

**TLV225x, TLV225xA**  
**Advanced LinCMOS™ RAIL-TO-RAIL**  
**VERY LOW-POWER OPERATIONAL AMPLIFIERS**

SLOS185D – FEBRUARY 1997 – REVISED AUGUST 2006

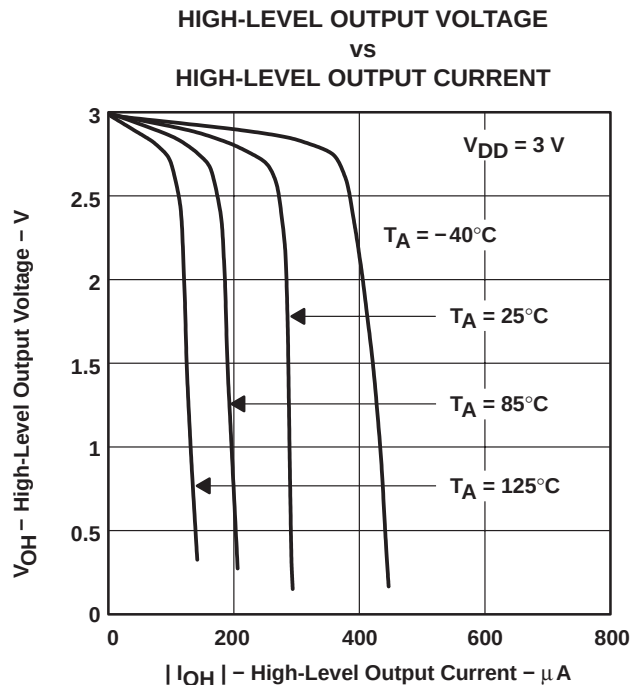
- **Output Swing Includes Both Supply Rails**
- **Low Noise . . . 19 nV/√Hz Typ at f = 1 kHz**
- **Low Input Bias Current . . . 1 pA Typ**
- **Fully Specified for Both Single-Supply and Split-Supply Operation**
- **Very Low Power . . . 34 μA Per Channel Typ**
- **Common-Mode Input Voltage Range Includes Negative Rail**
- **Low Input Offset Voltage**  
850 μV Max at T<sub>A</sub> = 25°C
- **Wide Supply Voltage Range**  
2.7 V to 8 V
- **Macromodel Included**
- **Available in Q-Temp Automotive**  
HighRel Automotive Applications  
Configuration Control / Print Support  
Qualification to Automotive Standards

## description

The TLV2252 and TLV2254 are dual and quad low-voltage operational amplifiers from Texas Instruments. Both devices exhibit rail-to-rail output performance for increased dynamic range in single- or split-supply applications. The TLV225x family consumes only 34 μA of supply current per channel. This micropower operation makes them good choices for battery-powered applications. This family is fully characterized at 3 V and 5 V and is optimized for low-voltage applications. The noise performance has been dramatically improved over previous generations of CMOS amplifiers. The TLV225x has a noise level of 19 nV/√Hz at 1kHz, four times lower than competitive micropower solutions.

The TLV225x, 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 combined with 3-V operation, 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 TLV225xA family is available and has a maximum input offset voltage of 850 μV.

The TLV2252/4 also make great upgrades to the TLV2322/4 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. If your 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.



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

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

**TEXAS  
INSTRUMENTS**

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# TLV225x, TLV225xA

## Advanced LinCMOS™ RAIL-TO-RAIL

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#### TLV2252 AVAILABLE OPTIONS

| T <sub>A</sub> | V <sub>IO</sub> max<br>AT 25°C | PACKAGED DEVICES         |                           |                           |                         |                    |                            |
|----------------|--------------------------------|--------------------------|---------------------------|---------------------------|-------------------------|--------------------|----------------------------|
|                |                                | SMALL<br>OUTLINE†<br>(D) | CHIP<br>CARRIER<br>(FK)   | CERAMIC<br>DIP<br>(JG)    | PLASTIC<br>DIP<br>(P)   | TSSOP‡<br>(PW)     | CERAMIC<br>FLATPACK<br>(U) |
| –40°C to 125°C | 850 µV<br>1500 µV              | TLV2252AID<br>TLV2252ID  | —<br>—                    | —<br>—                    | TLV2252AIP<br>TLV2252IP | TLV2252AIPWLE<br>— | —<br>—                     |
| –40°C to 125°C | 850 µV<br>1500 µV              | TLV2252AQD<br>TLV2252QD  | —<br>—                    | —<br>—                    | —<br>—                  | —<br>—             | —<br>—                     |
| –55°C to 125°C | 850 µV<br>1500 µV              | —<br>—                   | TLV2252AMFK<br>TLV2252MFK | TLV2252AMJG<br>TLV2252MJG | —<br>—                  | —<br>—             | TLV2252AMU<br>TLV2252MU    |

† The D packages are available taped and reeled. Add R suffix to device type (e.g., TLV2252CDR).

‡ The PW package is available only left-end taped and reeled.

§ Chips are tested at 25°C.

#### TLV2254 AVAILABLE OPTIONS

| T <sub>A</sub> | V <sub>IO</sub> max<br>AT 25°C | PACKAGED DEVICES         |                           |                         |                         |                    |                            |
|----------------|--------------------------------|--------------------------|---------------------------|-------------------------|-------------------------|--------------------|----------------------------|
|                |                                | SMALL<br>OUTLINE†<br>(D) | CHIP<br>CARRIER<br>(FK)   | CERAMIC<br>DIP<br>(J)   | PLASTIC<br>DIP<br>(N)   | TSSOP‡<br>(PW)     | CERAMIC<br>FLATPACK<br>(W) |
| –40°C to 125°C | 850 µV<br>1500 µV              | TLV2254AID<br>TLV2254ID  | —<br>—                    | —<br>—                  | TLV2254AIN<br>TLV2254IN | TLV2254AIPWLE<br>— | —<br>—                     |
| –40°C to 125°C | 850 µV<br>1500 µV              | TLV2254AQD<br>TLV2254QD  | —<br>—                    | —<br>—                  | —<br>—                  | —<br>—             | —<br>—                     |
| –55°C to 125°C | 850 µV<br>1500 µV              | —<br>—                   | TLV2254AMFK<br>TLV2254MFK | TLV2254AMJ<br>TLV2254MJ | —<br>—                  | —<br>—             | TLV2254AMW<br>TLV2254MW    |

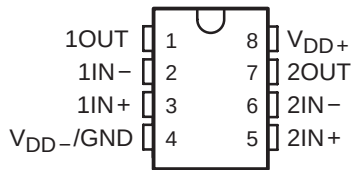
† The D packages are available taped and reeled. Add R suffix to device type (e.g., TLV2254CDR).

‡ The PW package is available only left-end taped and reeled.

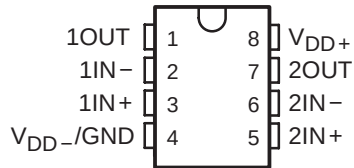
§ Chips are tested at 25°C.

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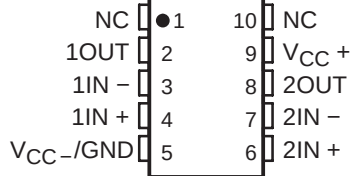
**TLV2252I, TLV2252AI**  
**TLV2252Q, TLV2252AQ**  
**D, P, OR PW PACKAGE**  
**(TOP VIEW)**



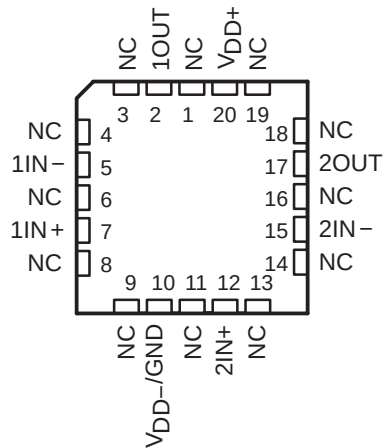
**TLV2252M, TLV2252AM . . . JG PACKAGE**  
**(TOP VIEW)**



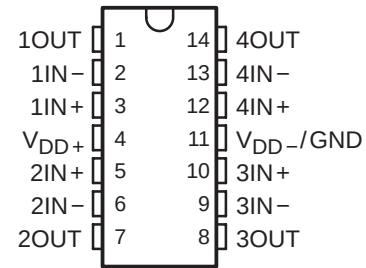
**TLV2252M, TLV2252AM . . . U PACKAGE**  
**(TOP VIEW)**



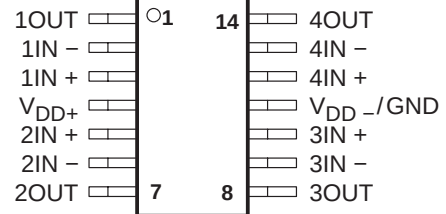
**TLV2252M, TLV2252AM . . . FK PACKAGE**  
**(TOP VIEW)**



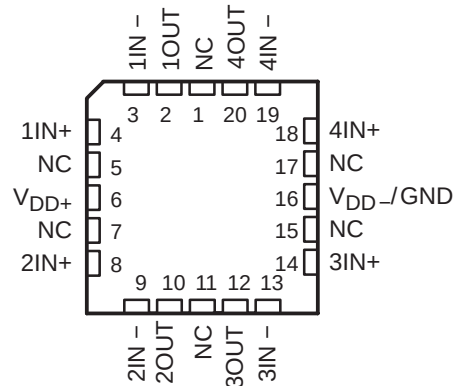
**TLV2254I, TLV2254AI, TLV2254Q, TLV2254AQ . . . D OR N PACKAGE**  
**TLV2254M, TLV2254AM . . . J OR W PACKAGE**  
**(TOP VIEW)**



**TLV2254I, TLV2254AI . . . PW PACKAGE**  
**(TOP VIEW)**



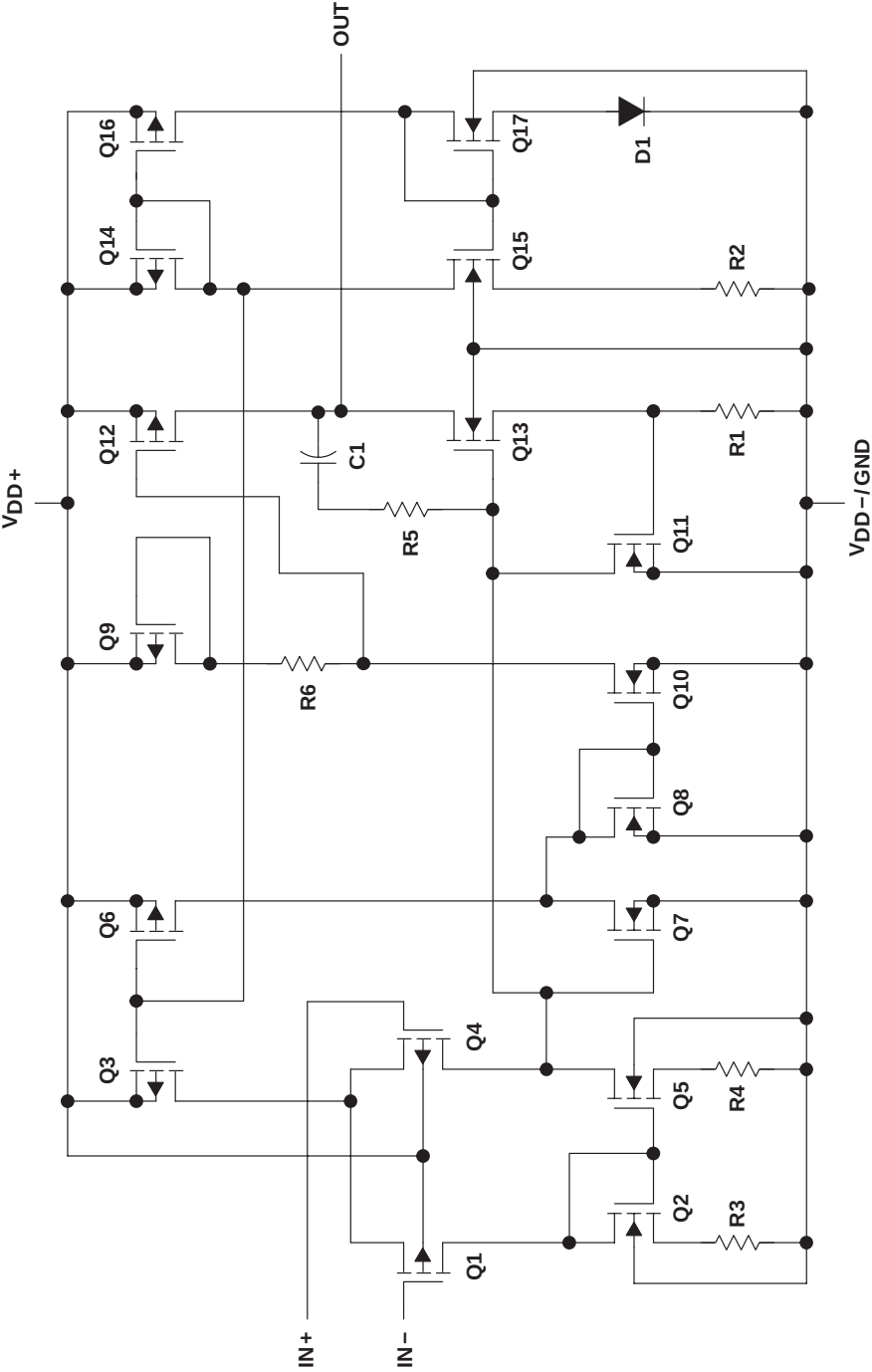
**TLV2254M, TLV2254AM . . . FK PACKAGE**  
**(TOP VIEW)**



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equivalent schematic (each amplifier)



| ACTUAL DEVICE COMPONENT COUNT† |         |         |
|--------------------------------|---------|---------|
| COMPONENT                      | TLV2252 | TLV2254 |
| 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)<sup>†</sup>**

|                                                                                        |                                       |
|----------------------------------------------------------------------------------------|---------------------------------------|
| Supply voltage, $V_{DD}$ (see Note 1)                                                  | 16 V                                  |
| Differential input voltage, $V_{ID}$ (see Note 2)                                      | $\pm V_{DD}$                          |
| Input voltage range, $V_I$ (any input, see Note 1)                                     | $V_{DD} - 0.3 \text{ V}$ to $V_{DD+}$ |
| Input current, $I_I$ (each input)                                                      | $\pm 5 \text{ mA}$                    |
| Output current, $I_O$                                                                  | $\pm 50 \text{ mA}$                   |
| Total current into $V_{DD+}$                                                           | $\pm 50 \text{ mA}$                   |
| Total current out of $V_{DD-}$                                                         | $\pm 50 \text{ mA}$                   |
| Duration of short-circuit current (at or below) 25°C (see Note 3)                      | unlimited                             |
| Continuous total power dissipation                                                     | See Dissipation Rating Table          |
| Operating free-air temperature range, $T_A$ : I Suffix                                 | -40°C to 125°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: D, N, P, and PW packages | 260°C                                 |
| J, JG, U, and W packages                                                               | 300°C                                 |

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

- NOTES: 1. All voltage values, except differential voltages, are with respect to  $V_{DD-}$ .  
2. Differential voltages are at the noninverting input with respect to the inverting input. Excessive current flows when input is brought below  $V_{DD-} - 0.3 \text{ V}$ .  
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 | $T_A \leq 25^\circ\text{C}$<br>POWER RATING | DERATING FACTOR<br>ABOVE $T_A = 25^\circ\text{C}$ | $T_A = 85^\circ\text{C}$<br>POWER RATING | $T_A = 125^\circ\text{C}$<br>POWER RATING |
|---------|---------------------------------------------|---------------------------------------------------|------------------------------------------|-------------------------------------------|
| D-8     | 725 mW                                      | 5.8 mW/°C                                         | 377 mW                                   | 145 mW                                    |
| D-14    | 950 mW                                      | 7.6 mW/°C                                         | 494 mW                                   | 190 mW                                    |
| FK      | 1375 mW                                     | 11.0 mW/°C                                        | 715 mW                                   | 275 mW                                    |
| J       | 1375 mW                                     | 11.0 mW/°C                                        | 715 mW                                   | 275 mW                                    |
| JG      | 1050 mW                                     | 8.4 mW/°C                                         | 546 mW                                   | 210 mW                                    |
| N       | 1150 mW                                     | 9.2 mW/°C                                         | 598 mW                                   | 230 mW                                    |
| P       | 1000 mW                                     | 8.0 mW/°C                                         | 520 mW                                   | 200 mW                                    |
| PW-8    | 525 mW                                      | 4.2 mW/°C                                         | 273 mW                                   | 105 mW                                    |
| PW-14   | 700 mW                                      | 5.6 mW/°C                                         | 364 mW                                   | 140 mW                                    |
| U       | 700 mW                                      | 5.5 mW/°C                                         | 370 mW                                   | 150 mW                                    |
| W       | 700 mW                                      | 5.5 mW/°C                                         | 370 mW                                   | 150 mW                                    |

**recommended operating conditions**

|                                       | TLV225xI  |                 | TLV225xQ  |                 | TLV225xM  |                 | UNIT |
|---------------------------------------|-----------|-----------------|-----------|-----------------|-----------|-----------------|------|
|                                       | MIN       | MAX             | MIN       | MAX             | MIN       | MAX             |      |
| Supply voltage, $V_{DD}$ (see Note 1) | 2.7       | 8               | 2.7       | 8               | 2.7       | 8               | V    |
| Input voltage range, $V_I$            | $V_{DD-}$ | $V_{DD+} - 1.3$ | $V_{DD-}$ | $V_{DD+} - 1.3$ | $V_{DD-}$ | $V_{DD+} - 1.3$ | V    |
| Common-mode input voltage, $V_{IC}$   | $V_{DD-}$ | $V_{DD+} - 1.3$ | $V_{DD-}$ | $V_{DD+} - 1.3$ | $V_{DD-}$ | $V_{DD+} - 1.3$ | V    |
| Operating free-air temperature, $T_A$ | -40       | 125             | -40       | 125             | -55       | 125             | °C   |

NOTE 1: All voltage values, except differential voltages, are with respect to  $V_{DD-}$ .

