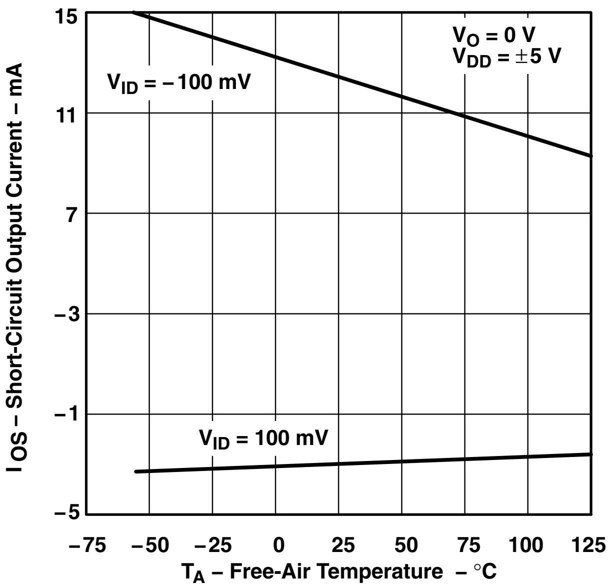



Figure 21

**OUTPUT VOLTAGE vs DIFFERENTIAL INPUT VOLTAGE**

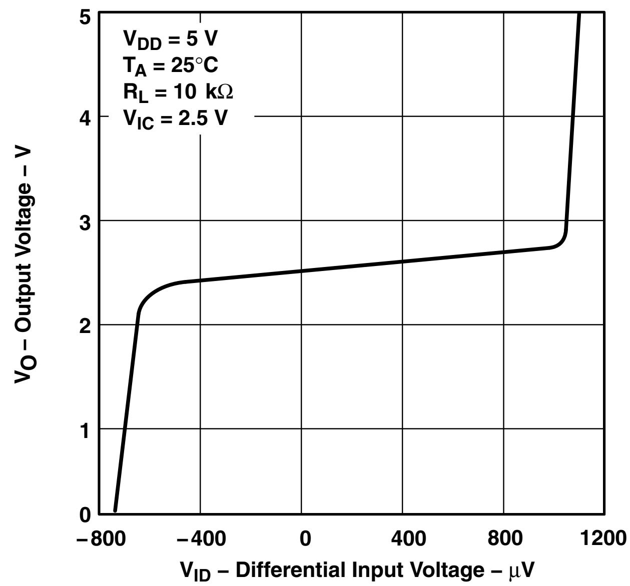



Figure 22

**OUTPUT VOLTAGE vs DIFFERENTIAL INPUT VOLTAGE**

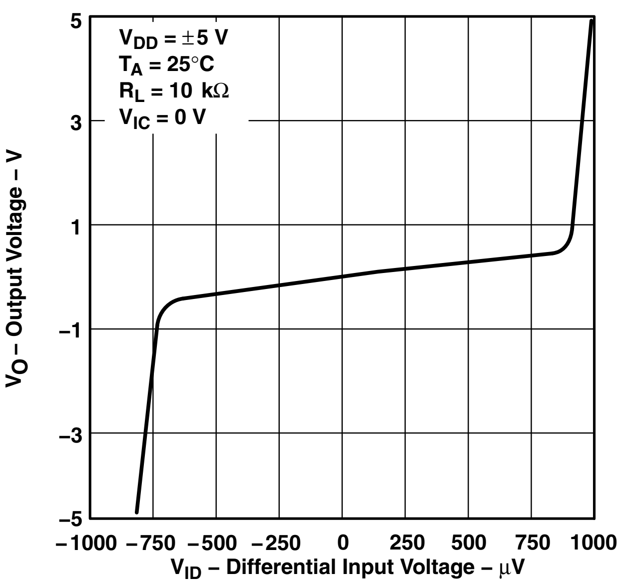



Figure 23

**LARGE-SIGNAL DIFFERENTIAL VOLTAGE AMPLIFICATION vs LOAD RESISTANCE**

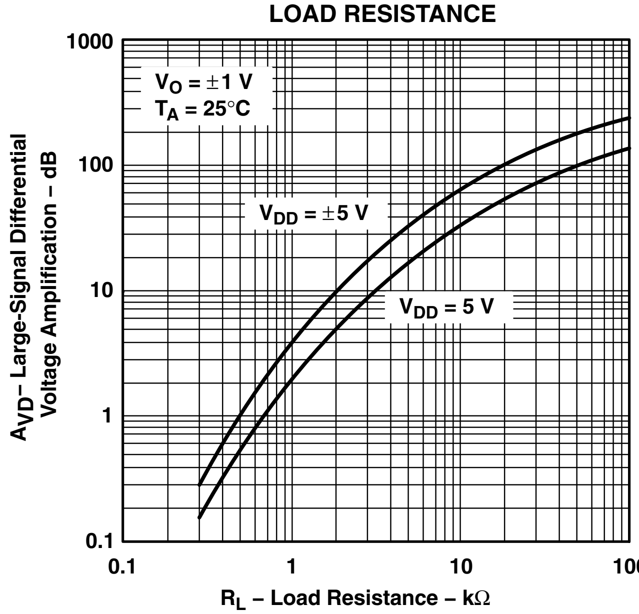



Figure 24

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

## TYPICAL CHARACTERISTICS

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

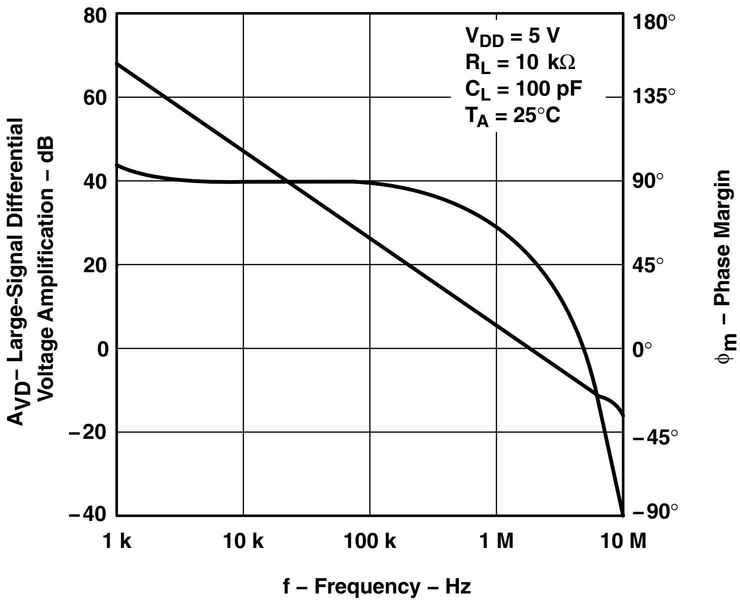



**Figure 25**

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

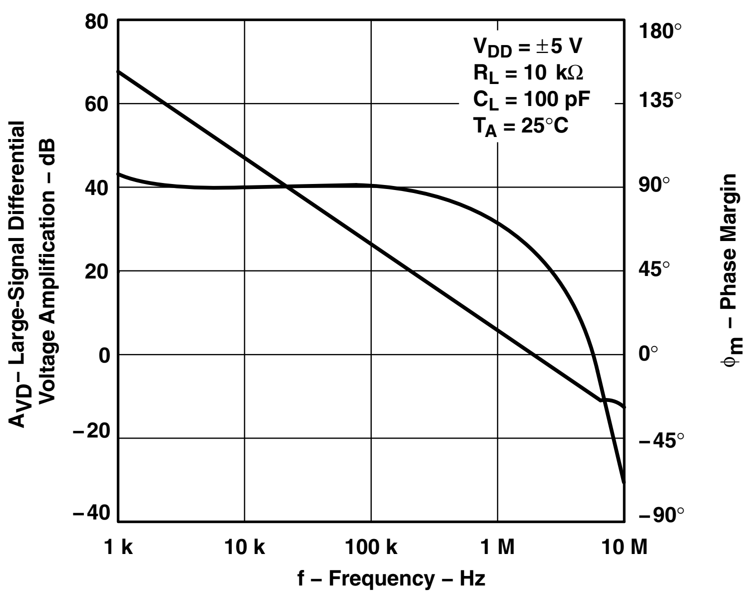



**Figure 26**

## TYPICAL CHARACTERISTICS

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

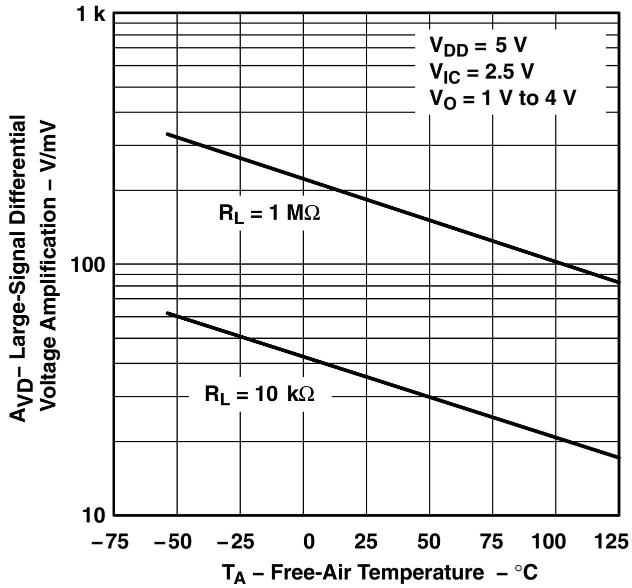



Figure 27

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

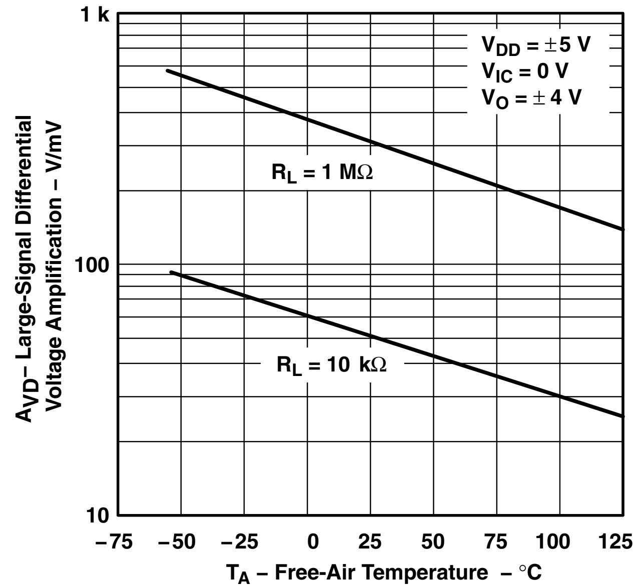



Figure 28

OUTPUT IMPEDANCE vs FREQUENCY

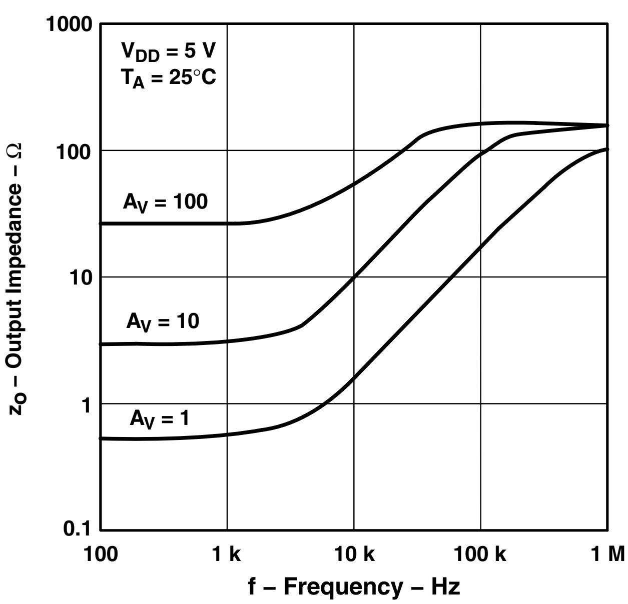



Figure 29

OUTPUT IMPEDANCE vs FREQUENCY

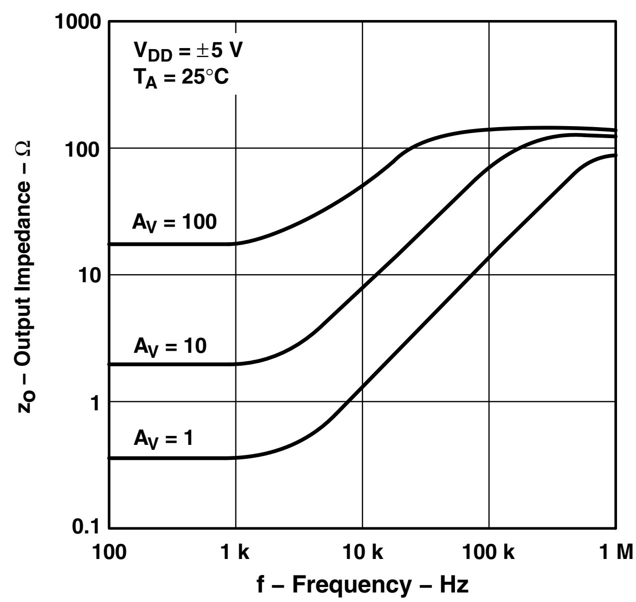



Figure 30

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

## TYPICAL CHARACTERISTICS

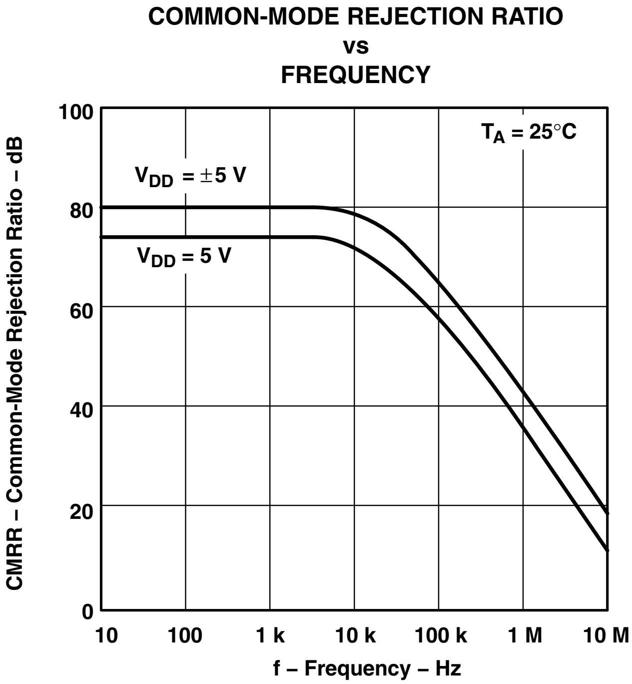



Figure 31

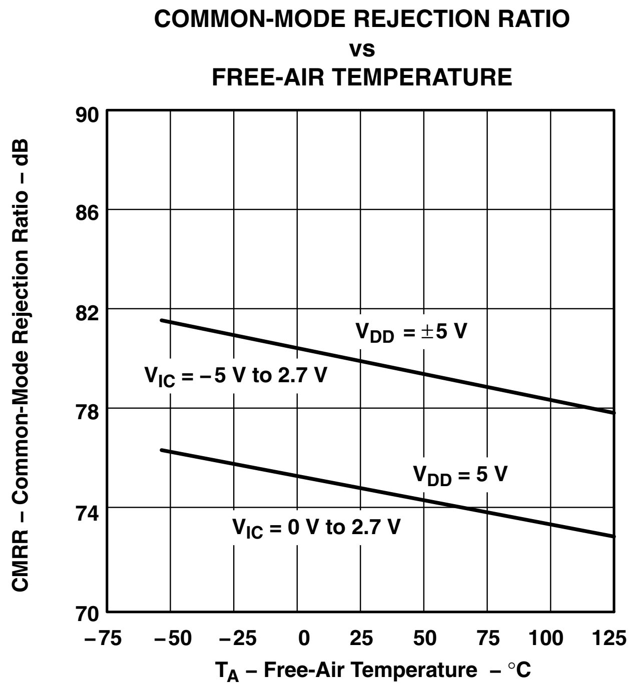



Figure 32

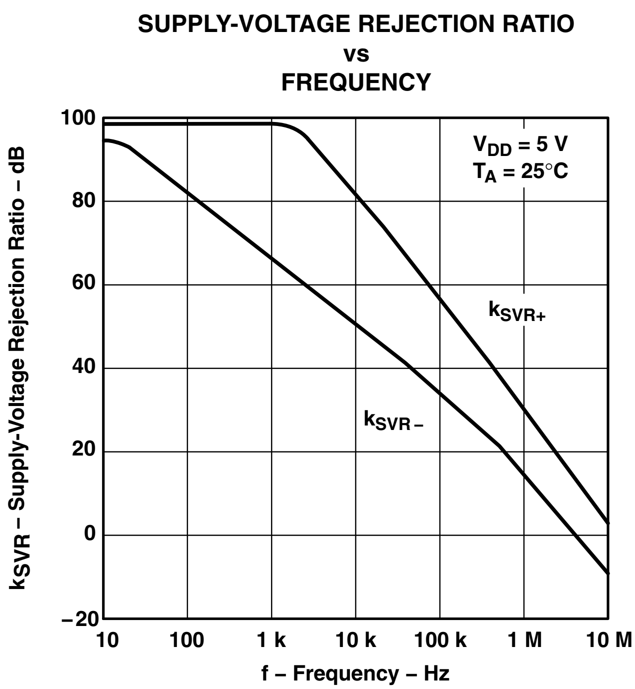



Figure 33

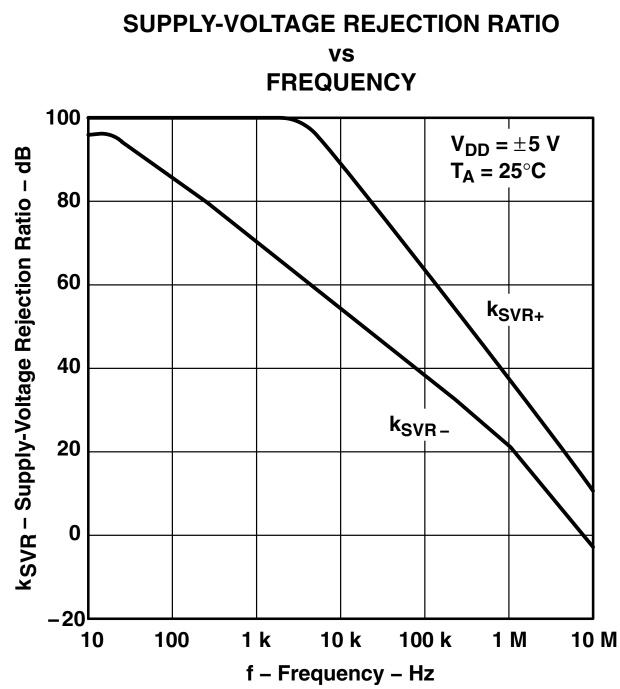



Figure 34

## TYPICAL CHARACTERISTICS

SUPPLY VOLTAGE REJECTION RATIO†
vs
FREE-AIR TEMPERATURE

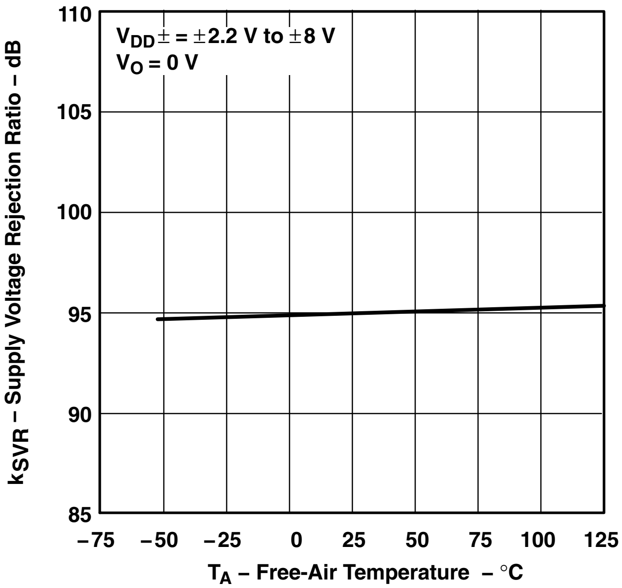



Figure 35

TLC2272
SUPPLY CURRENT†
vs
SUPPLY VOLTAGE

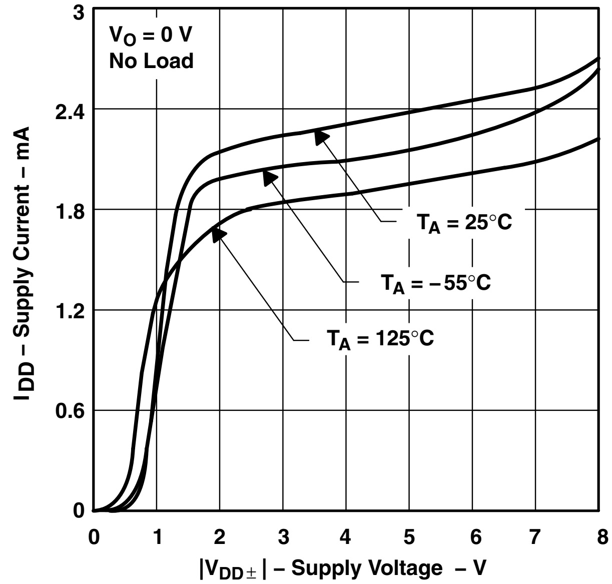



Figure 36

TLC2274
SUPPLY CURRENT†
vs
SUPPLY VOLTAGE

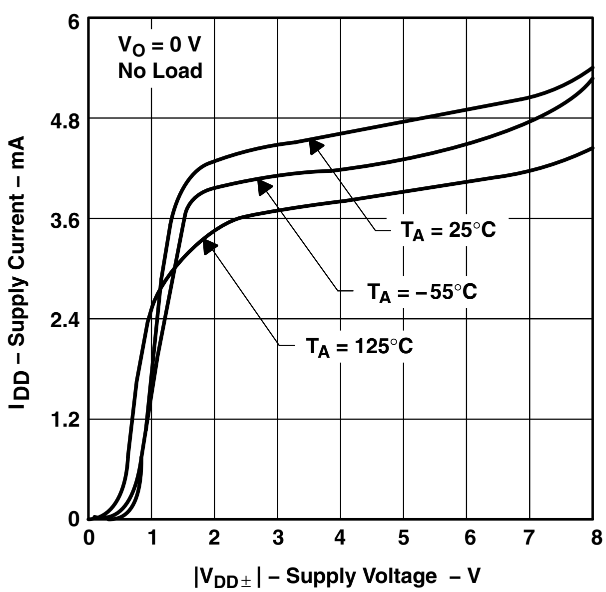



Figure 37

TLC2272
SUPPLY CURRENT†
vs
FREE-AIR TEMPERATURE

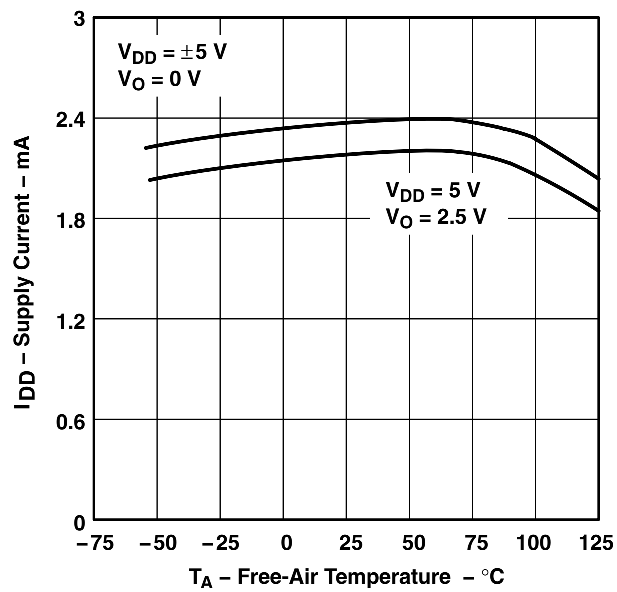



Figure 38

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

## TYPICAL CHARACTERISTICS

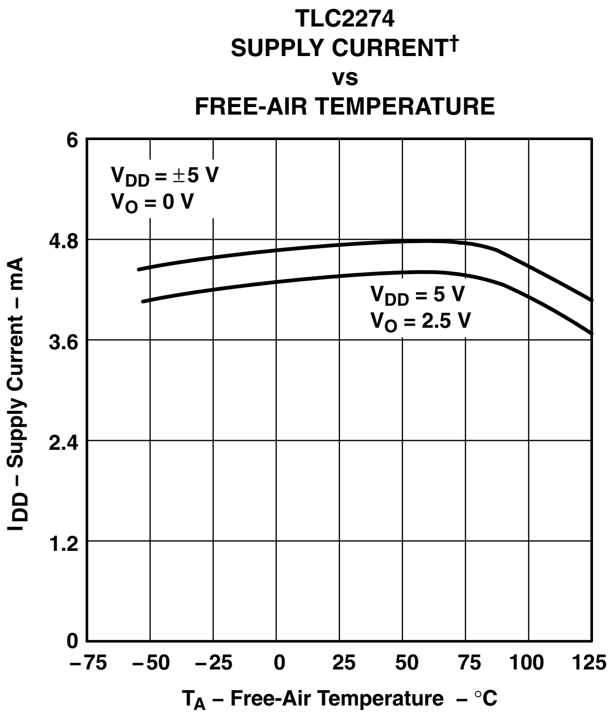



Figure 39

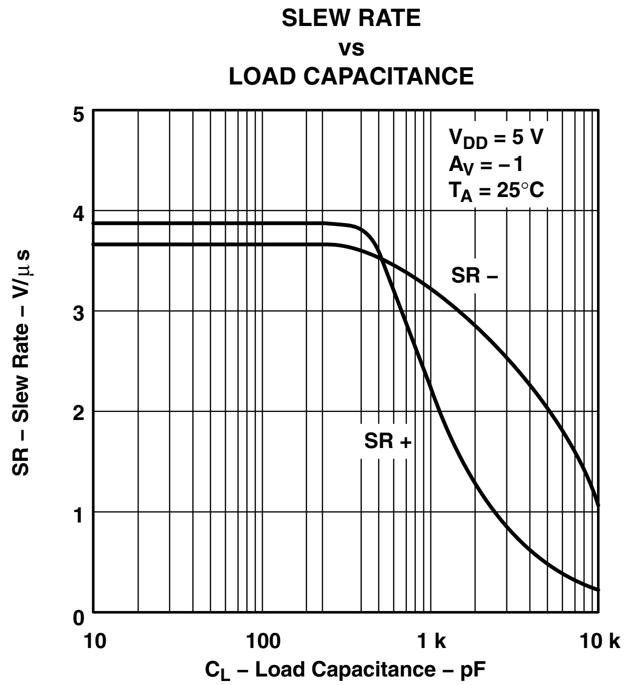



Figure 40

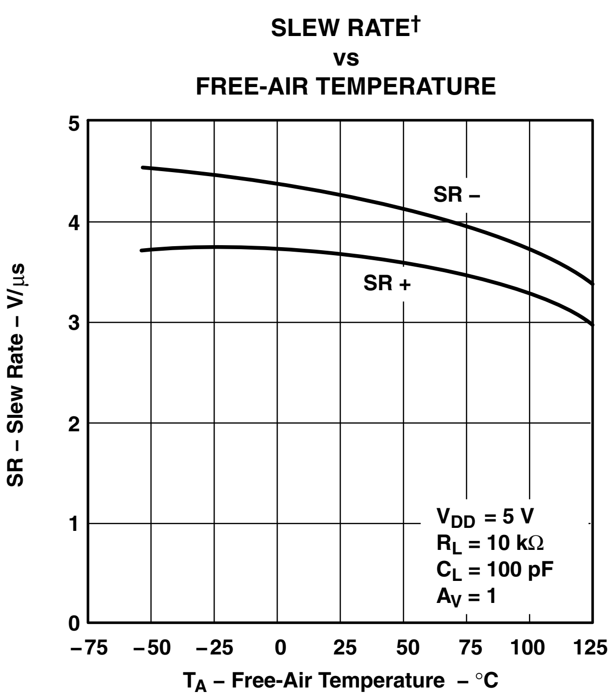



Figure 41

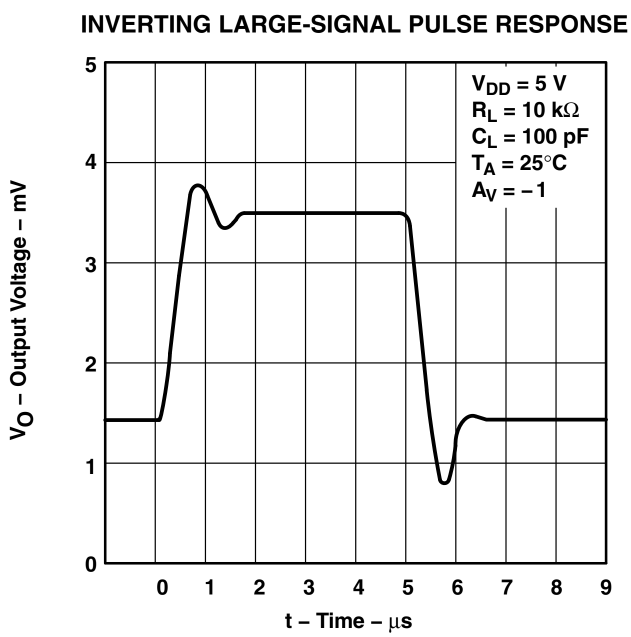



Figure 42

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

## TYPICAL CHARACTERISTICS

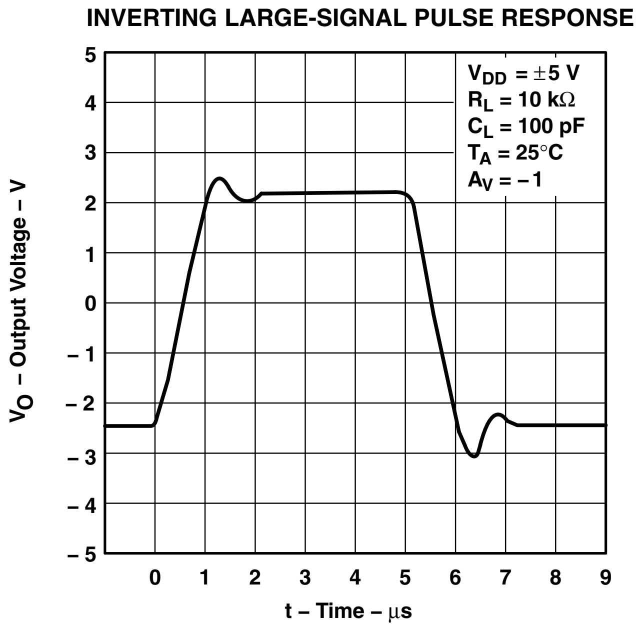