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TLV2252I electrical characteristics at specified free-air temperature,  $V_{DD} = 3\text{ V}$  (unless otherwise noted)

| PARAMETER                                                      | TEST CONDITIONS                                                                 | $T_A^\dagger$                       | TLV2252I   |             |      | TLV2252AI |             |      | UNIT                         |
|----------------------------------------------------------------|---------------------------------------------------------------------------------|-------------------------------------|------------|-------------|------|-----------|-------------|------|------------------------------|
|                                                                |                                                                                 |                                     | MIN        | TYP         | MAX  | MIN       | TYP         | MAX  |                              |
| $V_{IO}$ Input offset voltage                                  | $V_{DD} = \pm 1.5\text{ V}$ , $V_{IC} = 0$ ,<br>$V_O = 0$ , $R_S = 50\ \Omega$  | 25°C                                |            | 200         | 1500 |           | 200         | 850  | $\mu\text{V}$                |
|                                                                |                                                                                 | Full range                          |            |             | 1750 |           |             | 1000 |                              |
| $\alpha_{VIO}$ Temperature coefficient of input offset voltage |                                                                                 | 25°C to 85°C                        |            | 0.5         |      |           | 0.5         |      | $\mu\text{V}/^\circ\text{C}$ |
| Input offset voltage long-term drift (see Note 4)              |                                                                                 | 25°C                                |            | 0.003       |      |           | 0.003       |      | $\mu\text{V}/\text{mo}$      |
| $I_{IO}$ Input offset current                                  |                                                                                 | 25°C                                |            | 0.5         | 60   |           | 0.5         | 60   | pA                           |
|                                                                |                                                                                 | –40°C to 85°C                       |            |             | 150  |           |             | 150  |                              |
|                                                                |                                                                                 | Full range                          |            |             | 1000 |           |             | 1000 |                              |
| $I_{IB}$ Input bias current                                    |                                                                                 | 25°C                                |            | 1           | 60   |           | 1           | 60   | pA                           |
|                                                                |                                                                                 | –40°C to 85°C                       |            |             | 150  |           |             | 150  |                              |
|                                                                |                                                                                 | Full range                          |            |             | 1000 |           |             | 1000 |                              |
| $V_{ICR}$ Common-mode input voltage range                      | $R_S = 50\ \Omega$ , $ V_{IO}  \leq 5\text{ mV}$                                | 25°C                                | 0 to 2     | –0.3 to 2.2 |      | 0 to 2    | –0.3 to 2.2 |      | V                            |
|                                                                |                                                                                 | Full range                          | 0 to 1.7   |             |      | 0 to 1.7  |             |      |                              |
| $V_{OH}$ High-level output voltage                             | $I_{OH} = -20\ \mu\text{A}$                                                     | 25°C                                |            | 2.98        |      |           | 2.98        |      | V                            |
|                                                                | $I_{OH} = -75\ \mu\text{A}$                                                     | 25°C                                |            | 2.9         |      |           | 2.9         |      |                              |
|                                                                | $I_{OH} = -150\ \mu\text{A}$                                                    | Full range                          |            | 2.8         |      |           | 2.8         |      |                              |
| $V_{OL}$ Low-level output voltage                              | $V_{IC} = 1.5\text{ V}$ , $I_{OL} = 50\ \mu\text{A}$                            | 25°C                                |            | 10          |      |           | 10          |      | mV                           |
|                                                                |                                                                                 | Full range                          |            |             | 80   |           |             | 80   |                              |
|                                                                | $V_{IC} = 1.5\text{ V}$ , $I_{OL} = 500\ \mu\text{A}$                           | 25°C                                |            | 100         |      |           | 100         |      |                              |
|                                                                |                                                                                 | Full range                          |            |             | 150  |           |             | 150  |                              |
|                                                                | $V_{IC} = 1.5\text{ V}$ , $I_{OL} = 1\text{ mA}$                                | 25°C                                |            | 200         |      |           | 200         |      |                              |
|                                                                |                                                                                 | Full range                          |            |             | 300  |           |             | 300  |                              |
| $A_{VD}$ Large-signal differential voltage amplification       | $V_{IC} = 1.5\text{ V}$ , $V_O = 1\text{ V to }2\text{ V}$                      | $R_L = 100\text{ k}\Omega^\ddagger$ | 25°C       | 100         | 250  |           | 100         | 250  | V/mV                         |
|                                                                |                                                                                 |                                     | Full range | 10          |      |           | 10          |      |                              |
|                                                                |                                                                                 | $R_L = 1\text{ M}\Omega^\ddagger$   | 25°C       |             | 800  |           |             | 800  |                              |
| $r_{i(d)}$ Differential input resistance                       |                                                                                 | 25°C                                |            | $10^{12}$   |      |           | $10^{12}$   |      | $\Omega$                     |
| $r_{i(c)}$ Common-mode input resistance                        |                                                                                 | 25°C                                |            | $10^{12}$   |      |           | $10^{12}$   |      | $\Omega$                     |
| $C_{i(c)}$ Common-mode input capacitance                       | $f = 10\text{ kHz}$ , P package                                                 | 25°C                                |            | 8           |      |           | 8           |      | pF                           |
| $z_o$ Closed-loop output impedance                             | $f = 25\text{ kHz}$ , $A_V = 10$                                                | 25°C                                |            | 220         |      |           | 220         |      | $\Omega$                     |
| $CMRR$ Common-mode rejection ratio                             | $V_{IC} = 0\text{ to }1.7\text{ V}$ , $V_O = 1.5\text{ V}$ , $R_S = 50\ \Omega$ | 25°C                                |            | 65          | 75   |           | 65          | 77   | dB                           |
|                                                                |                                                                                 | Full range                          |            | 60          |      |           | 60          |      |                              |

$^\dagger$  Full range is –40°C to 125°C.

$^\ddagger$  Referenced to 1.5 V

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



**TLV2252I electrical characteristics at specified free-air temperature,  $V_{DD} = 3\text{ V}$  (unless otherwise noted) (continued)**

| PARAMETER                                                                    | TEST CONDITIONS                                                           | $T_A^\dagger$ | TLV2252I |     |     | TLV2252AI |     |     | UNIT          |
|------------------------------------------------------------------------------|---------------------------------------------------------------------------|---------------|----------|-----|-----|-----------|-----|-----|---------------|
|                                                                              |                                                                           |               | MIN      | TYP | MAX | MIN       | TYP | MAX |               |
| $k_{SVR}$ Supply voltage rejection ratio ( $\Delta V_{DD} / \Delta V_{IO}$ ) | $V_{DD} = 2.7\text{ V to } 8\text{ V}$ ,<br>$V_{IC} = V_{DD}/2$ , No load | 25°C          | 80       | 95  |     | 80        | 100 |     | dB            |
|                                                                              |                                                                           | Full range    | 80       |     |     | 80        |     |     |               |
| $I_{DD}$ Supply current                                                      | $V_O = 1.5\text{ V}$ , No load                                            | 25°C          |          | 68  | 125 |           | 68  | 125 | $\mu\text{A}$ |
|                                                                              |                                                                           | Full range    |          |     | 150 |           |     | 150 |               |

$^\dagger$  Full range is  $-40^\circ\text{C}$  to  $125^\circ\text{C}$ .

**TLV2252I operating characteristics at specified free-air temperature,  $V_{DD} = 3\text{ V}$**

| PARAMETER                                               | TEST CONDITIONS                                                                                                    | $T_A^\dagger$ | TLV2252I |       |     | TLV2252AI |       |     | UNIT                         |
|---------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------|---------------|----------|-------|-----|-----------|-------|-----|------------------------------|
|                                                         |                                                                                                                    |               | MIN      | TYP   | MAX | MIN       | TYP   | MAX |                              |
| SR Slew rate at unity gain                              | $V_O = 1.1\text{ V to } 1.9\text{ V}$ ,<br>$R_L = 100\text{ k}\Omega^\ddagger$ ,<br>$C_L = 100\text{ pF}^\ddagger$ | 25°C          | 0.07     | 0.1   |     | 0.07      | 0.1   |     | $\text{V}/\mu\text{s}$       |
|                                                         |                                                                                                                    | Full range    | 0.05     |       |     | 0.05      |       |     |                              |
| $V_n$ Equivalent input noise voltage                    | $f = 10\text{ Hz}$                                                                                                 | 25°C          |          | 35    |     |           | 35    |     | $\text{nV}/\sqrt{\text{Hz}}$ |
|                                                         | $f = 1\text{ kHz}$                                                                                                 | 25°C          |          | 19    |     |           | 19    |     |                              |
| $V_{N(PP)}$ Peak-to-peak equivalent input noise voltage | $f = 0.1\text{ Hz to } 1\text{ Hz}$                                                                                | 25°C          |          | 0.6   |     |           | 0.6   |     | $\mu\text{V}$                |
|                                                         | $f = 0.1\text{ Hz to } 10\text{ Hz}$                                                                               | 25°C          |          | 1.1   |     |           | 1.1   |     |                              |
| $I_n$ Equivalent input noise current                    |                                                                                                                    | 25°C          |          | 0.6   |     |           | 0.6   |     | $\text{fA}/\sqrt{\text{Hz}}$ |
| Gain-bandwidth product                                  | $f = 1\text{ kHz}$ , $R_L = 50\text{ k}\Omega^\ddagger$ ,<br>$C_L = 100\text{ pF}^\ddagger$                        | 25°C          |          | 0.187 |     |           | 0.187 |     | MHz                          |
| $B_{OM}$ Maximum output-swing bandwidth                 | $V_{O(PP)} = 1\text{ V}$ , $A_V = 1$ ,<br>$R_L = 50\text{ k}\Omega^\ddagger$ , $C_L = 100\text{ pF}^\ddagger$      | 25°C          |          | 60    |     |           | 60    |     | kHz                          |
| $\phi_m$ Phase margin at unity gain                     | $R_L = 50\text{ k}\Omega^\ddagger$ , $C_L = 100\text{ pF}^\ddagger$                                                | 25°C          |          | 63°   |     |           | 63°   |     |                              |
| Gain margin                                             |                                                                                                                    | 25°C          |          | 15    |     |           | 15    |     | dB                           |

$^\dagger$  Full range is  $-40^\circ\text{C}$  to  $125^\circ\text{C}$ .

$^\ddagger$  Referenced to 1.5 V

# TLV225x, TLV225xA

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### VERY LOW-POWER OPERATIONAL AMPLIFIERS

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TLV2252I electrical characteristics at specified free-air temperature,  $V_{DD} = 5\text{ V}$  (unless otherwise noted)

| PARAMETER                                                      | TEST CONDITIONS                                                                         | $T_A$ †                             | TLV2252I   |             |     | TLV2252AI |             |     | UNIT                         |
|----------------------------------------------------------------|-----------------------------------------------------------------------------------------|-------------------------------------|------------|-------------|-----|-----------|-------------|-----|------------------------------|
|                                                                |                                                                                         |                                     | MIN        | TYP         | MAX | MIN       | TYP         | MAX |                              |
| $V_{IO}$ Input offset voltage                                  | $V_{DD\pm} = \pm 2.5\text{ V}$ ,<br>$V_O = 0$ ,<br>$V_{IC} = 0$ ,<br>$R_S = 50\ \Omega$ | 25°C                                | 200        | 1500        |     | 200       | 850         |     | $\mu\text{V}$                |
|                                                                |                                                                                         | Full range                          |            | 1750        |     |           | 1000        |     |                              |
| $\alpha_{VIO}$ Temperature coefficient of input offset voltage |                                                                                         | 25°C to 85°C                        | 0.5        |             |     | 0.5       |             |     | $\mu\text{V}/^\circ\text{C}$ |
| Input offset voltage long-term drift (see Note 4)              |                                                                                         | 25°C                                | 0.003      |             |     | 0.003     |             |     | $\mu\text{V}/\text{mo}$      |
| $I_{IO}$ Input offset current                                  |                                                                                         | 25°C                                | 0.5        | 60          |     | 0.5       | 60          |     | pA                           |
|                                                                |                                                                                         | –40°C to 85°C                       |            | 150         |     |           | 150         |     |                              |
|                                                                |                                                                                         | Full range                          |            | 1000        |     |           | 1000        |     |                              |
| $I_{IB}$ Input bias current                                    |                                                                                         | 25°C                                | 1          | 60          |     | 1         | 60          |     | pA                           |
|                                                                |                                                                                         | –40°C to 85°C                       |            | 150         |     |           | 150         |     |                              |
|                                                                |                                                                                         | Full range                          |            | 1000        |     |           | 1000        |     |                              |
| $V_{ICR}$ Common-mode input voltage range                      | $ V_{IO}  \leq 5\text{ mV}$ ,<br>$R_S = 50\ \Omega$                                     | 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                             | $I_{OH} = -20\ \mu\text{A}$                                                             | 25°C                                | 4.98       |             |     | 4.98      |             |     | V                            |
|                                                                | $I_{OH} = -75\ \mu\text{A}$                                                             | 25°C                                | 4.9        | 4.94        |     | 4.9       | 4.94        |     |                              |
|                                                                |                                                                                         | Full range                          | 4.8        |             |     | 4.8       |             |     |                              |
|                                                                | $I_{OH} = -150\ \mu\text{A}$                                                            | 25°C                                | 4.8        | 4.88        |     | 4.8       | 4.88        |     |                              |
| $V_{OL}$ Low-level output voltage                              | $V_{IC} = 2.5\text{ V}$ ,<br>$I_{OL} = 50\ \mu\text{A}$                                 | 25°C                                | 0.01       |             |     | 0.01      |             |     | V                            |
|                                                                |                                                                                         | Full range                          |            | 0.06        |     |           | 0.06        |     |                              |
|                                                                | $V_{IC} = 2.5\text{ V}$ ,<br>$I_{OL} = 500\ \mu\text{A}$                                | 25°C                                | 0.09       | 0.15        |     | 0.09      | 0.15        |     |                              |
|                                                                |                                                                                         | Full range                          |            | 0.15        |     |           | 0.15        |     |                              |
|                                                                | $V_{IC} = 2.5\text{ V}$ ,<br>$I_{OL} = 1\text{ mA}$                                     | 25°C                                | 0.2        | 0.3         |     | 0.2       | 0.3         |     |                              |
|                                                                |                                                                                         | Full range                          |            | 0.3         |     |           | 0.3         |     |                              |
| $A_{VD}$ Large-signal differential voltage amplification       | $V_{IC} = 2.5\text{ V}$ ,<br>$V_O = 1\text{ V to }4\text{ V}$                           | $R_L = 100\text{ k}\Omega^\ddagger$ | 25°C       | 100         | 350 | 100       | 350         |     | V/mV                         |
|                                                                |                                                                                         |                                     | Full range | 10          |     | 10        |             |     |                              |
|                                                                |                                                                                         | $R_L = 1\text{ M}\Omega^\ddagger$   | 25°C       | 1700        |     | 1700      |             |     |                              |
| $r_{i(d)}$ Differential input resistance                       |                                                                                         | 25°C                                |            | $10^{12}$   |     |           | $10^{12}$   |     | $\Omega$                     |
| $r_{i(c)}$ Common-mode input resistance                        |                                                                                         | 25°C                                |            | $10^{12}$   |     |           | $10^{12}$   |     | $\Omega$                     |
| $c_{i(c)}$ Common-mode input capacitance                       | $f = 10\text{ kHz}$ ,<br>P package                                                      | 25°C                                |            | 8           |     |           | 8           |     | pF                           |
| $z_o$ Closed-loop output impedance                             | $f = 25\text{ kHz}$ ,<br>$A_V = 10$                                                     | 25°C                                |            | 200         |     |           | 200         |     | $\Omega$                     |
| $CMRR$ Common-mode rejection ratio                             | $V_{IC} = 0\text{ to }2.7\text{ V}$ ,<br>$V_O = 2.5\text{ V}$ ,<br>$R_S = 50\ \Omega$   | 25°C                                | 70         | 83          |     | 70        | 83          |     | dB                           |
|                                                                |                                                                                         | Full range                          | 70         |             |     | 70        |             |     |                              |

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





**TLV2252I electrical characteristics at specified free-air temperature,  $V_{DD} = 5\text{ V}$  (unless otherwise noted) (continued)**

| PARAMETER                                                                  | TEST CONDITIONS                                                          | $T_A^\dagger$ | TLV2252I |     |     | TLV2252AI |     |     | UNIT          |
|----------------------------------------------------------------------------|--------------------------------------------------------------------------|---------------|----------|-----|-----|-----------|-----|-----|---------------|
|                                                                            |                                                                          |               | MIN      | TYP | MAX | MIN       | TYP | MAX |               |
| $k_{SVR}$ Supply voltage rejection ratio ( $\Delta V_{DD}/\Delta V_{IO}$ ) | $V_{DD} = 4.4\text{ V to }8\text{ V}$ ,<br>$V_{IC} = V_{DD}/2$ , No load | 25°C          | 80       | 95  |     | 80        | 95  |     | dB            |
|                                                                            |                                                                          | Full range    | 80       |     |     | 80        |     |     |               |
| $I_{DD}$ Supply current                                                    | $V_O = 2.5\text{ V}$ , No load                                           | 25°C          |          | 70  | 125 |           | 70  | 125 | $\mu\text{A}$ |
|                                                                            |                                                                          | Full range    |          |     | 150 |           |     | 150 |               |

$^\dagger$  Full range is  $-40^\circ\text{C}$  to  $125^\circ\text{C}$ .

**TLV2252I operating characteristics at specified free-air temperature,  $V_{DD} = 5\text{ V}$**

| PARAMETER          |                                             | TEST CONDITIONS                                                                                                 |                                                             | T <sub>A</sub> <sup>†</sup> | TLV2252I |      |     | TLV2252AI |      |     | UNIT   |
|--------------------|---------------------------------------------|-----------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------|-----------------------------|----------|------|-----|-----------|------|-----|--------|
|                    |                                             |                                                                                                                 |                                                             |                             | MIN      | TYP  | MAX | MIN       | TYP  | MAX |        |
| SR                 | Slew rate at unity gain                     | V <sub>O</sub> = 1.5 V to 3.5 V, R <sub>L</sub> = 100 kΩ <sup>‡</sup> ,<br>C <sub>L</sub> = 100 pF <sup>‡</sup> |                                                             | 25°C                        | 0.07     | 0.12 |     | 0.07      | 0.12 |     | V/μs   |
|                    |                                             |                                                                                                                 |                                                             | Full range                  | 0.05     |      |     | 0.05      |      |     |        |
| V <sub>n</sub>     | Equivalent input noise voltage              | f = 10 Hz                                                                                                       |                                                             | 25°C                        | 36       |      |     | 36        |      |     | nV/√Hz |
|                    |                                             | f = 1 kHz                                                                                                       |                                                             | 25°C                        | 19       |      |     | 19        |      |     |        |
| V <sub>N(PP)</sub> | 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 <sub>n</sub>     | Equivalent input noise current              |                                                                                                                 |                                                             | 25°C                        | 0.6      |      |     | 0.6       |      |     | fA/√Hz |
| THD + N            | Total harmonic distortion plus noise        | V <sub>O</sub> = 0.5 V to 2.5 V,<br>f = 20 kHz,<br>R <sub>L</sub> = 50 kΩ <sup>‡</sup>                          | A <sub>V</sub> = 1                                          | 25°C                        | 0.2%     |      |     | 0.2%      |      |     |        |
|                    |                                             |                                                                                                                 | A <sub>V</sub> = 10                                         |                             | 1%       |      |     | 1%        |      |     |        |
|                    | Gain-bandwidth product                      | f = 50 kHz,<br>C <sub>L</sub> = 100 pF <sup>‡</sup>                                                             | R <sub>L</sub> = 50 kΩ <sup>‡</sup> ,                       | 25°C                        | 0.2      |      |     | 0.2       |      |     | MHz    |
| B <sub>OM</sub>    | Maximum output-swing bandwidth              | V <sub>O(PP)</sub> = 2 V,<br>R <sub>L</sub> = 50 kΩ <sup>‡</sup> ,                                              | A <sub>V</sub> = 1,<br>C <sub>L</sub> = 100 pF <sup>‡</sup> | 25°C                        | 30       |      |     | 30        |      |     | kHz    |
| φ <sub>m</sub>     | Phase margin at unity gain                  | R <sub>L</sub> = 50 kΩ <sup>‡</sup> ,<br>C <sub>L</sub> = 100 pF <sup>‡</sup>                                   |                                                             | 25°C                        | 63°      |      |     | 63°       |      |     |        |
|                    | Gain margin                                 |                                                                                                                 |                                                             | 25°C                        | 15       |      |     | 15        |      |     | dB     |

$^\dagger$  Full range is  $-40^\circ\text{C}$  to  $125^\circ\text{C}$ .

$^\ddagger$  Referenced to 2.5 V

# TLV225x, TLV225xA

## Advanced LinCMOS™ RAIL-TO-RAIL

### VERY LOW-POWER OPERATIONAL AMPLIFIERS

SLOS185D – FEBRUARY 1997 – REVISED AUGUST 2006

TLV2254I electrical characteristics at specified free-air temperature,  $V_{DD} = 3\text{ V}$  (unless otherwise noted)

| PARAMETER         |                                                   | TEST CONDITIONS                                                                           |                                      | T <sub>A</sub> <sup>†</sup> | TLV2254I         |          |        | TLV2254AI        |     |      | UNIT  |
|-------------------|---------------------------------------------------|-------------------------------------------------------------------------------------------|--------------------------------------|-----------------------------|------------------|----------|--------|------------------|-----|------|-------|
|                   |                                                   |                                                                                           |                                      |                             | MIN              | TYP      | MAX    | MIN              | TYP | MAX  |       |
| V <sub>IO</sub>   | Input offset voltage                              | V <sub>DD±</sub> = ±1.5 V, V <sub>O</sub> = 0, V <sub>IC</sub> = 0, R <sub>S</sub> = 50 Ω |                                      | 25°C                        | 200              | 1500     |        | 200              | 850 | μV   |       |
|                   | Full range                                        |                                                                                           |                                      | 1750                        |                  |          | 1000   |                  |     |      |       |
| α <sub>VIO</sub>  | 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 <sub>IO</sub>   | Input offset current                              |                                                                                           |                                      | 25°C                        | 0.5              | 60       |        | 0.5              | 60  | pA   |       |
|                   |                                                   |                                                                                           |                                      | –40°C to 85°C               | 150              |          |        | 150              |     |      |       |
|                   |                                                   |                                                                                           |                                      | Full range                  | 1000             |          |        | 1000             |     |      |       |
| I <sub>IB</sub>   | Input bias current                                |                                                                                           |                                      | 25°C                        | 1                | 60       |        | 1                | 60  | pA   |       |
|                   |                                                   |                                                                                           |                                      | –40°C to 85°C               | 150              |          |        | 150              |     |      |       |
|                   |                                                   |                                                                                           |                                      | Full range                  | 1000             |          |        | 1000             |     |      |       |
| V <sub>ICR</sub>  | Common-mode input voltage range                   | R <sub>S</sub> = 50 Ω,  V <sub>IO</sub>   ≤ 5 mV                                          | 25°C                                 | 0 to 2                      | –0.3 to 2.2      |          | 0 to 2 | –0.3 to 2.2      | V   |      |       |
|                   |                                                   |                                                                                           | Full range                           | 0 to 1.7                    |                  | 0 to 1.7 |        |                  |     |      |       |
| V <sub>OH</sub>   | High-level output voltage                         | I <sub>OH</sub> = –20 μA                                                                  | 25°C                                 | 2.98                        |                  |          | 2.98   |                  |     | V    |       |
|                   |                                                   | I <sub>OH</sub> = –75 μA                                                                  | 25°C                                 | 2.9                         |                  |          | 2.9    |                  |     |      |       |
|                   |                                                   |                                                                                           | Full range                           | 2.8                         |                  |          | 2.8    |                  |     |      |       |
|                   |                                                   | I <sub>OH</sub> = –150 μA                                                                 | 25°C                                 | 2.8                         |                  |          | 2.8    |                  |     |      |       |
| V <sub>OL</sub>   | Low-level output voltage                          | V <sub>IC</sub> = 1.5 V, I <sub>OL</sub> = 50 μA                                          | 25°C                                 | 10                          |                  |          | 10     |                  |     | mV   |       |
|                   |                                                   |                                                                                           | Full range                           | 80                          |                  |          | 80     |                  |     |      |       |
|                   |                                                   | V <sub>IC</sub> = 1.5 V, I <sub>OL</sub> = 500 μA                                         | 25°C                                 | 100                         |                  |          | 100    |                  |     |      |       |
|                   |                                                   |                                                                                           | Full range                           | 150                         |                  |          | 150    |                  |     |      |       |
|                   |                                                   | V <sub>IC</sub> = 1.5 V, I <sub>OL</sub> = 1 mA                                           | 25°C                                 | 200                         |                  |          | 200    |                  |     |      |       |
|                   |                                                   |                                                                                           | Full range                           | 300                         |                  |          | 300    |                  |     |      |       |
| A <sub>VD</sub>   | Large-signal differential voltage amplification   | V <sub>IC</sub> = 1.5 V, V <sub>O</sub> = 1 V to 2 V                                      | R <sub>L</sub> = 100 kΩ <sup>‡</sup> | 25°C                        | 100              | 225      |        | 100              | 225 | V/mV |       |
|                   |                                                   |                                                                                           |                                      | Full range                  | 10               |          |        | 10               |     |      |       |
|                   |                                                   |                                                                                           | R <sub>L</sub> = 1 MΩ <sup>‡</sup>   | 25°C                        | 800              |          |        | 800              |     |      |       |
| r <sub>i(d)</sub> | Differential input resistance                     |                                                                                           |                                      | 25°C                        | 10 <sup>12</sup> |          |        | 10 <sup>12</sup> |     |      | Ω     |
| r <sub>i(c)</sub> | Common-mode input resistance                      |                                                                                           |                                      | 25°C                        | 10 <sup>12</sup> |          |        | 10 <sup>12</sup> |     |      | Ω     |
| c <sub>i(c)</sub> | Common-mode input capacitance                     | f = 10 kHz,                                                                               | N package                            | 25°C                        | 8                |          |        | 8                |     |      | pF    |
| z <sub>o</sub>    | Closed-loop output impedance                      | f = 25 kHz,                                                                               | A <sub>V</sub> = 10                  | 25°C                        | 220              |          |        | 220              |     |      | Ω     |
| CMRR              | Common-mode rejection ratio                       | V <sub>IC</sub> = 0 to 1.7 V, V <sub>O</sub> = 1.5 V, R <sub>S</sub> = 50 Ω               | 25°C                                 | 65                          | 75               |          | 65     | 77               | dB  |      |       |
|                   |                                                   |                                                                                           | Full range                           | 60                          |                  |          | 60     |                  |     |      |       |

$^\dagger$  Full range is –40°C to 125°C.

$^\ddagger$  Referenced to 1.5 V

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



**TLV2254I electrical characteristics at specified free-air temperature,  $V_{DD} = 3\text{ V}$  (unless otherwise noted) (continued)**

| PARAMETER                                                                  | TEST CONDITIONS                                                          | $T_A^\dagger$ | TLV2254I |     |     | TLV2254AI |     |     | UNIT          |
|----------------------------------------------------------------------------|--------------------------------------------------------------------------|---------------|----------|-----|-----|-----------|-----|-----|---------------|
|                                                                            |                                                                          |               | MIN      | TYP | MAX | MIN       | TYP | MAX |               |
| $k_{SVR}$ Supply voltage rejection ratio ( $\Delta V_{DD}/\Delta V_{IO}$ ) | $V_{DD} = 2.7\text{ V to }8\text{ V}$ ,<br>$V_{IC} = V_{DD}/2$ , No load | 25°C          | 80       | 95  |     | 80        | 100 |     | dB            |
|                                                                            |                                                                          | Full range    | 80       |     |     | 80        |     |     |               |
| $I_{DD}$ Supply current (four amplifiers)                                  | $V_O = 1.5\text{ V}$ , No load                                           | 25°C          |          | 135 | 250 |           | 135 | 250 | $\mu\text{A}$ |
|                                                                            |                                                                          | Full range    |          |     | 300 |           |     | 300 |               |

$^\dagger$  Full range is  $-40^\circ\text{C}$  to  $125^\circ\text{C}$ .

**TLV2254I operating characteristics at specified free-air temperature,  $V_{DD} = 3\text{ V}$**

| PARAMETER                                               | TEST CONDITIONS                                                                                                     | $T_A^\dagger$ | TLV2254I |       |     | TLV2254AI |       |     | UNIT                         |
|---------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|---------------|----------|-------|-----|-----------|-------|-----|------------------------------|
|                                                         |                                                                                                                     |               | MIN      | TYP   | MAX | MIN       | TYP   | MAX |                              |
| SR Slew rate at unity gain                              | $V_O = 0.7\text{ V to }1.7\text{ V}$ ,<br>$R_L = 100\text{ k}\Omega^\ddagger$ ,<br>$C_L = 100\text{ pF}^\ddagger$   | 25°C          | 0.07     | 0.1   |     | 0.07      | 0.1   |     | $\text{V}/\mu\text{s}$       |
|                                                         |                                                                                                                     | Full range    | 0.05     |       |     | 0.05      |       |     |                              |
| $V_n$ Equivalent input noise voltage                    | $f = 10\text{ Hz}$                                                                                                  | 25°C          |          | 35    |     |           | 35    |     | $\text{nV}/\sqrt{\text{Hz}}$ |
|                                                         | $f = 1\text{ kHz}$                                                                                                  | 25°C          |          | 19    |     |           | 19    |     |                              |
| $V_{N(PP)}$ Peak-to-peak equivalent input noise voltage | $f = 0.1\text{ Hz to }1\text{ Hz}$                                                                                  | 25°C          |          | 0.6   |     |           | 0.6   |     | $\mu\text{V}$                |
|                                                         | $f = 0.1\text{ Hz to }10\text{ Hz}$                                                                                 | 25°C          |          | 1.1   |     |           | 1.1   |     |                              |
| $I_n$ Equivalent input noise current                    |                                                                                                                     | 25°C          |          | 0.6   |     |           | 0.6   |     | $\text{fA}/\sqrt{\text{Hz}}$ |
| Gain-bandwidth product                                  | $f = 1\text{ kHz}$ ,<br>$R_L = 50\text{ k}\Omega^\ddagger$ ,<br>$C_L = 100\text{ pF}^\ddagger$                      | 25°C          |          | 0.187 |     |           | 0.187 |     | MHz                          |
| $B_{OM}$ Maximum output-swing bandwidth                 | $V_{O(PP)} = 1\text{ V}$ ,<br>$A_V = 1$ ,<br>$R_L = 50\text{ k}\Omega^\ddagger$ ,<br>$C_L = 100\text{ pF}^\ddagger$ | 25°C          |          | 60    |     |           | 60    |     | kHz                          |
| $\phi_m$ Phase margin at unity gain                     | $R_L = 50\text{ k}\Omega^\ddagger$ ,<br>$C_L = 100\text{ pF}^\ddagger$                                              | 25°C          |          | 63°   |     |           | 63°   |     |                              |
| Gain margin                                             |                                                                                                                     | 25°C          |          | 15    |     |           | 15    |     | dB                           |

$^\dagger$  Full range is  $-40^\circ\text{C}$  to  $85^\circ\text{C}$ .

$^\ddagger$  Referenced to 1.5 V

# TLV225x, TLV225xA

## Advanced LinCMOS™ RAIL-TO-RAIL

### VERY LOW-POWER OPERATIONAL AMPLIFIERS

SLOS185D – FEBRUARY 1997 – REVISED AUGUST 2006

TLV2254I electrical characteristics at specified free-air temperature,  $V_{DD} = 5\text{ V}$  (unless otherwise noted)

| PARAMETER         |                                                   | TEST CONDITIONS                                                                           | T <sub>A</sub> †         | TLV2254I         |             |          | TLV2254AI        |       |      | UNIT |
|-------------------|---------------------------------------------------|-------------------------------------------------------------------------------------------|--------------------------|------------------|-------------|----------|------------------|-------|------|------|
|                   |                                                   |                                                                                           |                          | MIN              | TYP         | MAX      | MIN              | TYP   | MAX  |      |
| V <sub>IO</sub>   | Input offset voltage                              | V <sub>DD±</sub> = ±2.5 V, V <sub>O</sub> = 0, V <sub>IC</sub> = 0, R <sub>S</sub> = 50 Ω | 25°C                     | 200              | 1500        | 200      | 850              | μV    |      |      |
|                   |                                                   |                                                                                           | Full range               | 1750             |             |          | 1000             |       |      |      |
| αV <sub>IO</sub>  | 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 <sub>IO</sub>   | Input offset current                              |                                                                                           | 25°C                     | 0.5              | 60          | 0.5      | 60               | pA    |      |      |
|                   |                                                   |                                                                                           | –40°C to 85°C            | 150              |             |          | 150              |       |      |      |
|                   |                                                   |                                                                                           | Full range               | 1000             |             |          | 1000             |       |      |      |
| I <sub>IB</sub>   | Input bias current                                |                                                                                           | 25°C                     | 1                | 60          | 1        | 60               | pA    |      |      |
|                   |                                                   |                                                                                           | –40°C to 85°C            | 150              |             |          | 150              |       |      |      |
|                   |                                                   |                                                                                           | Full range               | 1000             |             |          | 1000             |       |      |      |
| V <sub>ICR</sub>  | Common-mode input voltage range                   | V <sub>IO</sub>   ≤5 mV, R <sub>S</sub> = 50 Ω                                            | 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 <sub>OH</sub>   | High-level output voltage                         | I <sub>OH</sub> = –20 μA                                                                  | 25°C                     | 4.98             |             | 4.98     |                  | V     |      |      |
|                   |                                                   | I <sub>OH</sub> = –75 μA                                                                  | 25°C                     | 4.9              | 4.94        | 4.9      | 4.94             |       |      |      |
|                   |                                                   |                                                                                           | Full range               | 4.8              |             | 4.8      |                  |       |      |      |
|                   |                                                   | I <sub>OH</sub> = –150 μA                                                                 | 25°C                     | 4.8              | 4.88        | 4.8      | 4.88             |       |      |      |
| V <sub>OL</sub>   | Low-level output voltage                          | V <sub>IC</sub> = 2.5 V, I <sub>OL</sub> = 50 μA                                          | 25°C                     | 0.01             |             | 0.01     |                  | V     |      |      |
|                   |                                                   |                                                                                           | Full range               | 0.06             |             | 0.06     |                  |       |      |      |
|                   |                                                   | V <sub>IC</sub> = 2.5 V, I <sub>OL</sub> = 500 μA                                         | 25°C                     | 0.09             | 0.15        | 0.09     | 0.15             |       |      |      |
|                   |                                                   |                                                                                           | Full range               | 0.15             |             | 0.15     |                  |       |      |      |
|                   |                                                   | V <sub>IC</sub> = 2.5 V, I <sub>OL</sub> = 1 mA                                           | 25°C                     | 0.2              | 0.3         | 0.2      | 0.3              |       |      |      |
|                   |                                                   |                                                                                           | Full range               | 0.3              |             | 0.3      |                  |       |      |      |
| A <sub>VD</sub>   | Large-signal differential voltage amplification   | V <sub>IC</sub> = 2.5 V, V <sub>O</sub> = 1 V to 4 V                                      | R <sub>L</sub> = 100 kΩ‡ | 25°C             | 100         | 350      | 100              | 350   | V/mV |      |
|                   |                                                   |                                                                                           |                          | Full range       | 10          |          | 10               |       |      |      |
|                   |                                                   |                                                                                           | R <sub>L</sub> = 1 MΩ‡   | 25°C             | 1700        |          | 1700             |       |      |      |
| r <sub>i(d)</sub> | Differential input resistance                     |                                                                                           | 25°C                     | 10 <sup>12</sup> |             |          | 10 <sup>12</sup> | Ω     |      |      |
| r <sub>i(c)</sub> | Common-mode input resistance                      |                                                                                           | 25°C                     | 10 <sup>12</sup> |             |          | 10 <sup>12</sup> | Ω     |      |      |
| c <sub>i(c)</sub> | Common-mode input capacitance                     | f = 10 kHz, N package                                                                     | 25°C                     | 8                |             |          | 8                | pF    |      |      |
| z <sub>o</sub>    | Closed-loop output impedance                      | f = 25 kHz, A <sub>V</sub> = 10                                                           | 25°C                     | 200              |             |          | 200              | Ω     |      |      |
| CMRR              | Common-mode rejection ratio                       | V <sub>IC</sub> = 0 to 2.7 V, V <sub>O</sub> = 2.5 V, R <sub>S</sub> = 50 Ω               | 25°C                     | 70               | 83          | 70       | 83               | dB    |      |      |
|                   |                                                   |                                                                                           | Full range               | 70               |             | 70       |                  |       |      |      |

$^\dagger$  Full range is –40°C to 125°C.

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



**TLV2254I electrical characteristics at specified free-air temperature,  $V_{DD} = 5\text{ V}$  (unless otherwise noted) (continued)**

| PARAMETER                                                                  | TEST CONDITIONS                                                           | $T_A^\dagger$ | TLV2254I |     |     | TLV2254AI |     |     | UNIT          |
|----------------------------------------------------------------------------|---------------------------------------------------------------------------|---------------|----------|-----|-----|-----------|-----|-----|---------------|
|                                                                            |                                                                           |               | MIN      | TYP | MAX | MIN       | TYP | MAX |               |
| $k_{SVR}$ Supply voltage rejection ratio ( $\Delta V_{DD}/\Delta V_{IO}$ ) | $V_{DD} = 4.4\text{ V to } 8\text{ V}$ ,<br>$V_{IC} = V_{DD}/2$ , No load | 25°C          | 80       | 95  |     | 80        | 95  |     | dB            |
|                                                                            |                                                                           | Full range    | 80       |     |     | 80        |     |     |               |
| $I_{DD}$ Supply current (four amplifiers)                                  | $V_O = 2.5\text{ V}$ , No load                                            | 25°C          |          | 140 | 250 |           | 140 | 250 | $\mu\text{A}$ |
|                                                                            |                                                                           | Full range    |          |     | 300 |           |     | 300 |               |

$^\dagger$  Full range is – 40°C to 125°C.