Figure 43

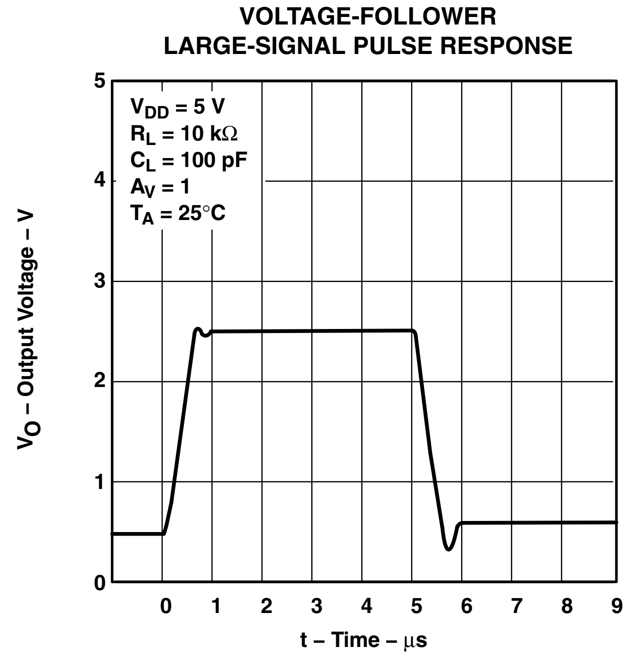



Figure 44

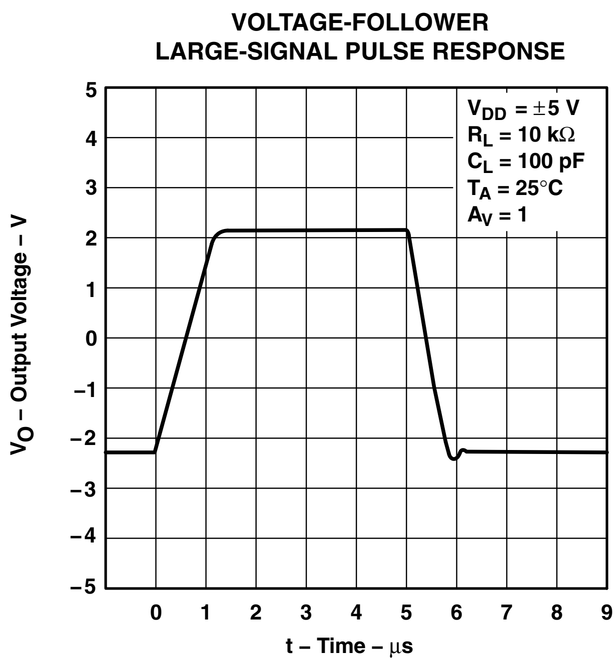



Figure 45

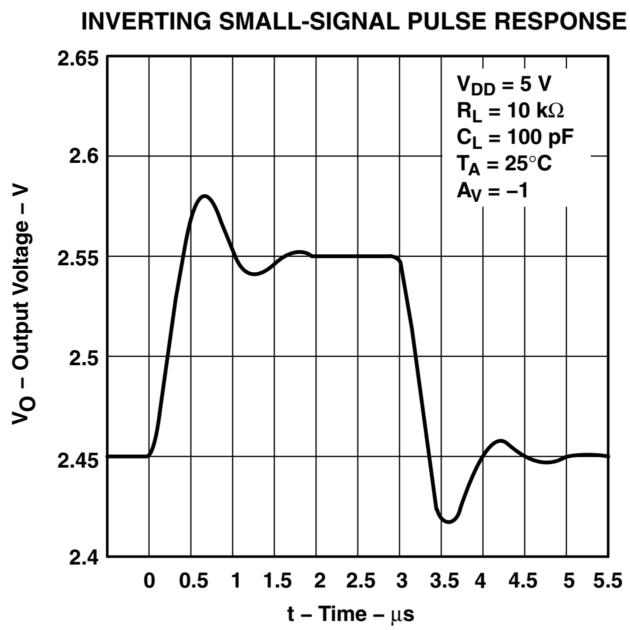



Figure 46

## TYPICAL CHARACTERISTICS

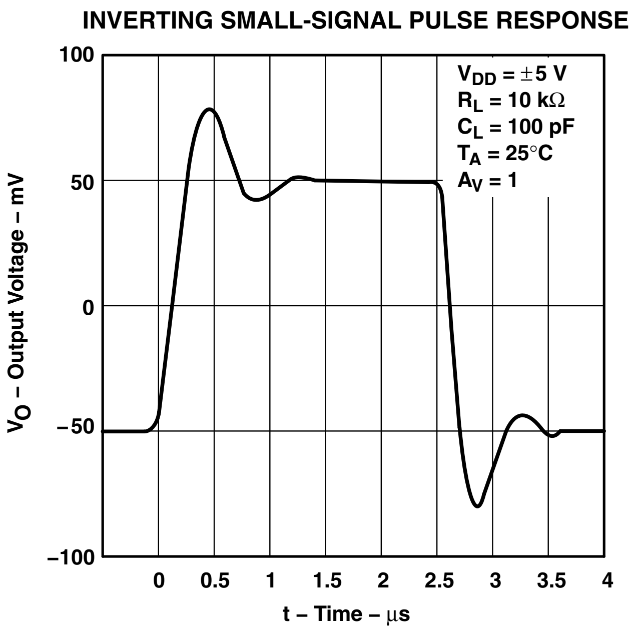



Figure 47

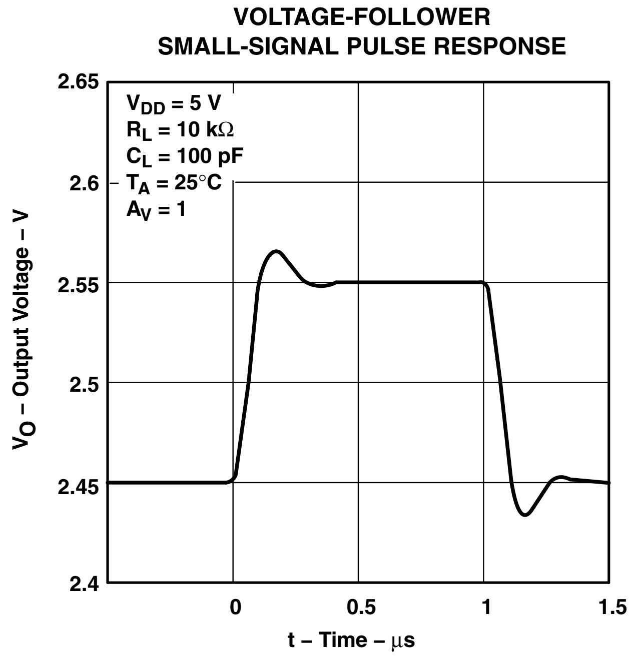



Figure 48

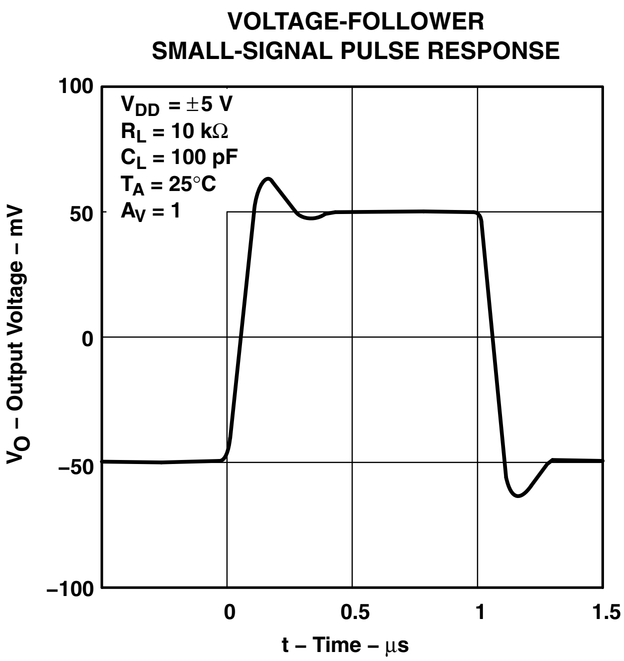



Figure 49

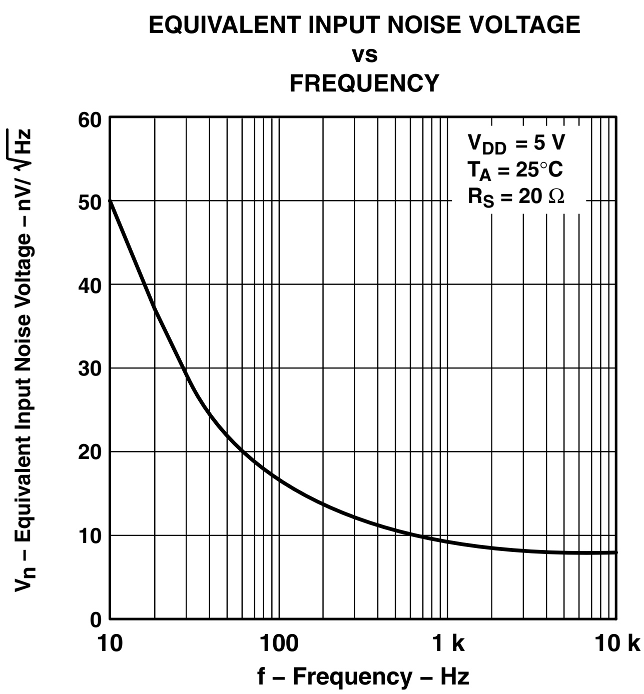



Figure 50

## TYPICAL CHARACTERISTICS

### EQUIVALENT INPUT NOISE VOLTAGE vs FREQUENCY

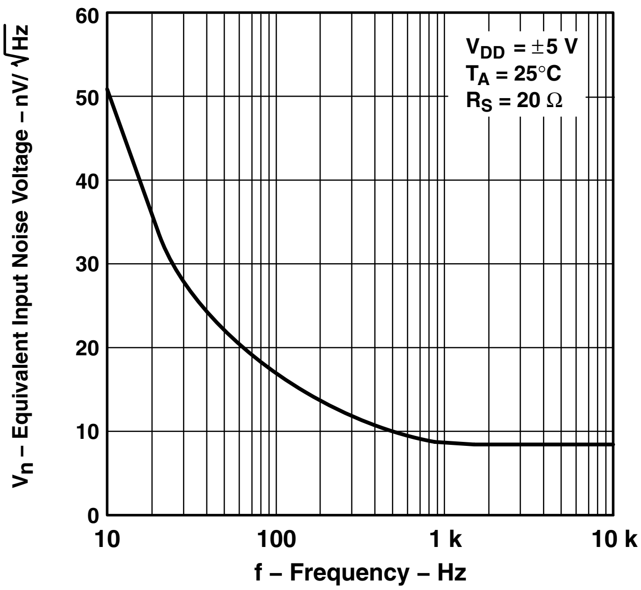



Figure 51

### NOISE VOLTAGE OVER A 10 SECOND PERIOD

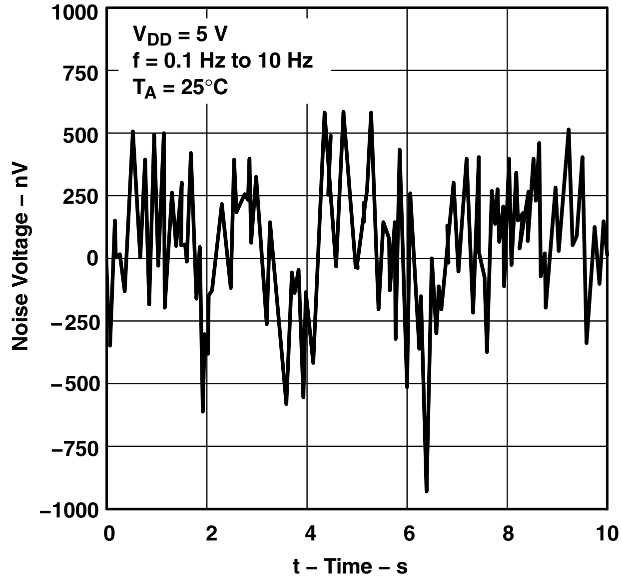



Figure 52

### INTEGRATED NOISE VOLTAGE vs FREQUENCY

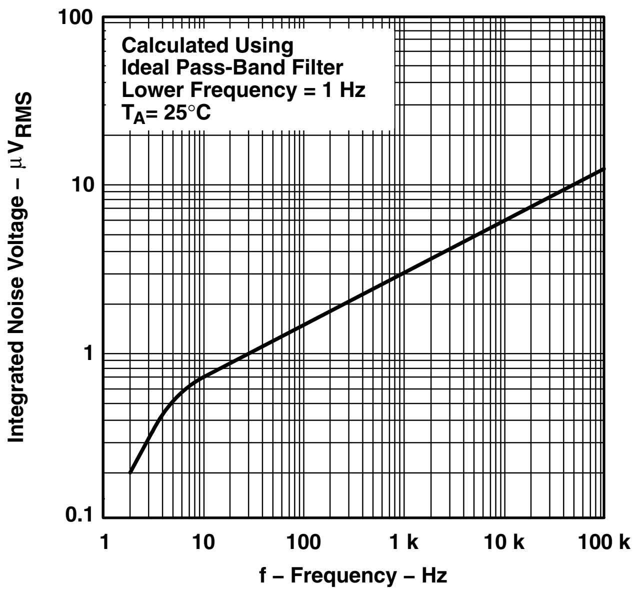



Figure 53

### TOTAL HARMONIC DISTORTION PLUS NOISE vs FREQUENCY

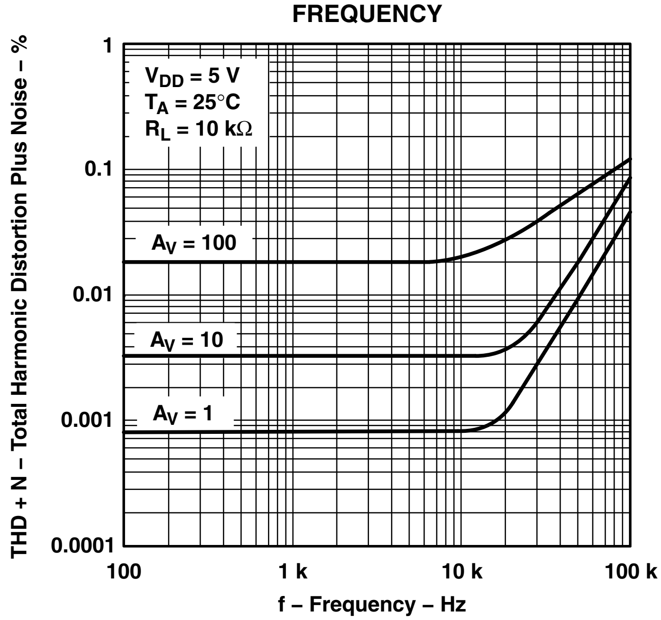



Figure 54

## TYPICAL CHARACTERISTICS

GAIN-BANDWIDTH PRODUCT
vs
SUPPLY VOLTAGE

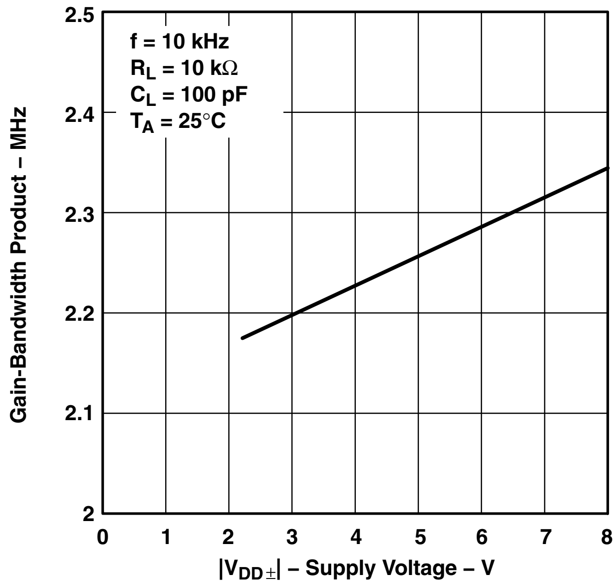



Figure 55

GAIN-BANDWIDTH PRODUCT†
vs
FREE-AIR TEMPERATURE

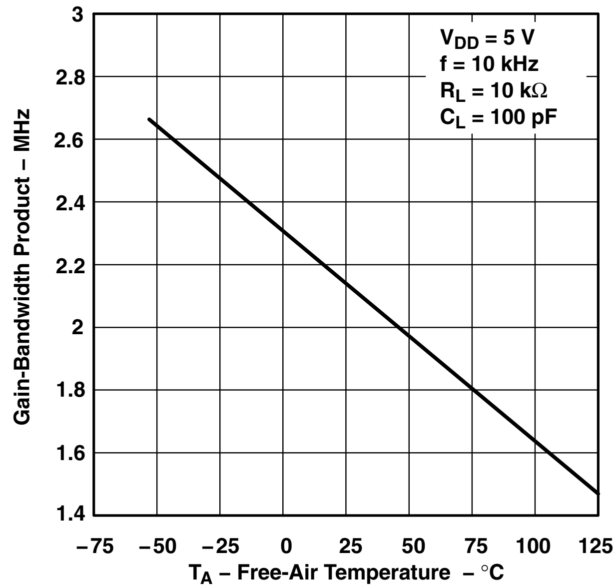



Figure 56

PHASE MARGIN
vs
LOAD CAPACITANCE

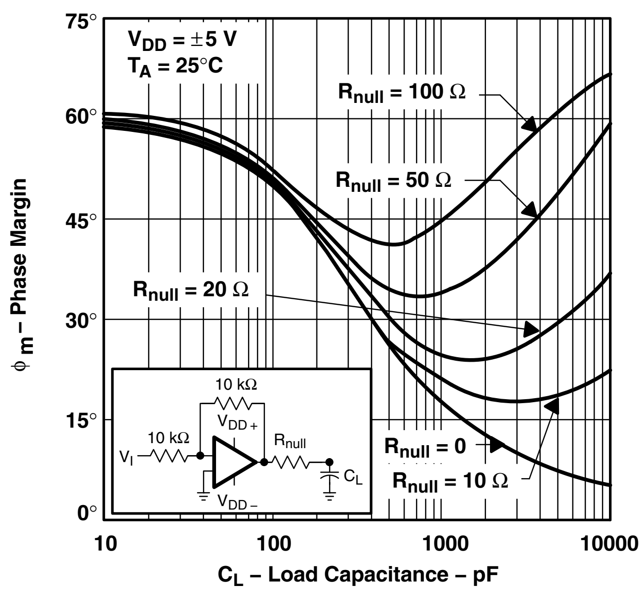