**TLV2254I operating characteristics at specified free-air temperature,  $V_{DD} = 5\text{ V}$**

| PARAMETER          |                                             | TEST CONDITIONS                                                                                                          |                     | T <sub>A</sub> <sup>†</sup> | TLV2254I |      |     | TLV2254AI |      |     | UNIT   |
|--------------------|---------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|---------------------|-----------------------------|----------|------|-----|-----------|------|-----|--------|
|                    |                                             |                                                                                                                          |                     |                             | MIN      | TYP  | MAX | MIN       | TYP  | MAX |        |
| SR                 | Slew rate at unity gain                     | V <sub>O</sub> = 1.4 V to 2.6 V, R <sub>L</sub> = 100 kΩ <sup>‡</sup> , C <sub>L</sub> = 100 pF <sup>‡</sup>             |                     | 25°C                        | 0.07     | 0.12 |     | 0.07      | 0.12 |     | V/μs   |
|                    |                                             |                                                                                                                          |                     | Full range                  | 0.05     |      |     | 0.05      |      |     |        |
| V <sub>n</sub>     | Equivalent input noise voltage              | f = 10 Hz                                                                                                                |                     | 25°C                        | 36       |      |     | 36        |      |     | nV/√Hz |
|                    |                                             | f = 1 kHz                                                                                                                |                     | 25°C                        | 19       |      |     | 19        |      |     |        |
| V <sub>N(PP)</sub> | 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 <sub>n</sub>     | Equivalent input noise current              |                                                                                                                          |                     | 25°C                        | 0.6      |      |     | 0.6       |      |     | fA/√Hz |
| THD + N            | Total harmonic distortion plus noise        | V <sub>O</sub> = 0.5 V to 2.5 V, f = 20 kHz, R <sub>L</sub> = 50 kΩ <sup>‡</sup>                                         | A <sub>V</sub> = 1  | 25°C                        | 0.2%     |      |     | 0.2%      |      |     |        |
|                    |                                             |                                                                                                                          | A <sub>V</sub> = 10 |                             | 1%       |      |     | 1%        |      |     |        |
|                    | Gain-bandwidth product                      | f = 50 kHz, R <sub>L</sub> = 50 kΩ <sup>‡</sup> , C <sub>L</sub> = 100 pF <sup>‡</sup>                                   |                     | 25°C                        | 0.2      |      |     | 0.2       |      |     | MHz    |
| B <sub>OM</sub>    | Maximum output-swing bandwidth              | V <sub>O(PP)</sub> = 2 V, R <sub>L</sub> = 50 kΩ <sup>‡</sup> , A <sub>V</sub> = 1, C <sub>L</sub> = 100 pF <sup>‡</sup> |                     | 25°C                        | 30       |      |     | 30        |      |     | kHz    |
| φ <sub>m</sub>     | Phase margin at unity gain                  | R <sub>L</sub> = 50 kΩ <sup>‡</sup> , C <sub>L</sub> = 100 pF <sup>‡</sup>                                               |                     | 25°C                        | 63°      |      |     | 63°       |      |     |        |
|                    | Gain margin                                 |                                                                                                                          |                     | 25°C                        | 15       |      |     | 15        |      |     | dB     |

$^\dagger$  Full range is – 40°C to 125°C.

$^\ddagger$  Referenced to 2.5 V

**TLV225x, TLV225xA**  
**Advanced LinCMOS™ RAIL-TO-RAIL**  
**VERY LOW-POWER OPERATIONAL AMPLIFIERS**

SLOS185D – FEBRUARY 1997 – REVISED AUGUST 2006

**TLV2252Q, and TLV2252M electrical characteristics at specified free-air temperature,  $V_{DD} = 3\text{ V}$  (unless otherwise noted)**

| PARAMETER                                                                    | TEST CONDITIONS                                                           | $T_A^\dagger$                       | TLV2252Q,<br>TLV2252M |             |      | TLV2252AQ,<br>TLV2252AM |             |      | UNIT                         |
|------------------------------------------------------------------------------|---------------------------------------------------------------------------|-------------------------------------|-----------------------|-------------|------|-------------------------|-------------|------|------------------------------|
|                                                                              |                                                                           |                                     | MIN                   | TYP         | MAX  | MIN                     | TYP         | MAX  |                              |
| $V_{IO}$ Input offset voltage                                                | $V_{DD} \pm \pm 1.5\text{ V}, V_{IC} = 0, V_O = 0, R_S = 50\ \Omega$      | 25°C                                |                       | 200         | 1500 |                         | 200         | 850  | $\mu\text{V}$                |
|                                                                              |                                                                           | Full range                          |                       |             | 1750 |                         |             | 1000 |                              |
| $\alpha_{VIO}$ Temperature coefficient of input offset voltage               |                                                                           | 25°C to 85°C                        |                       | 0.5         |      |                         | 0.5         |      | $\mu\text{V}/^\circ\text{C}$ |
| Input offset voltage long-term drift (see Note 4)                            |                                                                           | 25°C                                |                       | 0.003       |      |                         | 0.003       |      | $\mu\text{V}/\text{mo}$      |
| $I_{IO}$ Input offset current                                                |                                                                           | 25°C                                |                       | 0.5         | 60   |                         | 0.5         | 60   | $\text{pA}$                  |
|                                                                              |                                                                           | 125°C                               |                       |             | 1000 |                         |             | 1000 |                              |
| $I_{IB}$ Input bias current                                                  |                                                                           | 25°C                                |                       | 1           | 60   |                         | 1           | 60   | $\text{pA}$                  |
|                                                                              |                                                                           | 125°C                               |                       |             | 1000 |                         |             | 1000 |                              |
| $V_{ICR}$ Common-mode input voltage range                                    | $R_S = 50\ \Omega,  V_{IO}  \leq 5\text{ mV}$                             | 25°C                                | 0 to 2                | -0.3 to 2.2 |      | 0 to 2                  | -0.3 to 2.2 |      | $\text{V}$                   |
|                                                                              |                                                                           | Full range                          | 0 to 1.7              |             |      | 0 to 1.7                |             |      |                              |
| $V_{OH}$ High-level output voltage                                           | $I_{OH} = -20\ \mu\text{A}$                                               | 25°C                                |                       | 2.98        |      |                         | 2.98        |      | $\text{V}$                   |
|                                                                              | $I_{OH} = -75\ \mu\text{A}$                                               | 25°C                                |                       | 2.9         |      |                         | 2.9         |      |                              |
|                                                                              |                                                                           | Full range                          |                       | 2.8         |      |                         | 2.8         |      |                              |
|                                                                              | $I_{OH} = -150\ \mu\text{A}$                                              | 25°C                                |                       | 2.8         |      |                         | 2.8         |      |                              |
| $V_{OL}$ Low-level output voltage                                            | $V_{IC} = 1.5\text{ V}, I_{OL} = 50\ \mu\text{A}$                         | 25°C                                |                       | 10          |      |                         | 10          |      | $\text{mV}$                  |
|                                                                              | $V_{IC} = 1.5\text{ V}, I_{OL} = 500\ \mu\text{A}$                        | 25°C                                |                       | 100         | 150  |                         | 100         | 150  |                              |
|                                                                              |                                                                           | Full range                          |                       |             | 165  |                         |             | 165  |                              |
|                                                                              | $V_{IC} = 1.5\text{ V}, I_{OL} = 1\text{ mA}$                             | 25°C                                |                       | 200         | 300  |                         | 200         | 300  |                              |
|                                                                              |                                                                           | Full range                          |                       |             | 300  |                         |             | 300  |                              |
|                                                                              |                                                                           |                                     |                       |             |      |                         |             |      |                              |
| $A_{VD}$ Large-signal differential voltage amplification                     | $V_{IC} = 1.5\text{ V}, V_O = 1\text{ V to }2\text{ V}$                   | $R_L = 100\text{ k}\Omega^\ddagger$ | 25°C                  | 100         | 250  |                         | 100         | 250  | $\text{V/mV}$                |
|                                                                              |                                                                           |                                     | Full range            | 10          |      |                         | 10          |      |                              |
|                                                                              |                                                                           | $R_L = 1\text{ M}\Omega^\ddagger$   | 25°C                  |             | 800  |                         |             | 800  |                              |
| $r_{i(d)}$ Differential input resistance                                     |                                                                           | 25°C                                |                       | $10^{12}$   |      |                         | $10^{12}$   |      | $\Omega$                     |
| $r_{i(c)}$ Common-mode input resistance                                      |                                                                           | 25°C                                |                       | $10^{12}$   |      |                         | $10^{12}$   |      | $\Omega$                     |
| $C_{i(c)}$ Common-mode input capacitance                                     | $f = 10\text{ kHz}, \text{ P package}$                                    | 25°C                                |                       | 8           |      |                         | 8           |      | $\text{pF}$                  |
| $z_o$ Closed-loop output impedance                                           | $f = 25\text{ kHz}, A_V = 10$                                             | 25°C                                |                       | 220         |      |                         | 220         |      | $\Omega$                     |
| $\text{CMRR}$ Common-mode rejection ratio                                    | $V_{IC} = 0\text{ to }1.7\text{ V}, V_O = 1.5\text{ V}, R_S = 50\ \Omega$ | 25°C                                |                       | 65          | 75   |                         | 65          | 77   | $\text{dB}$                  |
|                                                                              |                                                                           | Full range                          |                       | 60          |      |                         | 60          |      |                              |
| $k_{SVR}$ Supply voltage rejection ratio ( $\Delta V_{DD} / \Delta V_{IO}$ ) | $V_{DD} = 2.7\text{ V to }8\text{ V}, V_{IC} = V_{DD}/2, \text{ No load}$ | 25°C                                |                       | 80          | 95   |                         | 80          | 100  | $\text{dB}$                  |
|                                                                              |                                                                           | Full range                          |                       | 80          |      |                         | 80          |      |                              |
| $I_{DD}$ Supply current                                                      | $V_O = 1.5\text{ V}, \text{ No load}$                                     | 25°C                                |                       | 68          | 125  |                         | 68          | 125  | $\mu\text{A}$                |
|                                                                              |                                                                           | Full range                          |                       |             | 150  |                         |             | 150  |                              |

$^\dagger$  Full range is  $-40^\circ\text{C}$  to  $125^\circ\text{C}$  for Q level part,  $-55^\circ\text{C}$  to  $125^\circ\text{C}$  for M level part.

$^\ddagger$  Referenced to 1.5 V

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



**TLV2252Q, and TLV2252M operating characteristics at specified free-air temperature,  $V_{DD} = 3\text{ V}$**

| PARAMETER                                               | TEST CONDITIONS                                                                                                         | $T_A^\dagger$ | TLV2252Q,<br>TLV2252M |       |     | TLV2252AQ,<br>TLV2252AM |       |     | UNIT                   |
|---------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------|---------------|-----------------------|-------|-----|-------------------------|-------|-----|------------------------|
|                                                         |                                                                                                                         |               | MIN                   | TYP   | MAX | MIN                     | TYP   | MAX |                        |
| SR      Slew rate at unity gain                         | $V_O = 0.8\text{ V to }1.4\text{ V}, \quad R_L = 100\text{ k}\Omega^\ddagger,$<br>$C_L = 100\text{ pF}^\ddagger$        | 25°C          | 0.07                  | 0.1   |     | 0.07                    | 0.1   |     | V/ $\mu\text{s}$       |
|                                                         |                                                                                                                         | Full range    | 0.05                  |       |     | 0.05                    |       |     |                        |
| $V_n$ Equivalent input noise voltage                    | $f = 10\text{ Hz}$                                                                                                      | 25°C          |                       | 35    |     |                         | 35    |     | nV/ $\sqrt{\text{Hz}}$ |
|                                                         | $f = 1\text{ kHz}$                                                                                                      | 25°C          |                       | 19    |     |                         | 19    |     |                        |
| $V_{N(PP)}$ Peak-to-peak equivalent input noise voltage | $f = 0.1\text{ Hz to }1\text{ Hz}$                                                                                      | 25°C          |                       | 0.6   |     |                         | 0.6   |     | $\mu\text{V}$          |
|                                                         | $f = 0.1\text{ Hz to }10\text{ Hz}$                                                                                     | 25°C          |                       | 1.1   |     |                         | 1.1   |     |                        |
| $I_n$ Equivalent input noise current                    |                                                                                                                         | 25°C          |                       | 0.6   |     |                         | 0.6   |     | fA/ $\sqrt{\text{Hz}}$ |
|                                                         | Gain-bandwidth product<br>$f = 1\text{ kHz}, \quad R_L = 50\text{ k}\Omega^\ddagger,$<br>$C_L = 100\text{ pF}^\ddagger$ | 25°C          |                       | 0.187 |     |                         | 0.187 |     | MHz                    |
| $B_{OM}$ Maximum output-swing bandwidth                 | $V_{O(PP)} = 1\text{ V}, \quad A_V = 1,$<br>$R_L = 50\text{ k}\Omega^\ddagger, \quad C_L = 100\text{ pF}^\ddagger$      | 25°C          |                       | 60    |     |                         | 60    |     | kHz                    |
| $\phi_m$ Phase margin at unity gain                     | $R_L = 50\text{ k}\Omega^\ddagger, \quad C_L = 100\text{ pF}^\ddagger$                                                  | 25°C          |                       | 63°   |     |                         | 63°   |     |                        |
|                                                         | Gain margin                                                                                                             | 25°C          |                       | 15    |     |                         | 15    |     | dB                     |

$^\dagger$  Full range is  $-40^\circ\text{C}$  to  $125^\circ\text{C}$  for Q level part,  $-55^\circ\text{C}$  to  $125^\circ\text{C}$  for M level part.

$^\ddagger$  Referenced to 1.5 V

# TLV225x, TLV225xA

## Advanced LinCMOS™ RAIL-TO-RAIL

### VERY LOW-POWER OPERATIONAL AMPLIFIERS

SLOS185D – FEBRUARY 1997 – REVISED AUGUST 2006

TLV2252Q, and TLV2252M electrical characteristics at specified free-air temperature,  $V_{DD} = 5\text{ V}$  (unless otherwise noted)

| PARAMETER                                                                  | TEST CONDITIONS                                                           | $T_A^\dagger$                       | TLV2252Q,<br>TLV2252M |             |     | TLV2252AQ,<br>TLV2252AM |             |     | UNIT                         |
|----------------------------------------------------------------------------|---------------------------------------------------------------------------|-------------------------------------|-----------------------|-------------|-----|-------------------------|-------------|-----|------------------------------|
|                                                                            |                                                                           |                                     | MIN                   | TYP         | MAX | MIN                     | TYP         | MAX |                              |
| $V_{IO}$ Input offset voltage                                              | $V_{DD} \pm \pm 2.5\text{ V}, V_{IC} = 0, V_O = 0, R_S = 50\ \Omega$      | 25°C                                | 200                   | 1500        |     | 200                     | 850         |     | $\mu\text{V}$                |
|                                                                            |                                                                           | Full range                          |                       | 1750        |     | 1000                    |             |     |                              |
| $\alpha_{VIO}$ Temperature coefficient of input offset voltage             |                                                                           | 25°C to 85°C                        | 0.5                   |             |     | 0.5                     |             |     | $\mu\text{V}/^\circ\text{C}$ |
| Input offset voltage long-term drift (see Note 4)                          |                                                                           | 25°C                                | 0.003                 |             |     | 0.003                   |             |     | $\mu\text{V}/\text{mo}$      |
| $I_{IO}$ Input offset current                                              |                                                                           | 25°C                                | 0.5                   | 60          |     | 0.5                     | 60          |     | pA                           |
|                                                                            |                                                                           | 125°C                               |                       | 1000        |     | 1000                    |             |     |                              |
| $I_{IB}$ Input bias current                                                |                                                                           | 25°C                                | 1                     | 60          |     | 1                       | 60          |     | pA                           |
|                                                                            |                                                                           | 125°C                               |                       | 1000        |     | 1000                    |             |     |                              |
| $V_{ICR}$ Common-mode input voltage range                                  | $ V_{IO}  \leq 5\text{ mV}, R_S = 50\ \Omega$                             | 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                                         | $I_{OH} = -20\ \mu\text{A}$                                               | 25°C                                | 4.98                  |             |     | 4.98                    |             |     | V                            |
|                                                                            | $I_{OH} = -75\ \mu\text{A}$                                               | 25°C                                | 4.9                   | 4.94        |     | 4.9                     | 4.94        |     |                              |
|                                                                            | Full range                                                                |                                     | 4.8                   |             |     | 4.8                     |             |     |                              |
|                                                                            | $I_{OH} = -150\ \mu\text{A}$                                              | 25°C                                | 4.8                   | 4.88        |     | 4.8                     | 4.88        |     |                              |
| $V_{OL}$ Low-level output voltage                                          | $V_{IC} = 2.5\text{ V}, I_{OL} = 50\ \mu\text{A}$                         | 25°C                                | 0.01                  |             |     | 0.01                    |             |     | V                            |
|                                                                            | $V_{IC} = 2.5\text{ V}, I_{OL} = 500\ \mu\text{A}$                        | 25°C                                | 0.09                  | 0.15        |     | 0.09                    | 0.15        |     |                              |
|                                                                            | Full range                                                                |                                     |                       | 0.15        |     |                         | 0.15        |     |                              |
|                                                                            | $V_{IC} = 2.5\text{ V}, I_{OL} = 1\text{ mA}$                             | 25°C                                | 0.2                   | 0.3         |     | 0.2                     | 0.3         |     |                              |
|                                                                            | Full range                                                                |                                     |                       | 0.3         |     |                         | 0.3         |     |                              |
| $A_{VD}$ Large-signal differential voltage amplification                   | $V_{IC} = 2.5\text{ V}, V_O = 1\text{ V to }4\text{ V}$                   | $R_L = 100\text{ k}\Omega^\ddagger$ | 25°C                  | 100         | 350 | 100                     | 350         |     | V/mV                         |
|                                                                            |                                                                           | Full range                          | 10                    |             |     | 10                      |             |     |                              |
|                                                                            |                                                                           | $R_L = 1\text{ M}\Omega^\ddagger$   | 25°C                  | 1700        |     | 1700                    |             |     |                              |
| $r_{i(d)}$ Differential input resistance                                   |                                                                           | 25°C                                | $10^{12}$             |             |     | $10^{12}$               |             |     | $\Omega$                     |
| $r_{i(c)}$ Common-mode input resistance                                    |                                                                           | 25°C                                | $10^{12}$             |             |     | $10^{12}$               |             |     | $\Omega$                     |
| $c_{i(c)}$ Common-mode input capacitance                                   | $f = 10\text{ kHz}, \text{ P package}$                                    | 25°C                                | 8                     |             |     | 8                       |             |     | pF                           |
| $z_o$ Closed-loop output impedance                                         | $f = 25\text{ kHz}, A_V = 10$                                             | 25°C                                | 200                   |             |     | 200                     |             |     | $\Omega$                     |
| $\text{CMRR}$ Common-mode rejection ratio                                  | $V_{IC} = 0\text{ to }2.7\text{ V}, V_O = 2.5\text{ V}, R_S = 50\ \Omega$ | 25°C                                | 70                    | 83          |     | 70                      | 83          |     | dB                           |
|                                                                            |                                                                           | Full range                          | 70                    |             |     | 70                      |             |     |                              |
| $k_{SVR}$ Supply voltage rejection ratio ( $\Delta V_{DD}/\Delta V_{IO}$ ) | $V_{DD} = 4.4\text{ V to }8\text{ V}, V_{IC} = V_{DD}/2, \text{ No load}$ | 25°C                                | 80                    | 95          |     | 80                      | 95          |     | dB                           |
|                                                                            |                                                                           | Full range                          | 80                    |             |     | 80                      |             |     |                              |

$^\dagger$  Full range is -40°C to 125°C for Q level part, -55°C to 125°C for M level part.

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





**TLV2252Q, and TLV2252M electrical characteristics at specified free-air temperature,  $V_{DD} = 5\text{ V}$  (unless otherwise noted) (continued)**

| PARAMETER               | TEST CONDITIONS                | $T_A^\dagger$ | TLV2252Q,<br>TLV2252M |     |     | TLV2252AQ,<br>TLV2252AM |     |     | UNIT          |
|-------------------------|--------------------------------|---------------|-----------------------|-----|-----|-------------------------|-----|-----|---------------|
|                         |                                |               | MIN                   | TYP | MAX | MIN                     | TYP | MAX |               |
| $I_{DD}$ Supply current | $V_O = 2.5\text{ V}$ , No load | 25°C          |                       | 70  | 125 |                         | 70  | 125 | $\mu\text{A}$ |
|                         |                                | Full range    |                       |     | 150 |                         |     | 150 |               |

$^\dagger$  Full range is  $-40^\circ\text{C}$  to  $125^\circ\text{C}$  for Q level part,  $-55^\circ\text{C}$  to  $125^\circ\text{C}$  for M level part.

**TLV2252Q, and TLV2252M operating characteristics at specified free-air temperature,  $V_{DD} = 5\text{ V}$**

| PARAMETER                                               | TEST CONDITIONS                                                                                                       | $T_A^\dagger$                                           | TLV2252Q,<br>TLV2252M |      |     | TLV2252AQ,<br>TLV2252AM |      |     | UNIT                         |
|---------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------|-----------------------|------|-----|-------------------------|------|-----|------------------------------|
|                                                         |                                                                                                                       |                                                         | MIN                   | TYP  | MAX | MIN                     | TYP  | MAX |                              |
| SR Slew rate at unity gain                              | $V_O = 1.25\text{ V}$ to $2.75\text{ V}$ ,<br>$R_L = 100\text{ k}\Omega^\ddagger$ ,<br>$C_L = 100\text{ pF}^\ddagger$ | 25°C                                                    | 0.07                  | 0.12 |     | 0.07                    | 0.12 |     | $\text{V}/\mu\text{s}$       |
|                                                         |                                                                                                                       | Full range                                              | 0.05                  |      |     | 0.05                    |      |     |                              |
| $V_n$ Equivalent input noise voltage                    | $f = 10\text{ Hz}$                                                                                                    | 25°C                                                    |                       | 36   |     |                         | 36   |     | $\text{nV}/\sqrt{\text{Hz}}$ |
|                                                         | $f = 1\text{ kHz}$                                                                                                    | 25°C                                                    |                       | 19   |     |                         | 19   |     |                              |
| $V_{N(PP)}$ Peak-to-peak equivalent input noise voltage | $f = 0.1\text{ Hz}$ to $1\text{ Hz}$                                                                                  | 25°C                                                    |                       | 0.7  |     |                         | 0.7  |     | $\mu\text{V}$                |
|                                                         | $f = 0.1\text{ Hz}$ to $10\text{ Hz}$                                                                                 | 25°C                                                    |                       | 1.1  |     |                         | 1.1  |     |                              |
| $I_n$ Equivalent input noise current                    |                                                                                                                       | 25°C                                                    |                       | 0.6  |     |                         | 0.6  |     | $\text{fA}/\sqrt{\text{Hz}}$ |
| THD + N Total harmonic distortion plus noise            | $V_O = 0.5\text{ V}$ to $2.5\text{ V}$ ,<br>$f = 20\text{ kHz}$ ,<br>$R_L = 50\text{ k}\Omega^\ddagger$               | $A_V = 1$                                               |                       | 0.2% |     |                         | 0.2% |     |                              |
|                                                         |                                                                                                                       | $A_V = 10$                                              |                       | 1%   |     |                         | 1%   |     |                              |
| Gain-bandwidth product                                  | $f = 50\text{ kHz}$ ,<br>$C_L = 100\text{ pF}^\ddagger$                                                               | $R_L = 50\text{ k}\Omega^\ddagger$ ,<br>25°C            |                       | 0.2  |     |                         | 0.2  |     | MHz                          |
| $B_{OM}$ Maximum output-swing bandwidth                 | $V_{O(PP)} = 2\text{ V}$ ,<br>$R_L = 50\text{ k}\Omega^\ddagger$                                                      | $A_V = 1$ ,<br>$C_L = 100\text{ pF}^\ddagger$ ,<br>25°C |                       | 30   |     |                         | 30   |     | kHz                          |
| $\phi_m$ Phase margin at unity gain                     | $R_L = 50\text{ k}\Omega^\ddagger$ ,<br>$C_L = 100\text{ pF}^\ddagger$                                                | 25°C                                                    |                       | 63°  |     |                         | 63°  |     |                              |
| Gain margin                                             |                                                                                                                       | 25°C                                                    |                       | 15   |     |                         | 15   |     | dB                           |

$^\dagger$  Full range is  $-40^\circ\text{C}$  to  $125^\circ\text{C}$  for Q level part,  $-55^\circ\text{C}$  to  $125^\circ\text{C}$  for M level part.

$^\ddagger$  Referenced to  $2.5\text{ V}$

# TLV225x, TLV225xA

## Advanced LinCMOS™ RAIL-TO-RAIL

### VERY LOW-POWER OPERATIONAL AMPLIFIERS

SLOS185D – FEBRUARY 1997 – REVISED AUGUST 2006

TLV2254Q, and TLV2254M electrical characteristics at specified free-air temperature,  $V_{DD} = 3\text{ V}$  (unless otherwise noted)

| PARAMETER                                                                  | TEST CONDITIONS                                                                     | $T_A^\dagger$                       | TLV2254Q,<br>TLV2254M |             |     | TLV2254AQ,<br>TLV2254AM |             |     | UNIT                         |
|----------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------|-----------------------|-------------|-----|-------------------------|-------------|-----|------------------------------|
|                                                                            |                                                                                     |                                     | MIN                   | TYP         | MAX | MIN                     | TYP         | MAX |                              |
| $V_{IO}$ Input offset voltage                                              | $V_{DD\pm} = \pm 1.5\text{ V}$ , $V_{IC} = 0$ ,<br>$V_O = 0$ , $R_S = 50\ \Omega$   | 25°C                                | 200                   | 1500        |     | 200                     | 850         |     | $\mu\text{V}$                |
|                                                                            |                                                                                     | Full range                          |                       | 1750        |     |                         | 1000        |     |                              |
| $\alpha_{VIO}$ Temperature coefficient of input offset voltage             |                                                                                     | 25°C to 125°C                       | 0.5                   |             |     | 0.5                     |             |     | $\mu\text{V}/^\circ\text{C}$ |
| Input offset voltage long-term drift (see Note 4)                          |                                                                                     | 25°C                                | 0.003                 |             |     | 0.003                   |             |     | $\mu\text{V}/\text{mo}$      |
| $I_{IO}$ Input offset current                                              |                                                                                     | 25°C                                | 0.5                   | 60          |     | 0.5                     | 60          |     | pA                           |
|                                                                            |                                                                                     | 125°C                               |                       | 1000        |     |                         | 1000        |     |                              |
| $I_{IB}$ Input bias current                                                |                                                                                     | 25°C                                | 1                     | 60          |     | 1                       | 60          |     | pA                           |
|                                                                            |                                                                                     | 125°C                               |                       | 1000        |     |                         | 1000        |     |                              |
| $V_{ICR}$ Common-mode input voltage range                                  | $R_S = 50\ \Omega$ , $ V_{IO}  \leq 5\text{ mV}$                                    | 25°C                                | 0 to 2                | -0.3 to 2.2 |     | 0 to 2                  | -0.3 to 2.2 |     | V                            |
|                                                                            |                                                                                     | Full range                          | 0 to 1.7              |             |     | 0 to 1.7                |             |     |                              |
| $V_{OH}$ High-level output voltage                                         | $I_{OH} = -20\ \mu\text{A}$                                                         | 25°C                                |                       | 2.98        |     |                         | 2.98        |     | V                            |
|                                                                            | $I_{OH} = -75\ \mu\text{A}$                                                         | 25°C                                |                       | 2.9         |     |                         | 2.9         |     |                              |
|                                                                            |                                                                                     | Full range                          |                       | 2.8         |     |                         | 2.8         |     |                              |
|                                                                            | $I_{OH} = -150\ \mu\text{A}$                                                        | 25°C                                |                       | 2.8         |     |                         | 2.8         |     |                              |
| $V_{OL}$ Low-level output voltage                                          | $V_{IC} = 1.5\text{ V}$ , $I_{OL} = 50\ \mu\text{A}$                                | 25°C                                |                       | 10          |     |                         | 10          |     | mV                           |
|                                                                            | $V_{IC} = 1.5\text{ V}$ , $I_{OL} = 500\ \mu\text{A}$                               | 25°C                                |                       | 100         | 150 |                         | 100         | 150 |                              |
|                                                                            |                                                                                     | Full range                          |                       |             | 165 |                         |             | 165 |                              |
|                                                                            | $V_{IC} = 1.5\text{ V}$ , $I_{OL} = 1\text{ mA}$                                    | 25°C                                |                       | 200         | 300 |                         | 200         | 300 |                              |
|                                                                            |                                                                                     | Full range                          |                       |             | 300 |                         |             | 300 |                              |
|                                                                            |                                                                                     |                                     |                       | 300         |     |                         |             | 300 |                              |
| $A_{VD}$ Large-signal differential voltage amplification                   | $V_{IC} = 1.5\text{ V}$ , $V_O = 1\text{ V to } 2\text{ V}$                         | $R_L = 100\text{ k}\Omega^\ddagger$ | 25°C                  | 100         | 225 |                         | 100         | 225 | V/mV                         |
|                                                                            |                                                                                     |                                     | Full range            | 10          |     |                         | 10          |     |                              |
|                                                                            |                                                                                     | $R_L = 1\text{ M}\Omega^\ddagger$   | 25°C                  |             | 800 |                         |             | 800 |                              |
| $r_{i(d)}$ Differential input resistance                                   |                                                                                     | 25°C                                |                       | $10^{12}$   |     |                         | $10^{12}$   |     | $\Omega$                     |
| $r_{i(c)}$ Common-mode input resistance                                    |                                                                                     | 25°C                                |                       | $10^{12}$   |     |                         | $10^{12}$   |     | $\Omega$                     |
| $C_{i(c)}$ Common-mode input capacitance                                   | $f = 10\text{ kHz}$ , N package                                                     | 25°C                                |                       | 8           |     |                         | 8           |     | pF                           |
| $z_o$ Closed-loop output impedance                                         | $f = 25\text{ kHz}$ , $A_V = 10$                                                    | 25°C                                |                       | 220         |     |                         | 220         |     | $\Omega$                     |
| CMRR Common-mode rejection ratio                                           | $V_{IC} = 0\text{ to } 1.7\text{ V}$ , $V_O = 1.5\text{ V}$ ,<br>$R_S = 50\ \Omega$ | 25°C                                | 65                    | 75          |     | 65                      | 77          |     | dB                           |
|                                                                            |                                                                                     | Full range                          |                       | 60          |     |                         | 60          |     |                              |
| $k_{SVR}$ Supply voltage rejection ratio ( $\Delta V_{DD}/\Delta V_{IO}$ ) | $V_{DD} = 2.7\text{ V to } 8\text{ V}$ ,<br>$V_{IC} = V_{DD}/2$ , No load           | 25°C                                | 80                    | 95          |     | 80                      | 100         |     | dB                           |
|                                                                            |                                                                                     | Full range                          |                       | 80          |     |                         | 80          |     |                              |

$^\dagger$  Full range is -40°C to 125°C for Q level part, -55°C to 125°C for M level part.

$^\ddagger$  Referenced to 1.5 V

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



**TLV2254Q, and TLV2254M electrical characteristics at specified free-air temperature,  $V_{DD} = 3\text{ V}$  (unless otherwise noted) (continued)**

| PARAMETER                                    | TEST CONDITIONS                | $T_A^\dagger$ | TLV2254Q,<br>TLV2254M |     |     | TLV2254AQ,<br>TLV2254AM |     |     | UNIT          |
|----------------------------------------------|--------------------------------|---------------|-----------------------|-----|-----|-------------------------|-----|-----|---------------|
|                                              |                                |               | MIN                   | TYP | MAX | MIN                     | TYP | MAX |               |
| $I_{DD}$ Supply current<br>(four amplifiers) | $V_O = 1.5\text{ V}$ , No load | 25°C          |                       | 135 | 250 |                         | 135 | 250 | $\mu\text{A}$ |
|                                              |                                | Full range    |                       |     | 300 |                         |     | 300 |               |

$^\dagger$  Full range is  $-40^\circ\text{C}$  to  $125^\circ\text{C}$  for Q level part,  $-55^\circ\text{C}$  to  $125^\circ\text{C}$  for M level part.

**TLV2254Q, and TLV2254M operating characteristics at specified free-air temperature,  $V_{DD} = 3\text{ V}$**

| PARAMETER                                               | TEST CONDITIONS                                                                                                     | $T_A^\dagger$ | TLV2254Q,<br>TLV2254M |       |     | TLV2254AQ,<br>TLV2254AM |       |     | UNIT                         |
|---------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|---------------|-----------------------|-------|-----|-------------------------|-------|-----|------------------------------|
|                                                         |                                                                                                                     |               | MIN                   | TYP   | MAX | MIN                     | TYP   | MAX |                              |
| SR Slew rate at unity gain                              | $V_O = 0.5\text{ V}$ to $1.7\text{ V}$ ,<br>$R_L = 100\text{ k}\Omega^\ddagger$ ,<br>$C_L = 100\text{ pF}^\ddagger$ | 25°C          | 0.07                  | 0.1   |     | 0.07                    | 0.1   |     | $\text{V}/\mu\text{s}$       |
|                                                         |                                                                                                                     | Full range    | 0.05                  |       |     | 0.05                    |       |     |                              |
| $V_n$ Equivalent input noise voltage                    | $f = 10\text{ Hz}$                                                                                                  | 25°C          |                       | 35    |     |                         | 35    |     | $\text{nV}/\sqrt{\text{Hz}}$ |
|                                                         | $f = 1\text{ kHz}$                                                                                                  | 25°C          |                       | 19    |     |                         | 19    |     |                              |
| $V_{N(PP)}$ Peak-to-peak equivalent input noise voltage | $f = 0.1\text{ Hz}$ to $1\text{ Hz}$                                                                                | 25°C          |                       | 0.6   |     |                         | 0.6   |     | $\mu\text{V}$                |
|                                                         | $f = 0.1\text{ Hz}$ to $10\text{ Hz}$                                                                               | 25°C          |                       | 1.1   |     |                         | 1.1   |     |                              |
| $I_n$ Equivalent input noise current                    |                                                                                                                     | 25°C          |                       | 0.6   |     |                         | 0.6   |     | $\text{fA}/\sqrt{\text{Hz}}$ |
| Gain-bandwidth product                                  | $f = 1\text{ kHz}$ ,<br>$R_L = 50\text{ k}\Omega^\ddagger$ ,<br>$C_L = 100\text{ pF}^\ddagger$                      | 25°C          |                       | 0.187 |     |                         | 0.187 |     | MHz                          |
| $B_{OM}$ Maximum output-swing bandwidth                 | $V_{O(PP)} = 1\text{ V}$ ,<br>$A_V = 1$ ,<br>$R_L = 50\text{ k}\Omega^\ddagger$ ,<br>$C_L = 100\text{ pF}^\ddagger$ | 25°C          |                       | 60    |     |                         | 60    |     | kHz                          |
| $\phi_m$ Phase margin at unity gain<br>Gain margin      | $R_L = 50\text{ k}\Omega^\ddagger$                                                                                  | 25°C          |                       | 63°   |     |                         | 63°   |     | dB                           |
|                                                         | $C_L = 100\text{ pF}^\ddagger$                                                                                      | 25°C          |                       | 15    |     |                         | 15    |     |                              |

$^\dagger$  Full range is  $-40^\circ\text{C}$  to  $125^\circ\text{C}$  for Q level part,  $-55^\circ\text{C}$  to  $125^\circ\text{C}$  for M level part.