Figure 57

GAIN MARGIN
vs
LOAD CAPACITANCE

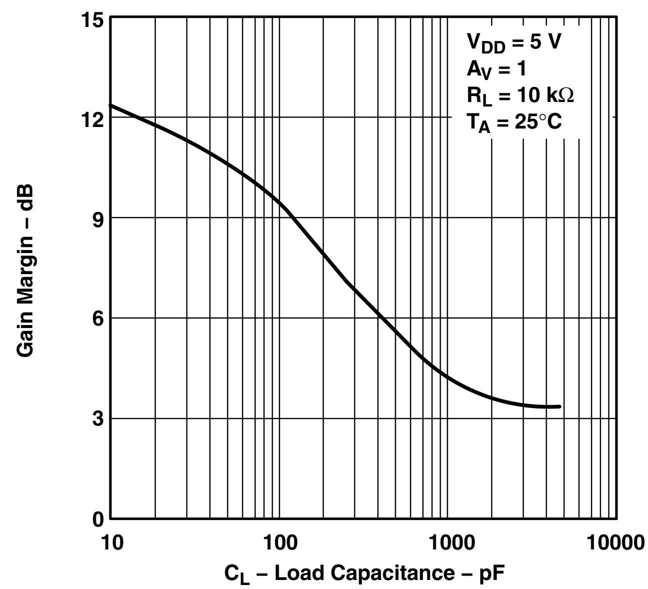



Figure 58

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

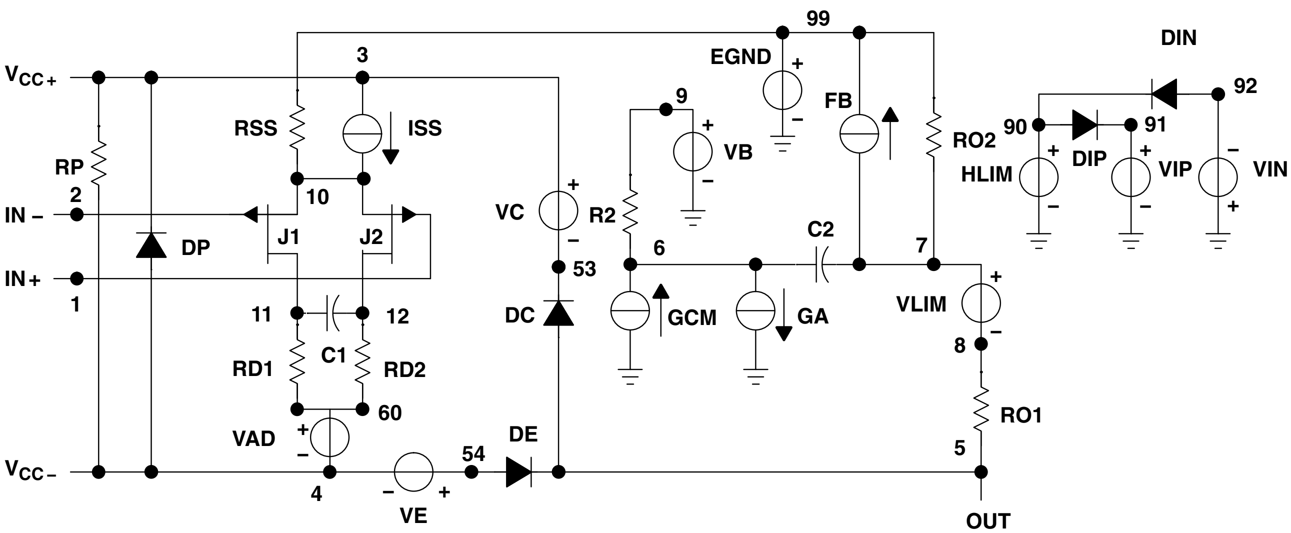
## APPLICATION INFORMATION

### 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 59 were generated using the TLC227x 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 TLC227x 1 2 3 4 5
        C1      11      1214E–12
        C2      6       760.00E–12
        DC      5       53DX
        DE      54      5DX
        DLP     90      91DX
        DLN     92      90DX
        DP      4       3DX
        EGND    99      0POLY (2) (3,0) (4,) 0 .5 .5
        FB      99      0POLY (5) VB VC VE VLP VLN 0
        + 984.9E3 –1E6 1E6 1E6 –1E6
        GA      6       011 12 377.0E–6
        GCM 0 6 10 99 134E–9
        ISS     3       10DC 216.OE–6
        HLIM    90      0VLIM 1K
        J1      11      210 JX
        J2      12      110 JX
        R2      6       9100.OE3
RD1     60      112.653E3
RD2     60      122.653E3
R01     8       550
R02     7       9950
RP      3       44.310E3
RSS     10      99925.9E3
VAD     60      4–.5