$^\ddagger$  Referenced to  $1.5\text{ V}$

# TLV225x, TLV225xA

## Advanced LinCMOS™ RAIL-TO-RAIL

### VERY LOW-POWER OPERATIONAL AMPLIFIERS

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TLV2254Q, and TLV2254M electrical characteristics at specified free-air temperature,  $V_{DD} = 5\text{ V}$  (unless otherwise noted)

| PARAMETER                                                                  | TEST CONDITIONS                                                                    | $T_A^\dagger$ | TLV2254Q,<br>TLV2254M |             |      | TLV2254AQ,<br>TLV2254AM |             |      | UNIT                         |
|----------------------------------------------------------------------------|------------------------------------------------------------------------------------|---------------|-----------------------|-------------|------|-------------------------|-------------|------|------------------------------|
|                                                                            |                                                                                    |               | MIN                   | TYP         | MAX  | MIN                     | TYP         | MAX  |                              |
| $V_{IO}$ Input offset voltage                                              | $V_{DD} \pm \pm 2.5\text{ V}$ , $V_{IC} = 0$ ,<br>$V_O = 0$ , $R_S = 50\ \Omega$   | 25°C          | 200                   | 1500        |      | 200                     | 850         |      | $\mu\text{V}$                |
|                                                                            |                                                                                    | Full range    |                       | 1750        |      |                         | 1000        |      |                              |
| $\alpha_{VIO}$ Temperature coefficient of input offset voltage             |                                                                                    | 25°C to 125°C | 0.5                   |             |      | 0.5                     |             |      | $\mu\text{V}/^\circ\text{C}$ |
| Input offset voltage long-term drift (see Note 4)                          |                                                                                    | 25°C          | 0.003                 |             |      | 0.003                   |             |      | $\mu\text{V}/\text{mo}$      |
| $I_{IO}$ Input offset current                                              |                                                                                    | 25°C          | 0.5                   | 60          |      | 0.5                     | 60          |      | $\text{pA}$                  |
|                                                                            |                                                                                    | 125°C         |                       | 1000        |      |                         | 1000        |      |                              |
| $I_{IB}$ Input bias current                                                |                                                                                    | 25°C          | 1                     | 60          |      | 1                       | 60          |      | $\text{pA}$                  |
|                                                                            |                                                                                    | 125°C         |                       | 1000        |      |                         | 1000        |      |                              |
| $V_{ICR}$ Common-mode input voltage range                                  | $ V_{IO}  \leq 5\text{ mV}$ , $R_S = 50\ \Omega$                                   | 25°C          | 0 to 4                | -0.3 to 4.2 |      | 0 to 4                  | -0.3 to 4.2 |      | $\text{V}$                   |
|                                                                            |                                                                                    | Full range    | 0 to 3.5              |             |      | 0 to 3.5                |             |      |                              |
| $V_{OH}$ High-level output voltage                                         | $I_{OH} = -20\ \mu\text{A}$                                                        | 25°C          |                       | 4.98        |      |                         | 4.98        |      | $\text{V}$                   |
|                                                                            | $I_{OH} = -75\ \mu\text{A}$                                                        | 25°C          | 4.9                   | 4.94        |      | 4.9                     | 4.94        |      |                              |
|                                                                            |                                                                                    | Full range    | 4.8                   |             |      | 4.8                     |             |      |                              |
|                                                                            | $I_{OH} = -150\ \mu\text{A}$                                                       | 25°C          | 4.8                   | 4.88        |      | 4.8                     | 4.88        |      |                              |
| $V_{OL}$ Low-level output voltage                                          | $V_{IC} = 2.5\text{ V}$ , $I_{OL} = 50\ \mu\text{A}$                               | 25°C          |                       | 0.01        |      |                         | 0.01        |      | $\text{V}$                   |
|                                                                            | $V_{IC} = 2.5\text{ V}$ , $I_{OL} = 500\ \mu\text{A}$                              | 25°C          |                       | 0.09        | 0.15 |                         | 0.09        | 0.15 |                              |
|                                                                            |                                                                                    | Full range    |                       |             | 0.15 |                         |             | 0.15 |                              |
|                                                                            | $V_{IC} = 2.5\text{ V}$ , $I_{OL} = 1\text{ mA}$                                   | 25°C          |                       | 0.2         | 0.3  |                         | 0.2         | 0.3  |                              |
|                                                                            |                                                                                    | Full range    |                       |             | 0.3  |                         |             | 0.3  |                              |
| $A_{VD}$ Large-signal differential voltage amplification                   | $V_{IC} = 2.5\text{ V}$ , $V_O = 1\text{ V to }4\text{ V}$                         | 25°C          | 100                   | 350         |      | 100                     | 350         |      | $\text{V/mV}$                |
|                                                                            |                                                                                    | Full range    | 10                    |             |      | 10                      |             |      |                              |
|                                                                            |                                                                                    | 25°C          |                       | 1700        |      |                         | 1700        |      |                              |
| $r_{i(d)}$ Differential input resistance                                   |                                                                                    | 25°C          |                       | $10^{12}$   |      |                         | $10^{12}$   |      | $\Omega$                     |
| $r_{i(c)}$ Common-mode input resistance                                    |                                                                                    | 25°C          |                       | $10^{12}$   |      |                         | $10^{12}$   |      | $\Omega$                     |
| $c_{i(c)}$ Common-mode input capacitance                                   | $f = 10\text{ kHz}$ , N package                                                    | 25°C          |                       | 8           |      |                         | 8           |      | $\text{pF}$                  |
| $z_o$ Closed-loop output impedance                                         | $f = 25\text{ kHz}$ , $A_V = 10$                                                   | 25°C          |                       | 200         |      |                         | 200         |      | $\Omega$                     |
| CMRR Common-mode rejection ratio                                           | $V_{IC} = 0\text{ to }2.7\text{ V}$ , $V_O = 2.5\text{ V}$ ,<br>$R_S = 50\ \Omega$ | 25°C          | 70                    | 83          |      | 70                      | 83          |      | $\text{dB}$                  |
|                                                                            |                                                                                    | Full range    | 70                    |             |      | 70                      |             |      |                              |
| $k_{SVR}$ Supply voltage rejection ratio ( $\Delta V_{DD}/\Delta V_{IO}$ ) | $V_{DD} = 4.4\text{ V to }8\text{ V}$ ,<br>$V_{IC} = V_{DD}/2$ , No load           | 25°C          | 80                    | 95          |      | 80                      | 95          |      | $\text{dB}$                  |
|                                                                            |                                                                                    | Full range    | 80                    |             |      | 80                      |             |      |                              |

$^\dagger$  Full range is  $-40^\circ\text{C}$  to  $125^\circ\text{C}$  for Q level part,  $-55^\circ\text{C}$  to  $125^\circ\text{C}$  for M level part.

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



**TLV2254Q, and TLV2254M electrical characteristics at specified free-air temperature,  $V_{DD} = 5\text{ V}$  (unless otherwise noted) (continued)**

| PARAMETER                                    | TEST CONDITIONS                | $T_A^\dagger$ | TLV2254Q,<br>TLV2254M |     |     | TLV2254AQ,<br>TLV2254AM |     |     | UNIT          |
|----------------------------------------------|--------------------------------|---------------|-----------------------|-----|-----|-------------------------|-----|-----|---------------|
|                                              |                                |               | MIN                   | TYP | MAX | MIN                     | TYP | MAX |               |
| $I_{DD}$ Supply current<br>(four amplifiers) | $V_O = 2.5\text{ V}$ , No load | 25°C          |                       | 140 | 250 |                         | 140 | 250 | $\mu\text{A}$ |
|                                              |                                | Full range    |                       |     | 300 |                         |     | 300 |               |

$^\dagger$  Full range is  $-40^\circ\text{C}$  to  $125^\circ\text{C}$  for Q level part,  $-55^\circ\text{C}$  to  $125^\circ\text{C}$  for M level part.

**TLV2254Q, and TLV2254M operating characteristics at specified free-air temperature,  $V_{DD} = 5\text{ V}$**

| PARAMETER          |                                             | TEST CONDITIONS                                                                                              |                                                          | T <sub>A</sub> <sup>†</sup> | TLV2254Q,<br>TLV2254M |      |     | TLV2254AQ,<br>TLV2254AM |      |     | UNIT   |
|--------------------|---------------------------------------------|--------------------------------------------------------------------------------------------------------------|----------------------------------------------------------|-----------------------------|-----------------------|------|-----|-------------------------|------|-----|--------|
|                    |                                             |                                                                                                              |                                                          |                             | MIN                   | TYP  | MAX | MIN                     | TYP  | MAX |        |
| SR                 | Slew rate at unity gain                     | V <sub>O</sub> = 0.5 V to 3.5 V, R <sub>L</sub> = 100 kΩ <sup>‡</sup> , C <sub>L</sub> = 100 pF <sup>‡</sup> |                                                          | 25°C                        | 0.07                  | 0.12 |     | 0.07                    | 0.12 |     | V/μs   |
|                    |                                             |                                                                                                              |                                                          | Full range                  | 0.05                  |      |     | 0.05                    |      |     |        |
| V <sub>n</sub>     | Equivalent input noise voltage              | f = 10 Hz                                                                                                    |                                                          | 25°C                        | 36                    |      |     | 36                      |      |     | nV/√Hz |
|                    |                                             | f = 1 kHz                                                                                                    |                                                          | 25°C                        | 19                    |      |     | 19                      |      |     |        |
| V <sub>N(PP)</sub> | 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 <sub>n</sub>     | Equivalent input noise current              |                                                                                                              |                                                          | 25°C                        | 0.6                   |      |     | 0.6                     |      |     | fA/√Hz |
| THD + N            | Total harmonic distortion plus noise        | V <sub>O</sub> = 0.5 V to 2.5 V, f = 20 kHz, R <sub>L</sub> = 50 kΩ <sup>‡</sup>                             | A <sub>V</sub> = 1                                       | 25°C                        | 0.2%                  |      |     | 0.2%                    |      |     |        |
|                    |                                             |                                                                                                              | A <sub>V</sub> = 10                                      |                             | 1%                    |      |     | 1%                      |      |     |        |
|                    | Gain-bandwidth product                      | f = 50 kHz, R <sub>L</sub> = 50 kΩ <sup>‡</sup> , C <sub>L</sub> = 100 pF <sup>‡</sup>                       |                                                          | 25°C                        | 0.2                   |      |     | 0.2                     |      |     | MHz    |
| B <sub>OM</sub>    | Maximum output-swing bandwidth              | V <sub>O(PP)</sub> = 2 V, R <sub>L</sub> = 50 kΩ <sup>‡</sup> ,                                              | A <sub>V</sub> = 1, C <sub>L</sub> = 100 pF <sup>‡</sup> | 25°C                        | 30                    |      |     | 30                      |      |     | kHz    |
| φ <sub>m</sub>     | Phase margin at unity gain                  | R <sub>L</sub> = 50 kΩ <sup>‡</sup> , C <sub>L</sub> = 100 pF <sup>‡</sup>                                   |                                                          | 25°C                        | 63°                   |      |     | 63°                     |      |     |        |
|                    | Gain margin                                 |                                                                                                              |                                                          | 25°C                        | 15                    |      |     | 15                      |      |     | dB     |

$^\dagger$  Full range is  $-40^\circ\text{C}$  to  $125^\circ\text{C}$  for Q level part,  $-55^\circ\text{C}$  to  $125^\circ\text{C}$  for M level part.

$^\ddagger$  Referenced to 2.5 V

**TLV225x, TLV225xA**  
**Advanced LinCMOS™ RAIL-TO-RAIL**  
**VERY LOW-POWER OPERATIONAL AMPLIFIERS**

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**TYPICAL CHARACTERISTICS**

**Table of Graphs**

|                 |                                                 |                                                | <b>FIGURE</b>    |
|-----------------|-------------------------------------------------|------------------------------------------------|------------------|
| $V_{IO}$        | Input offset voltage                            | Distribution<br>vs Common-mode 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                                   | vs Supply voltage<br>vs Free-air temperature   | 13<br>14         |
| $V_{OH}$        | High-level output voltage                       | vs High-level output current                   | 15, 18           |
| $V_{OL}$        | Low-level output voltage                        | vs Low-level output current                    | 16, 17, 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         |
| $V_{ID}$        | Differential input voltage                      | vs Output voltage                              | 23, 24           |
| $A_{VD}$        | Differential voltage amplification              | 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                              | 37, 38           |
| SR              | Slew rate                                       | vs Load capacitance<br>vs Free-air temperature | 39<br>40         |
| $V_O$           | Inverting large-signal pulse response           |                                                | 41, 42           |
| $V_O$           | Voltage-follower large-signal pulse response    |                                                | 43, 44           |
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| $V_n$           | Equivalent input noise voltage                  | vs Frequency                                   | 49, 50           |
|                 | Input noise voltage                             | 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 Supply voltage<br>vs Free-air temperature   | 54<br>55         |
| $\phi_m$        | Phase margin                                    | vs Frequency<br>vs Load capacitance            | 26, 27<br>56     |
|                 | 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

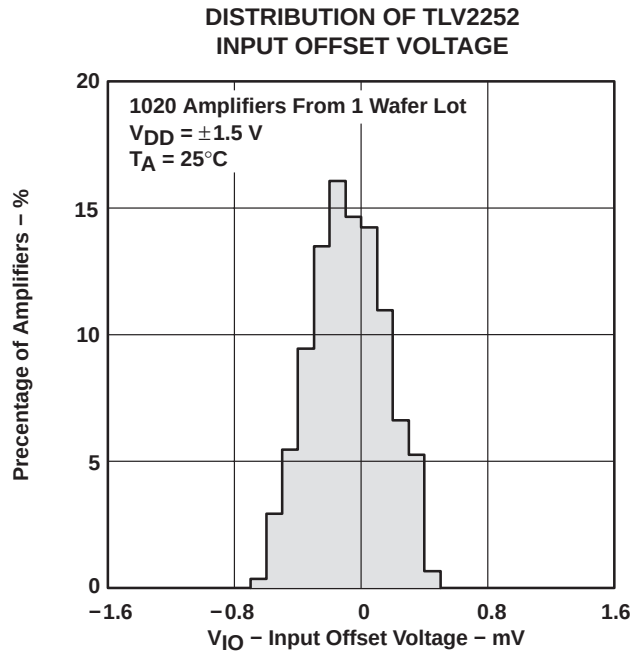


Figure 2

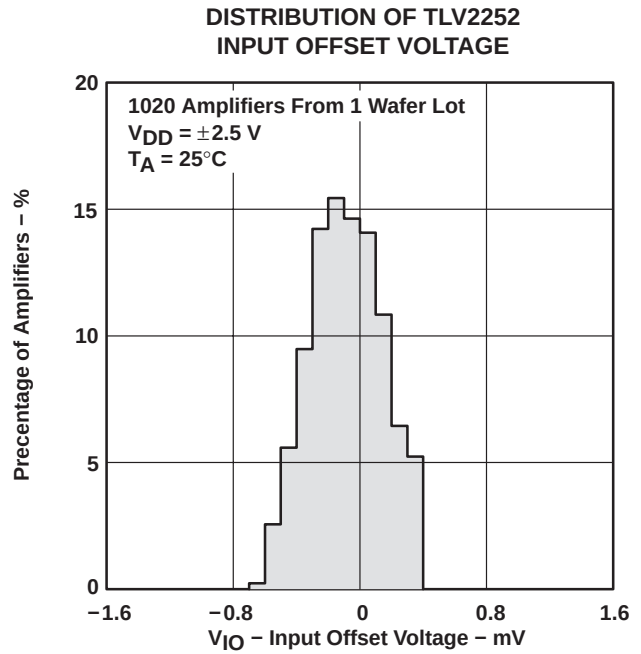


Figure 3

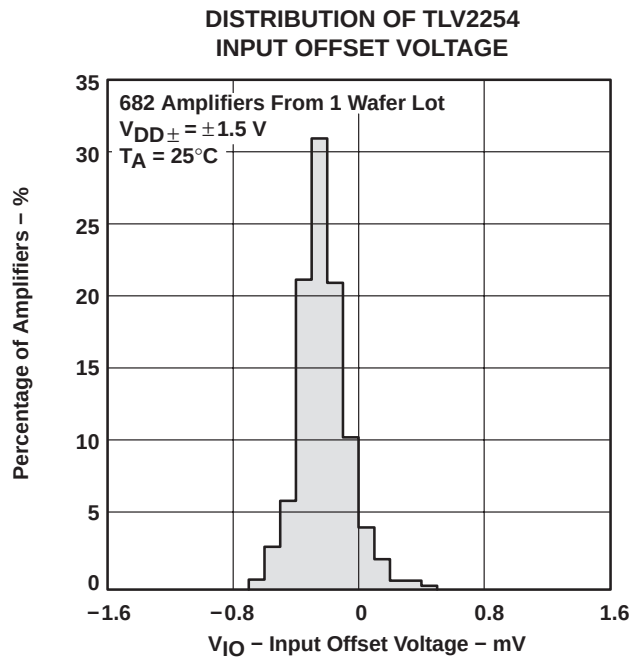


Figure 4

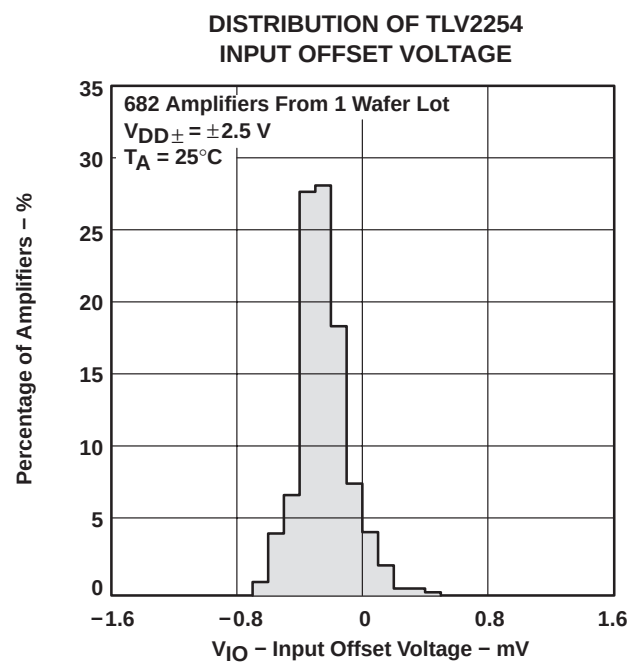


Figure 5

# TLV225x, TLV225xA

## Advanced LinCMOS™ RAIL-TO-RAIL

### VERY LOW-POWER OPERATIONAL AMPLIFIERS

SLOS185D – FEBRUARY 1997 – REVISED AUGUST 2006

#### TYPICAL CHARACTERISTICS

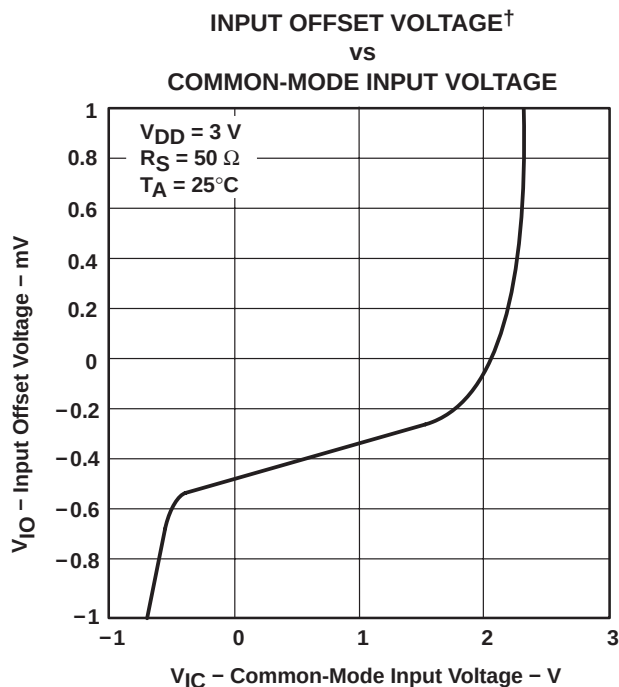


Figure 6

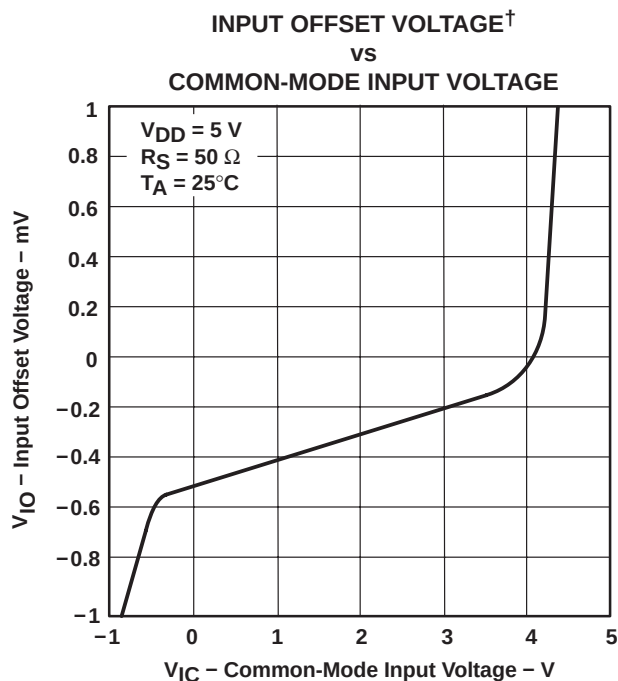


Figure 7

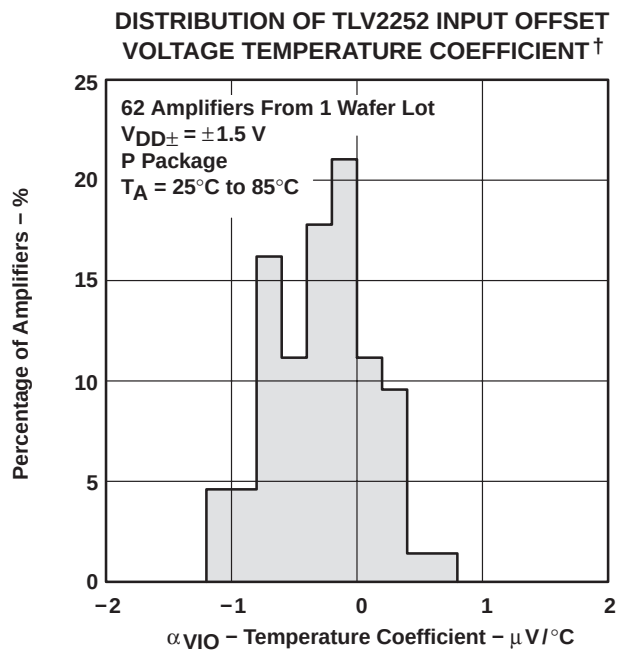


Figure 8

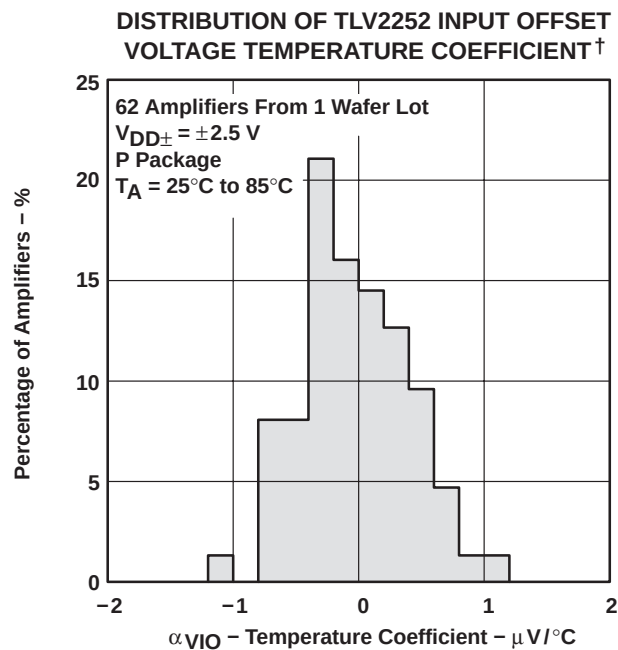


Figure 9

<sup>†</sup> For all curves where  $V_{DD} = 5\text{ V}$ , all loads are referenced to  $2.5\text{ V}$ . For all curves where  $V_{DD} = 3\text{ V}$ , all loads are referenced to  $1.5\text{ V}$ .



## TYPICAL CHARACTERISTICS

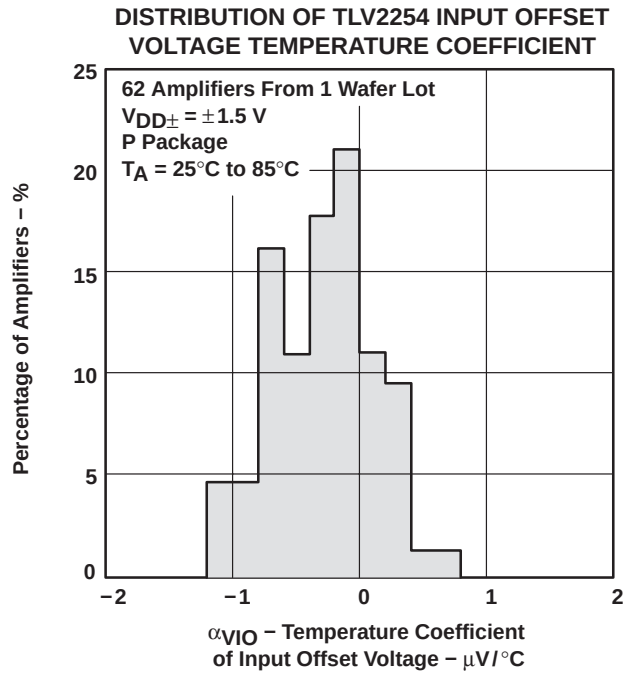


Figure 10

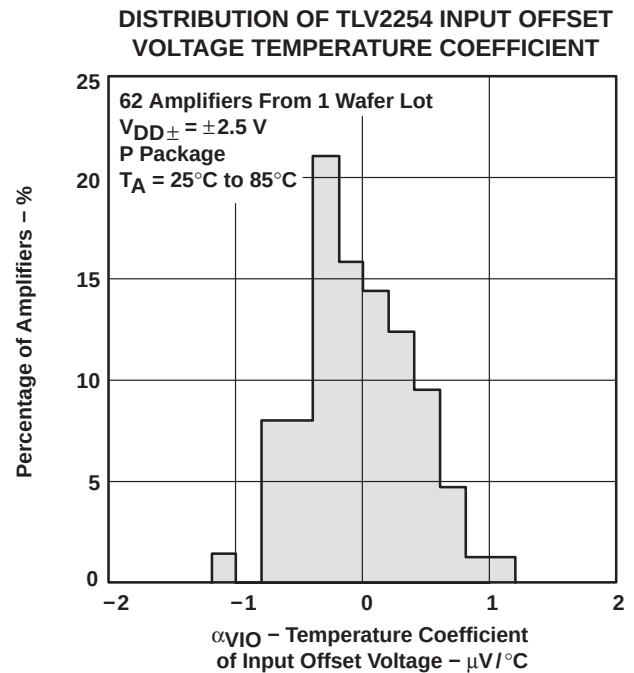


Figure 11

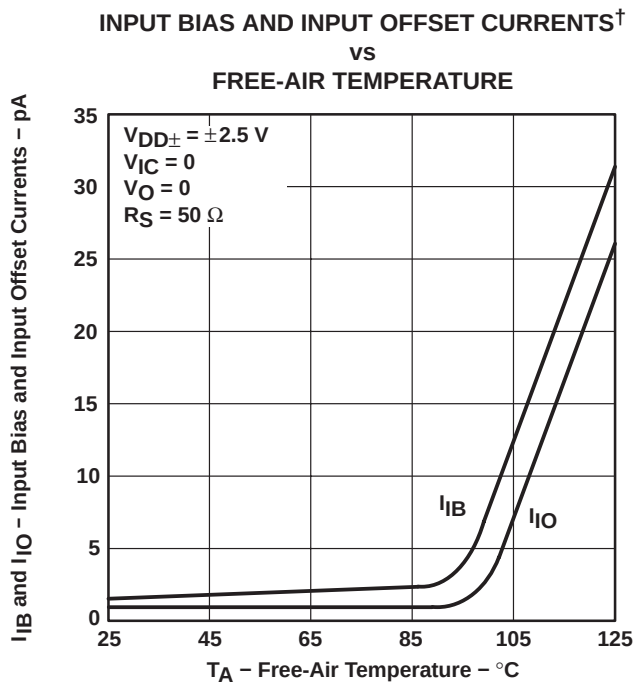


Figure 12

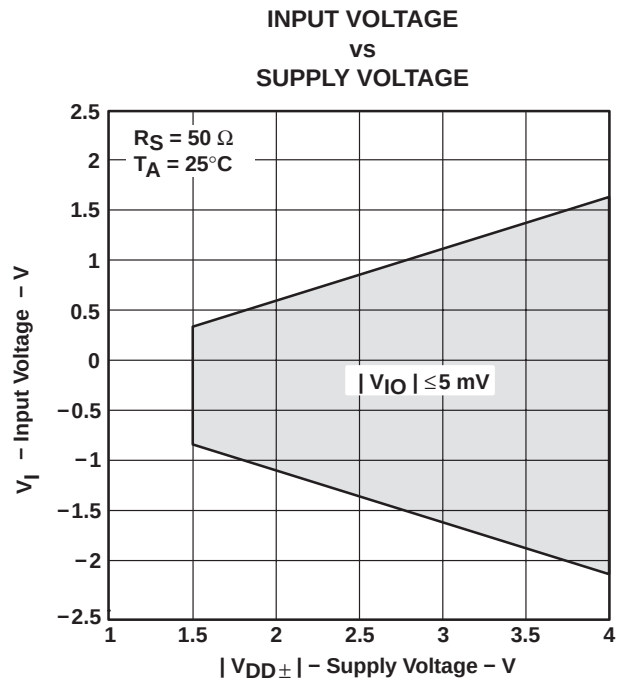


Figure 13

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

# TLV225x, TLV225xA

## Advanced LinCMOS™ RAIL-TO-RAIL

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#### TYPICAL CHARACTERISTICS

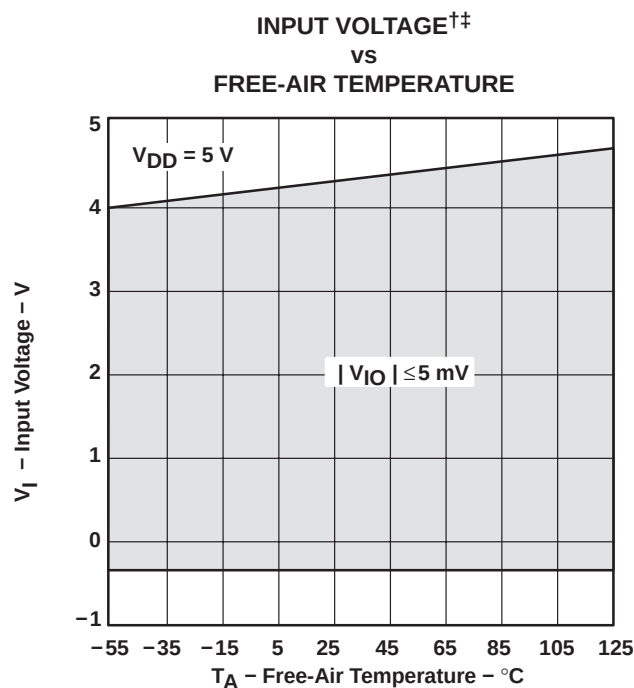


Figure 14

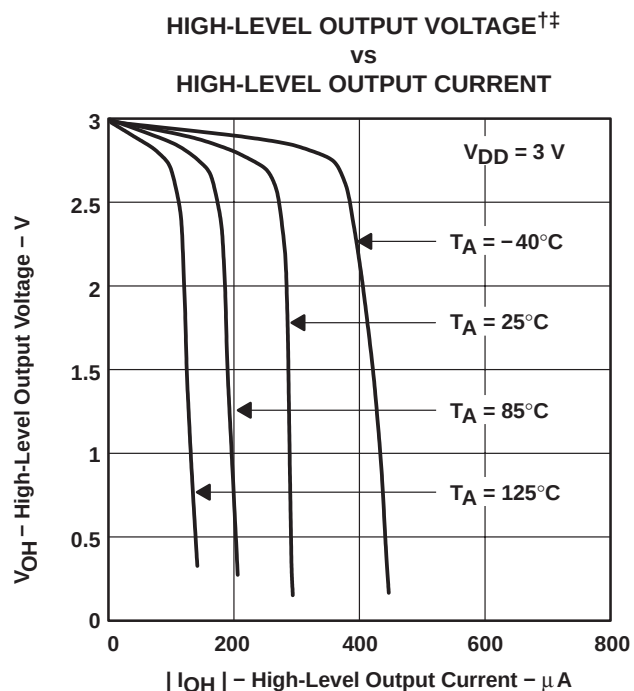


Figure 15

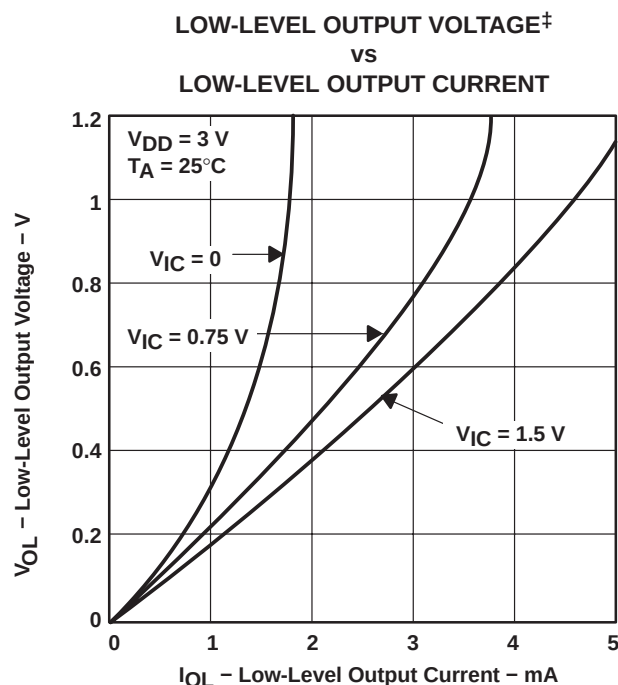


Figure 16

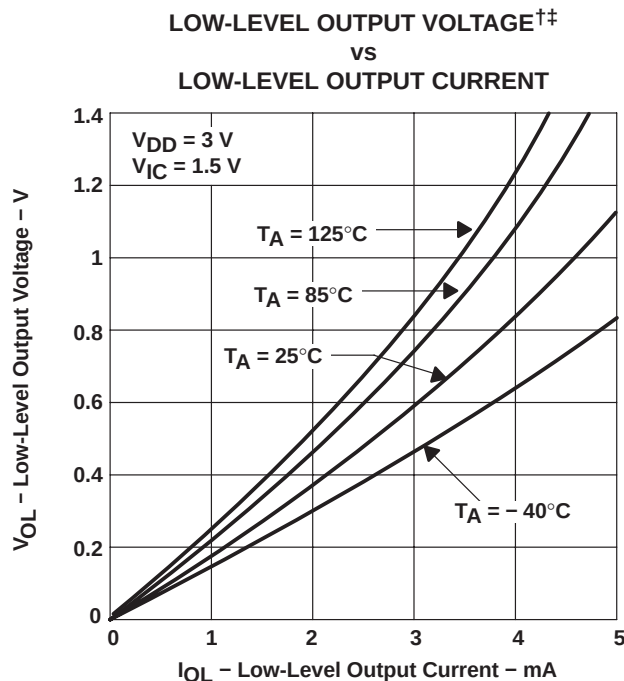
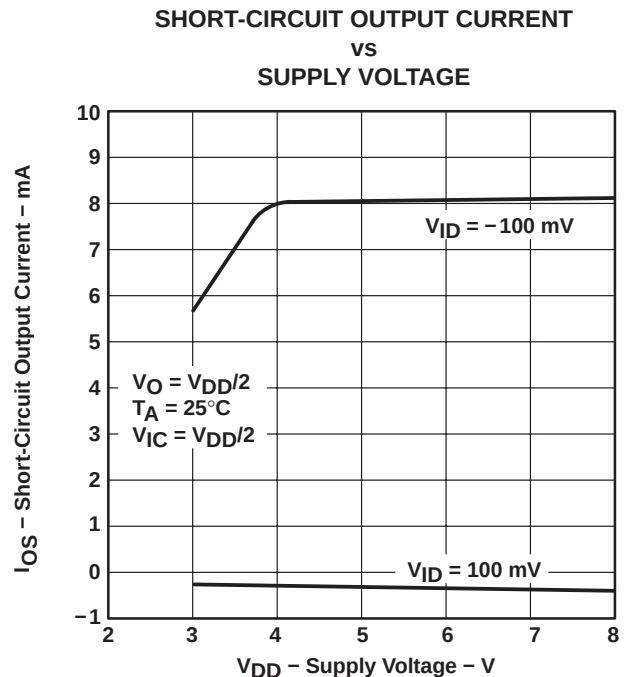
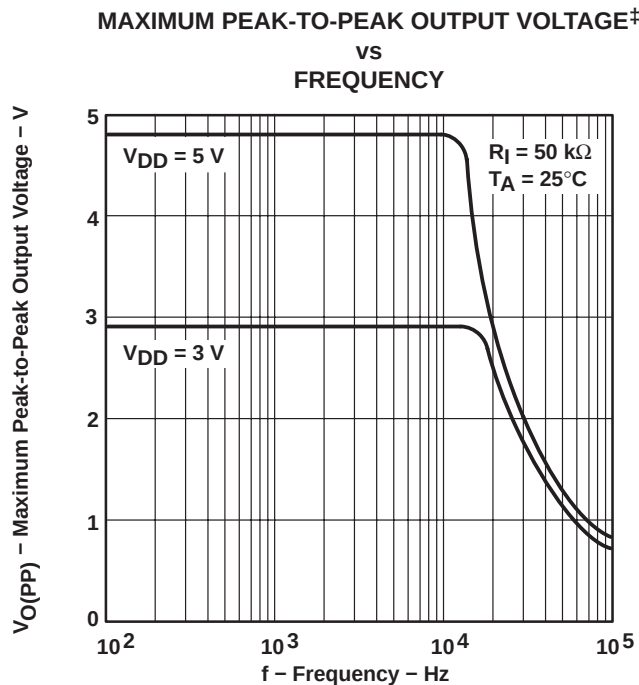
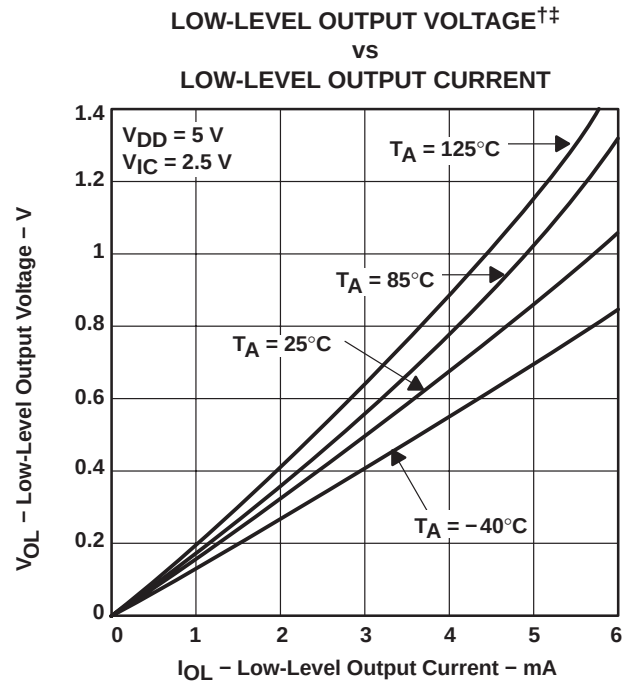
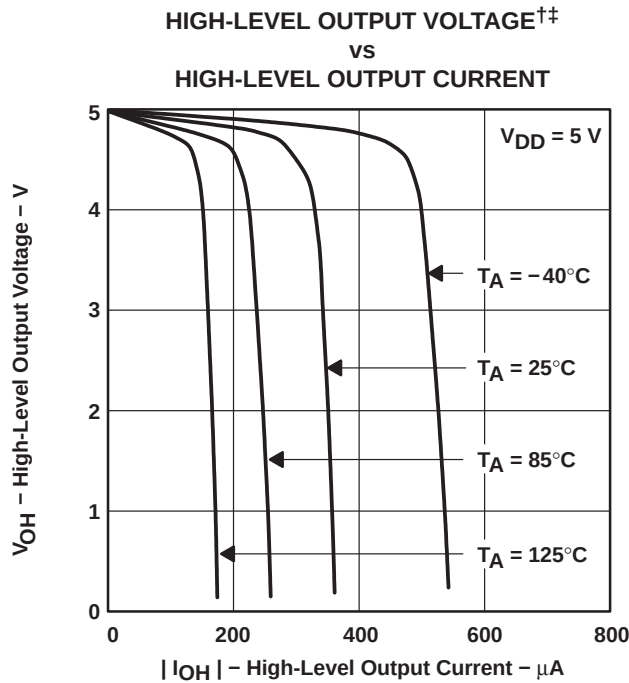