VB      9       0DC 0
VC 3 53 DC .78
VE      54      4DC .78
VLIM    7       8DC 0
VLP     91      0DC 1.9
VLN     0       92DC 9.4
.MODEL DX D (IS=800.0E–18)
.MODEL JX PJF (IS=1.500E–12BETA=1.316E-3
+ VTO=–.270)
.ENDS
```

**Figure 59. Boyle Macromodel and Subcircuit**

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

## PACKAGING INFORMATION

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead/Ball Finish | MSL Peak Temp (3) |
|---|---|---|---|---|---|---|---|---|
| TLC2272AQDRG4Q1 | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLC2272AQDRQ1 | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLC2272AQPWRG4Q1 | ACTIVE | TSSOP | PW | 8 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLC2272AQPWRQ1 | ACTIVE | TSSOP | PW | 8 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLC2272QDRG4Q1 | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLC2272QDRQ1 | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLC2272QPWRG4Q1 | ACTIVE | TSSOP | PW | 8 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLC2272QPWRQ1 | ACTIVE | TSSOP | PW | 8 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLC2274AQDRG4Q1 | ACTIVE | SOIC | D | 14 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLC2274AQDRQ1 | ACTIVE | SOIC | D | 14 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLC2274AQPWRG4Q1 | ACTIVE | TSSOP | PW | 14 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLC2274AQPWRQ1 | ACTIVE | TSSOP | PW | 14 | 2000 | TBD | CU NIPDAU | Level-1-250C-UNLIM |
| TLC2274QDRG4Q1 | ACTIVE | SOIC | D | 14 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLC2274QDRQ1 | ACTIVE | SOIC | D | 14 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLC2274QPWRG4Q1 | ACTIVE | TSSOP | PW | 14 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| TLC2274QPWRQ1 | ACTIVE | TSSOP | PW | 14 | 2000 | TBD | CU NIPDAU | Level-1-250C-UNLIM |

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

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

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

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In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

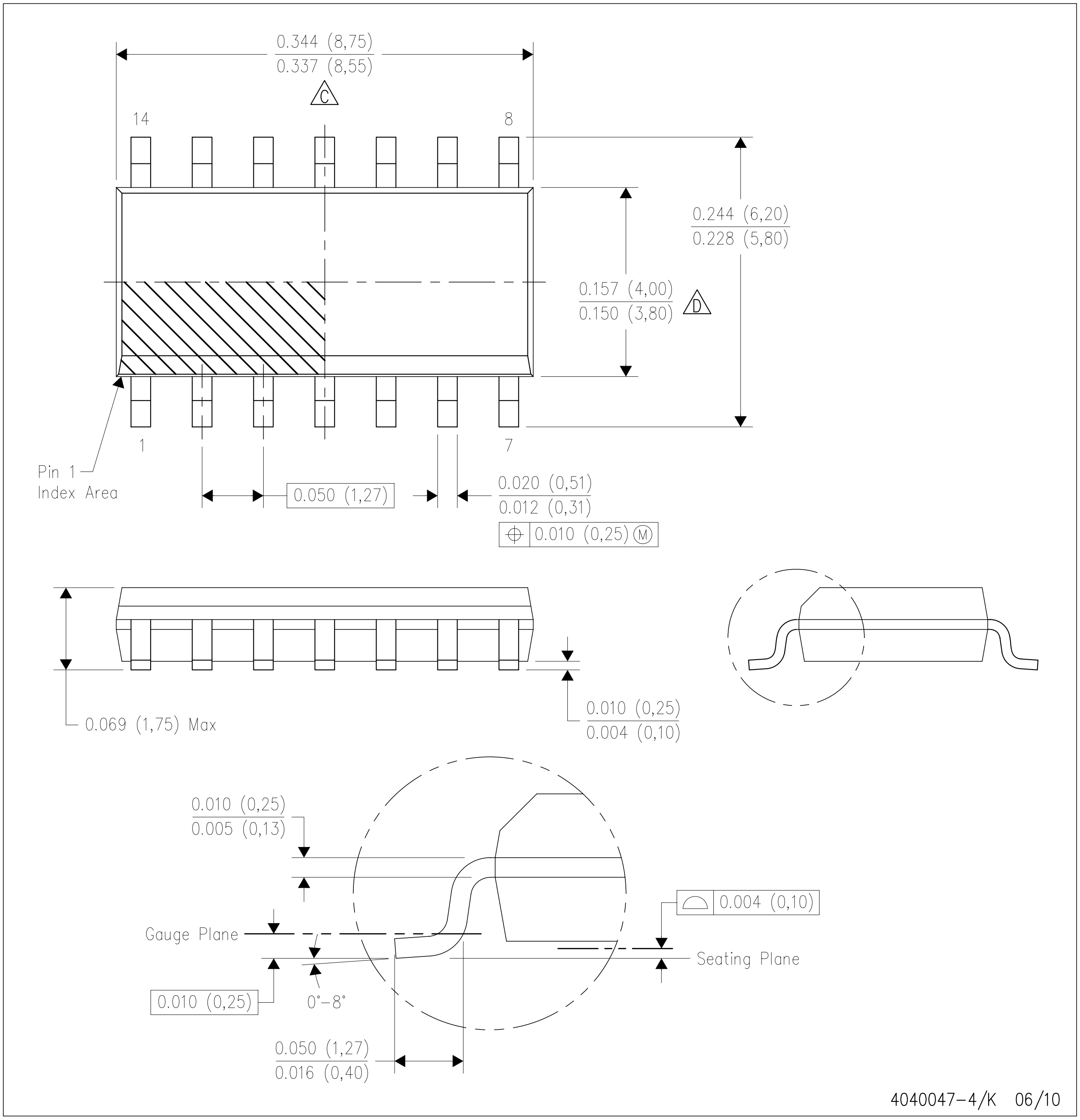
**OTHER QUALIFIED VERSIONS OF TLC2272-Q1, TLC2272A-Q1, TLC2274-Q1, TLC2274A-Q1 :**

- Catalog: TLC2272, TLC2272A, TLC2274, TLC2274A
- Enhanced Product: TLC2272A-EP, TLC2274-EP, TLC2274A-EP
- Military: TLC2272M, TLC2272AM, TLC2274M, TLC2274AM

NOTE: Qualified Version Definitions:

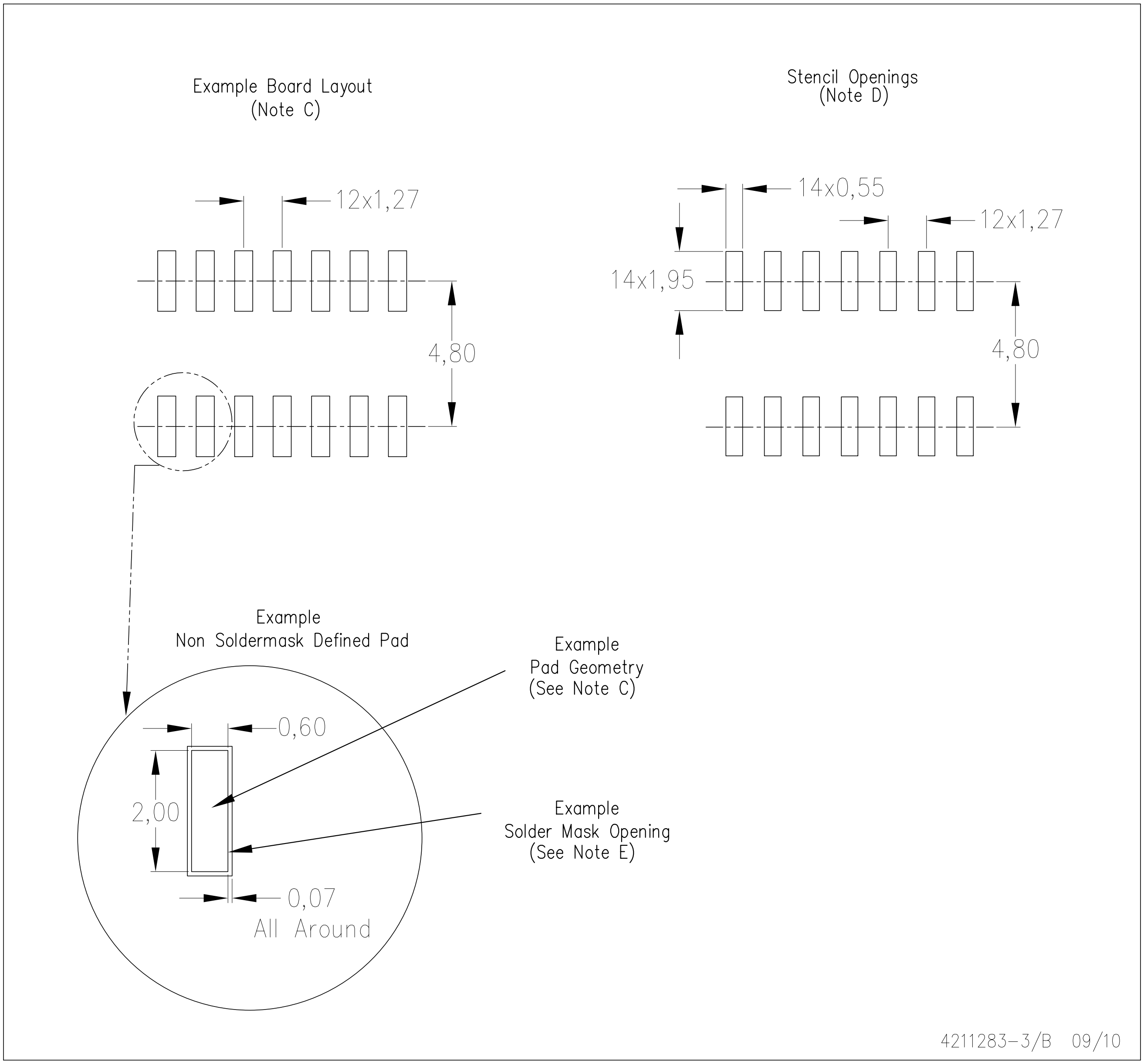
- Catalog - TI's standard catalog product
- Enhanced Product - Supports Defense, Aerospace and Medical Applications
- Military - QML certified for Military and Defense Applications

D (R–PDSO–G14) PLASTIC SMALL–OUTLINE PACKAGE



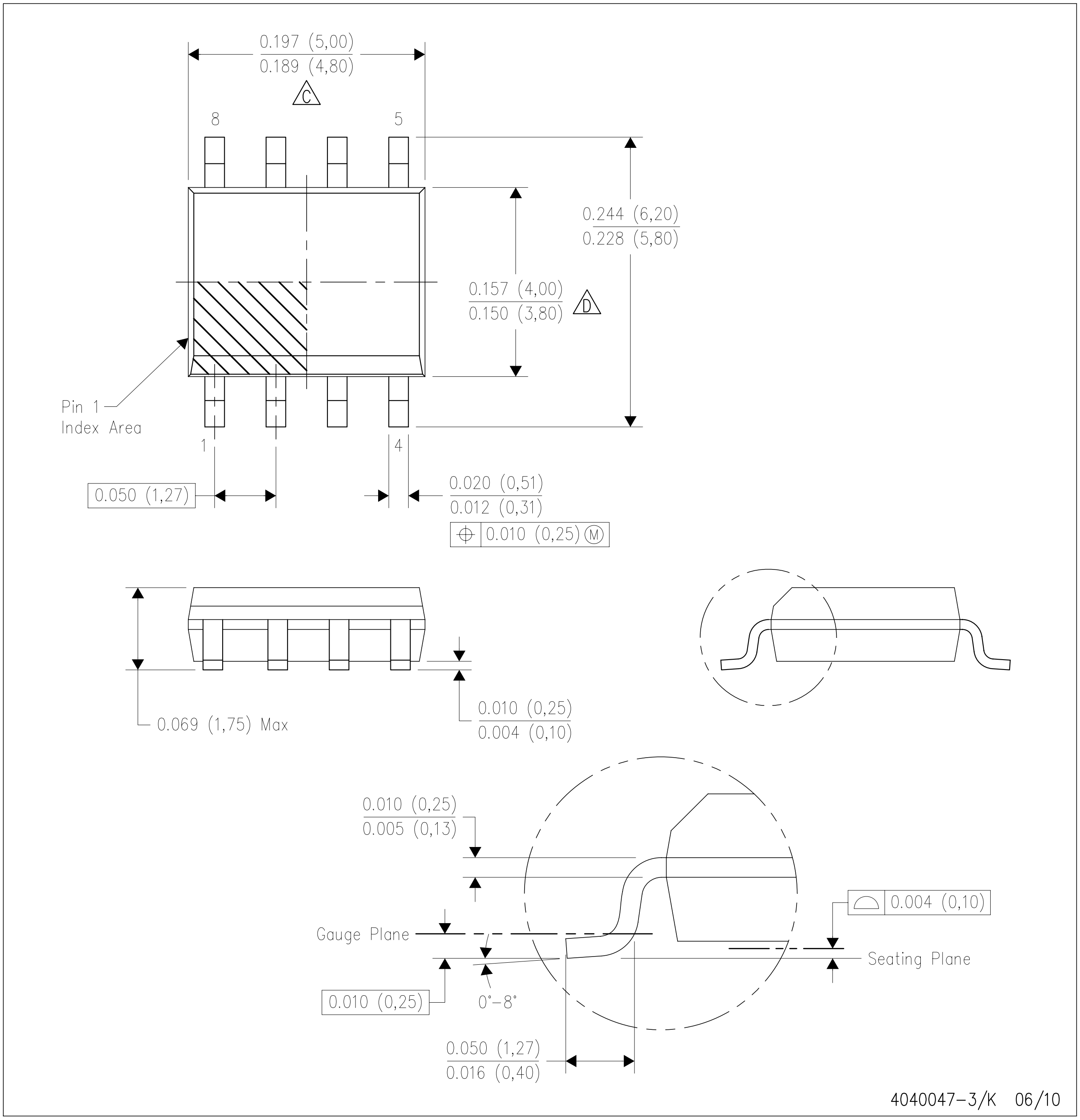

NOTES: A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed .006 (0,15) per end.
D. Body width does not include interlead flash. Interlead flash shall not exceed .017 (0,43) per side.
E. Reference JEDEC MS-012 variation AB.

D (R–PDSO–G14) PLASTIC SMALL OUTLINE



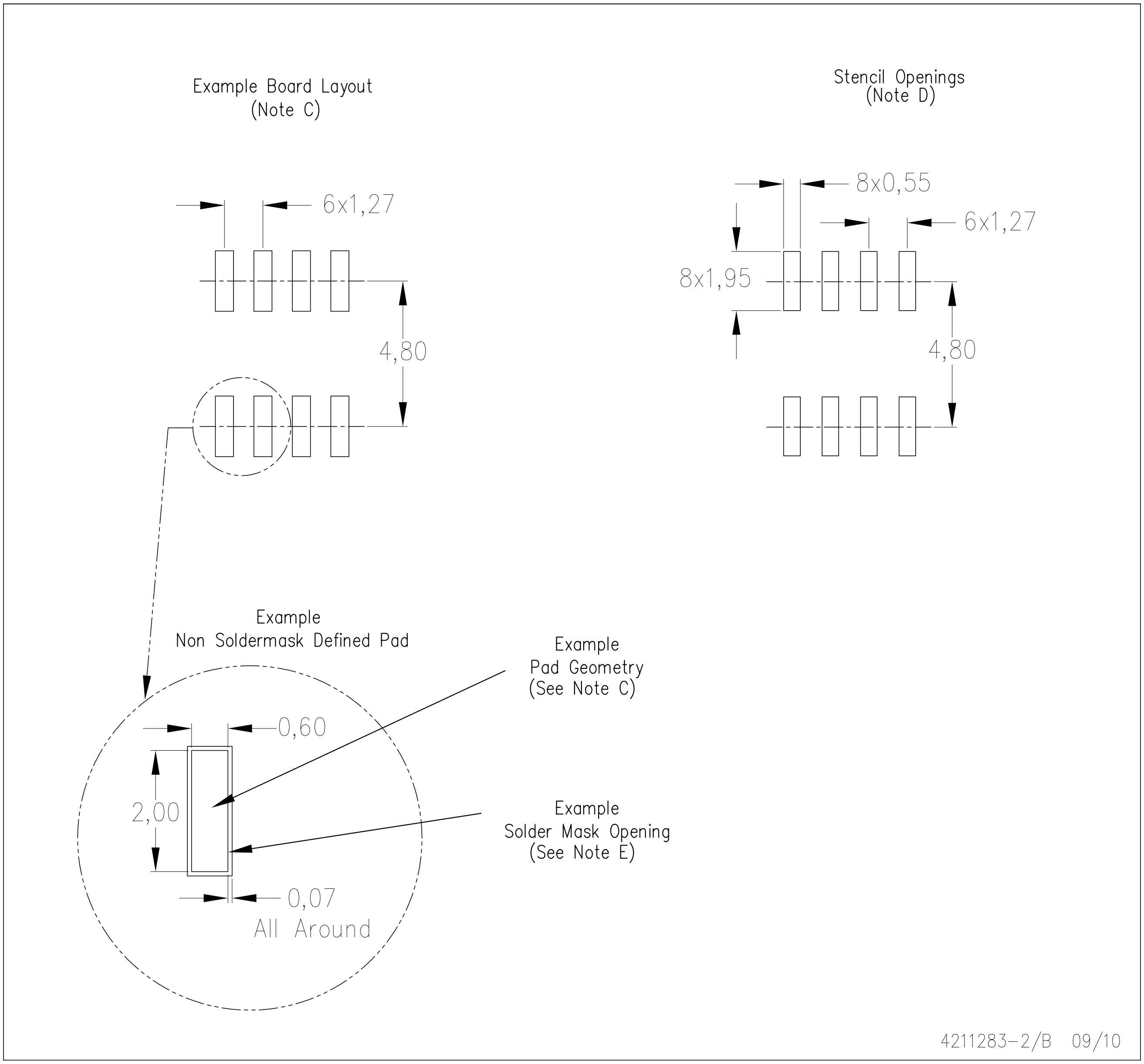

NOTES:
- A. All linear dimensions are in millimeters.
- B. This drawing is subject to change without notice.
- C. Publication IPC–7351 is recommended for alternate designs.
- D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should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

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




NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed .006 (0,15) per end.
D. Body width does not include interlead flash. Interlead flash shall not exceed .017 (0,43) per side.
E. Reference JEDEC MS-012 variation AA.

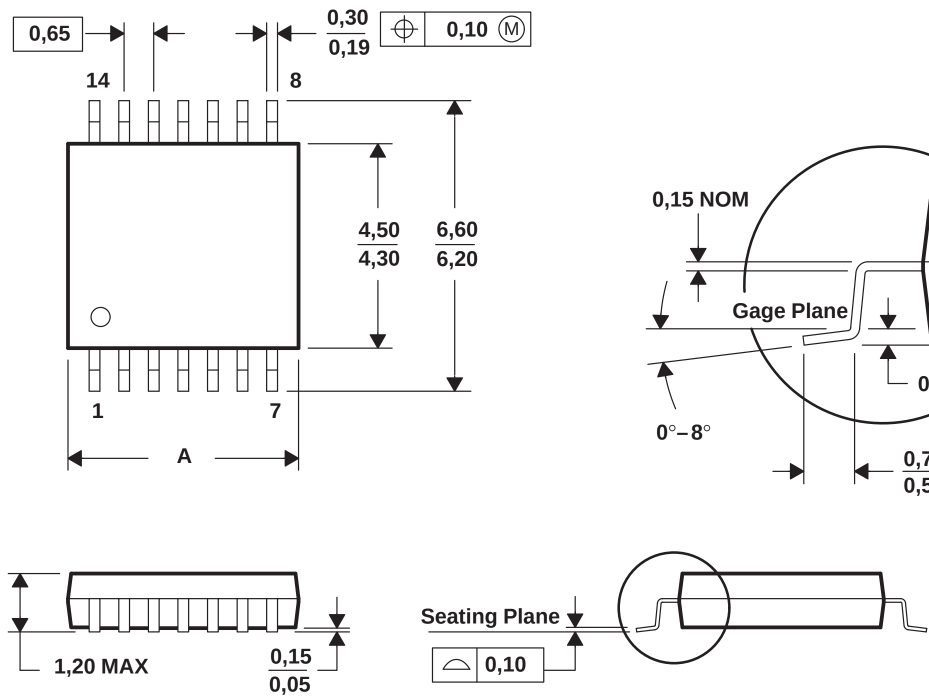
D (R-PDSO-G8) PLASTIC SMALL OUTLINE




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

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

**14 PINS SHOWN**

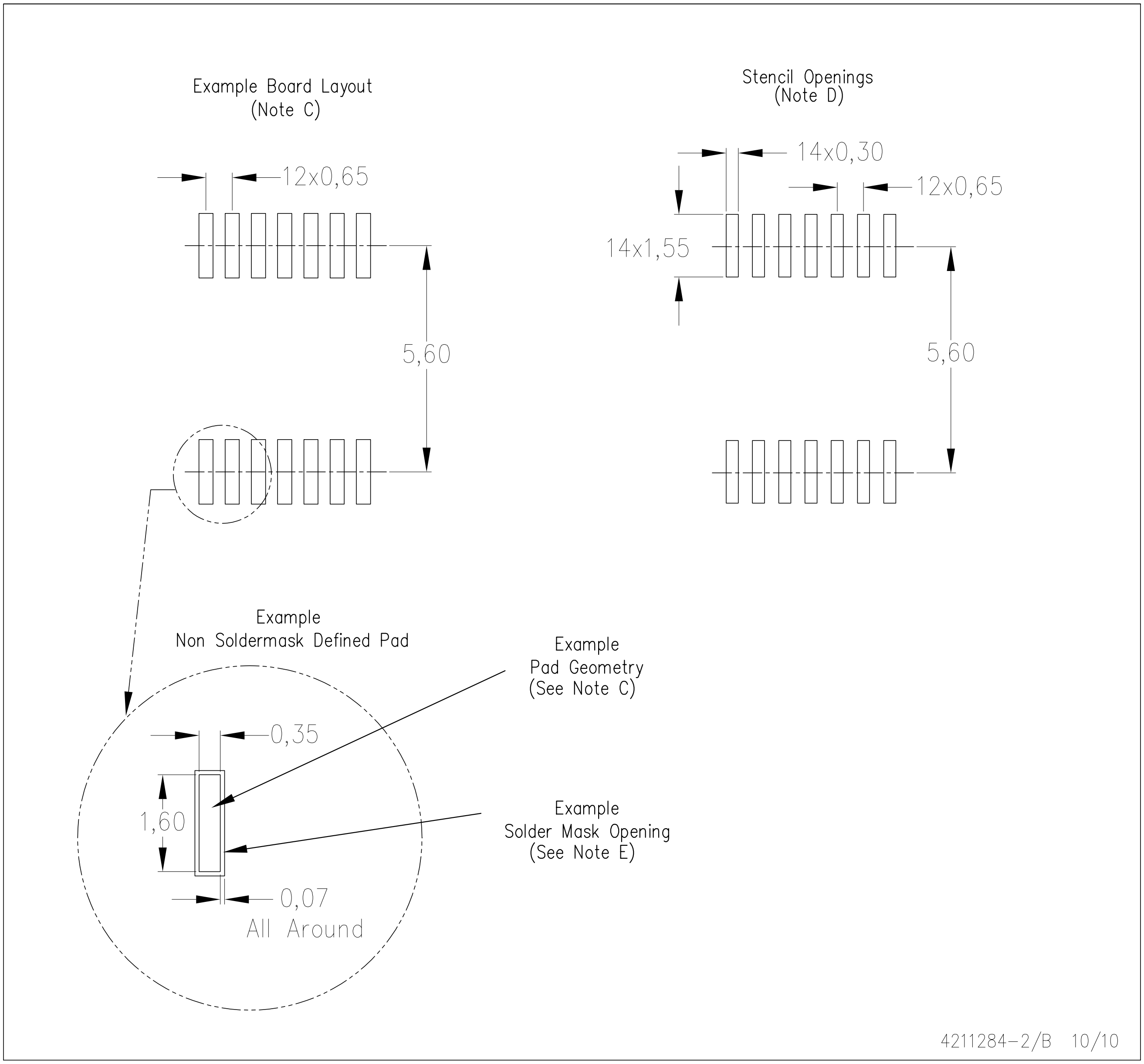



| PINS ** / DIM | 8 | 14 | 16 | 20 | 24 | 28 |
|---|---|---|---|---|---|---|
| A MAX | 3,10 | 5,10 | 5,10 | 6,60 | 7,90 | 9,80 |
| A MIN | 2,90 | 4,90 | 4,90 | 6,40 | 7,70 | 9,60 |

4040064/F 01/97

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

PW (R-PDSO-G14) PLASTIC SMALL OUTLINE




NOTES:

A. All linear dimensions are in millimeters.

B. This drawing is subject to change without notice.

C. Publication IPC-7351 is recommended for alternate designs.

D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC-7525 for other stencil recommendations.

E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

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