Figure 17

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

<sup>††</sup> For all curves where  $V_{DD} = 5 \text{ V}$ , all loads are referenced to 2.5 V. For all curves where  $V_{DD} = 3 \text{ V}$ , all loads are referenced to 1.5 V.

## TYPICAL CHARACTERISTICS



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

<sup>‡</sup> For all curves where  $V_{DD} = 5\text{ V}$ , all loads are referenced to 2.5 V. For all curves where  $V_{DD} = 3\text{ V}$ , all loads are referenced to 1.5 V.

# TLV225x, TLV225xA

## Advanced LinCMOS™ RAIL-TO-RAIL

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#### TYPICAL CHARACTERISTICS

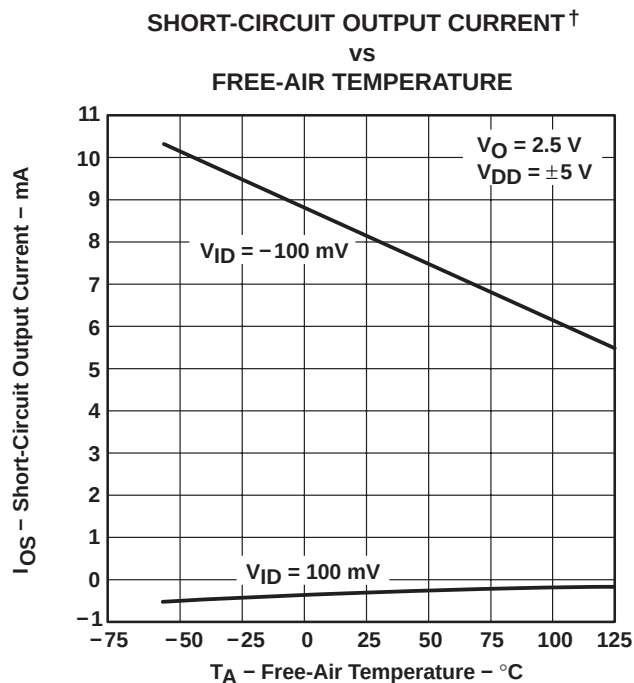


Figure 22

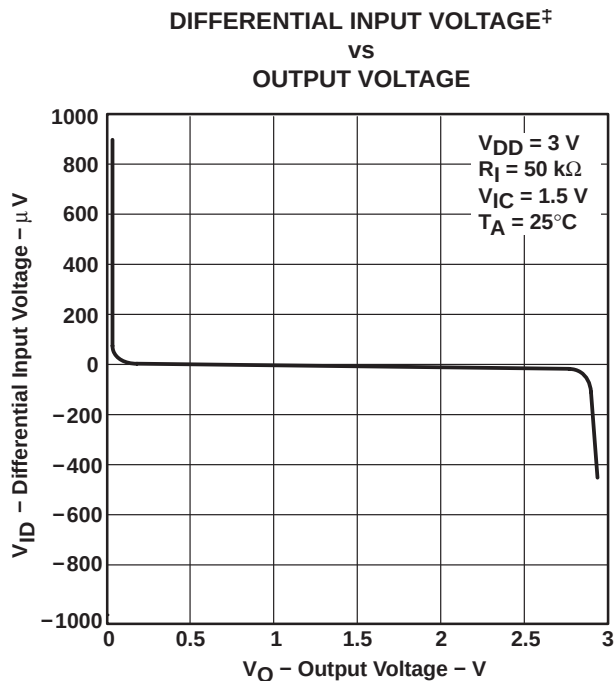


Figure 23

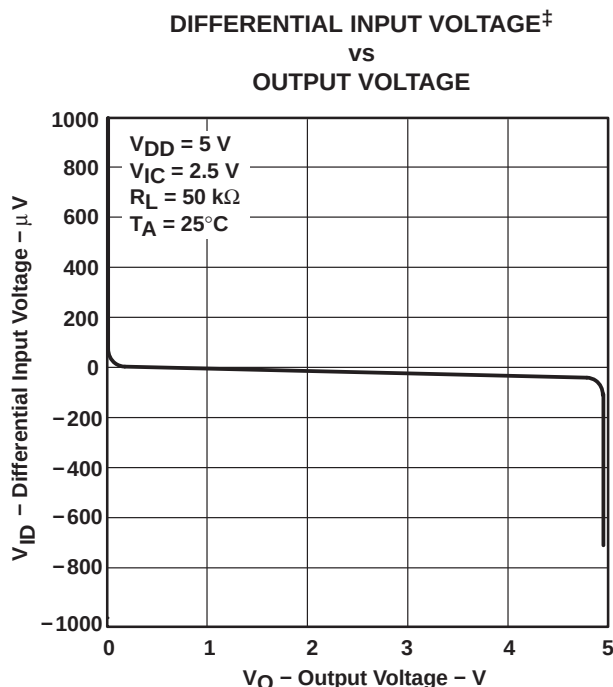


Figure 24

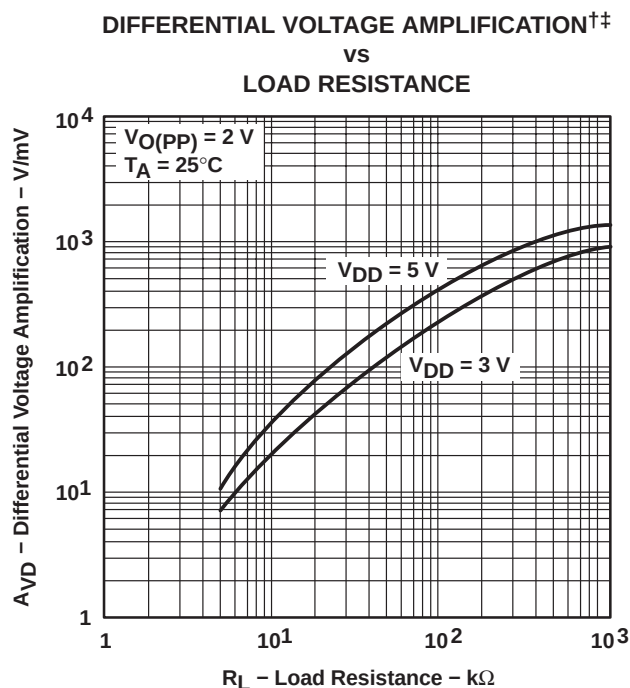


Figure 25

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

<sup>‡</sup> For all curves where  $V_{DD} = 5 \text{ V}$ , all loads are referenced to 2.5 V. For all curves where  $V_{DD} = 3 \text{ V}$ , all loads are referenced to 1.5 V.

## TYPICAL CHARACTERISTICS

LARGE-SIGNAL DIFFERENTIAL VOLTAGE<sup>†</sup>  
AMPLIFICATION AND PHASE MARGIN  
VS  
FREQUENCY

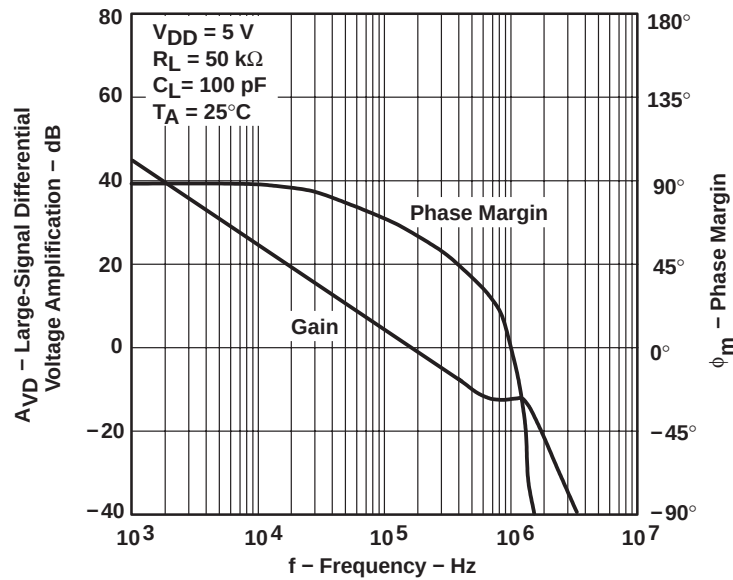


Figure 26

LARGE-SIGNAL DIFFERENTIAL VOLTAGE<sup>†</sup>  
AMPLIFICATION AND PHASE MARGIN  
VS  
FREQUENCY

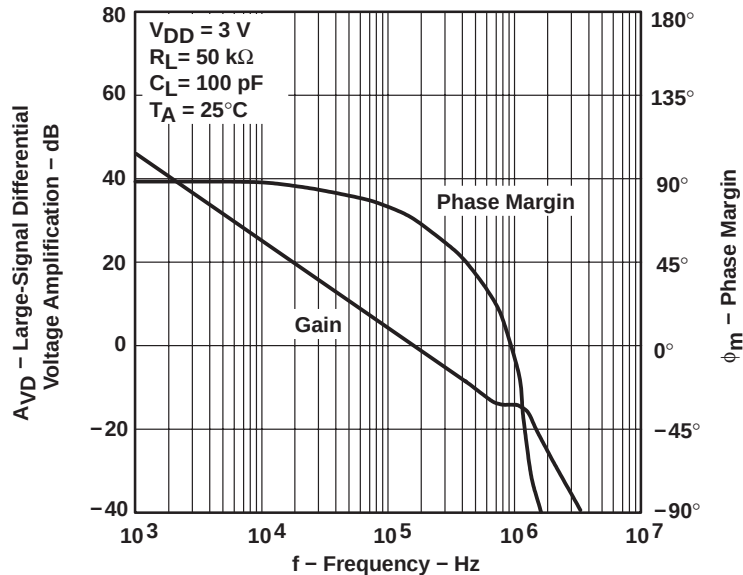


Figure 27

<sup>†</sup> For all curves where  $V_{DD} = 5\text{ V}$ , all loads are referenced to 2.5 V. For all curves where  $V_{DD} = 3\text{ V}$ , all loads are referenced to 1.5 V.

# TLV225x, TLV225xA

## Advanced LinCMOS™ RAIL-TO-RAIL

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#### TYPICAL CHARACTERISTICS

LARGE-SIGNAL DIFFERENTIAL<sup>†‡</sup>  
VOLTAGE AMPLIFICATION  
vs  
FREE-AIR TEMPERATURE

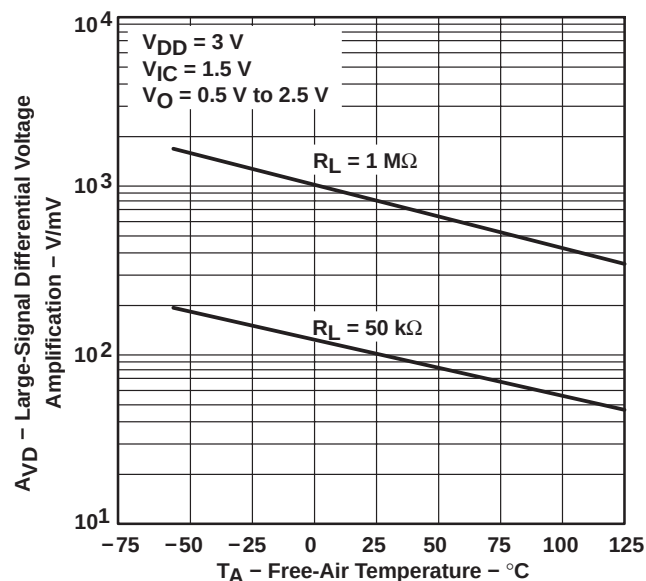


Figure 28

LARGE-SIGNAL DIFFERENTIAL<sup>†‡</sup>  
VOLTAGE AMPLIFICATION  
vs  
FREE-AIR TEMPERATURE

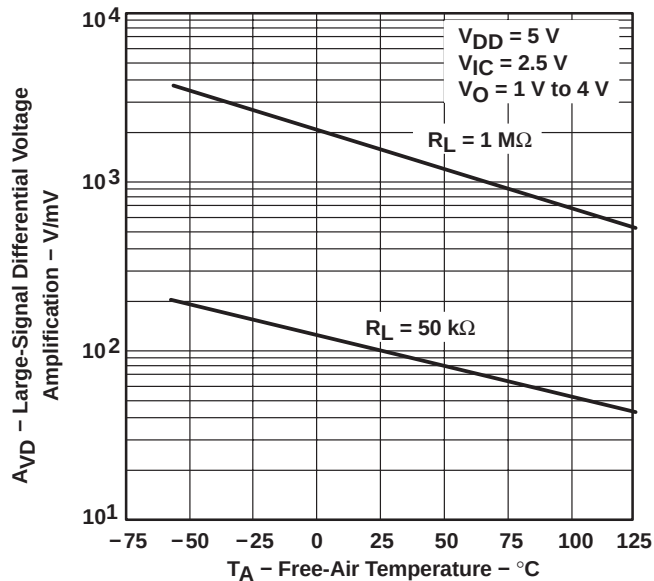


Figure 29

OUTPUT IMPEDANCE<sup>‡</sup>  
vs  
FREQUENCY

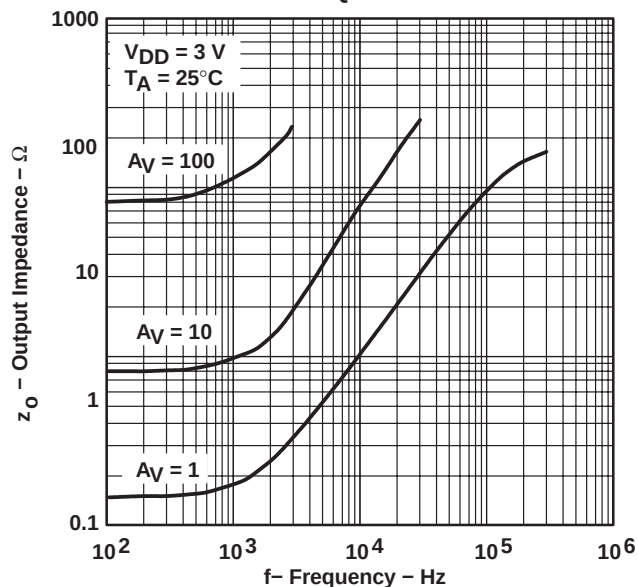


Figure 30

OUTPUT IMPEDANCE<sup>‡</sup>  
vs  
FREQUENCY

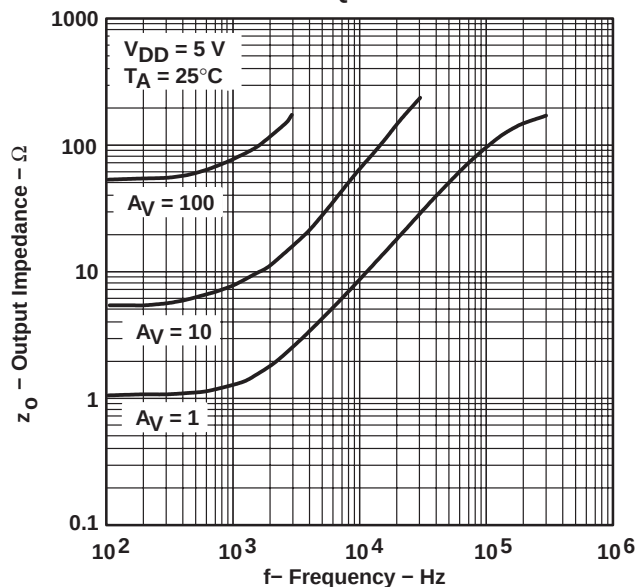


Figure 31

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

<sup>‡</sup> For all curves where  $V_{DD} = 5$  V, all loads are referenced to 2.5 V. For all curves where  $V_{DD} = 3$  V, all loads are referenced to 1.5 V.

## TYPICAL CHARACTERISTICS

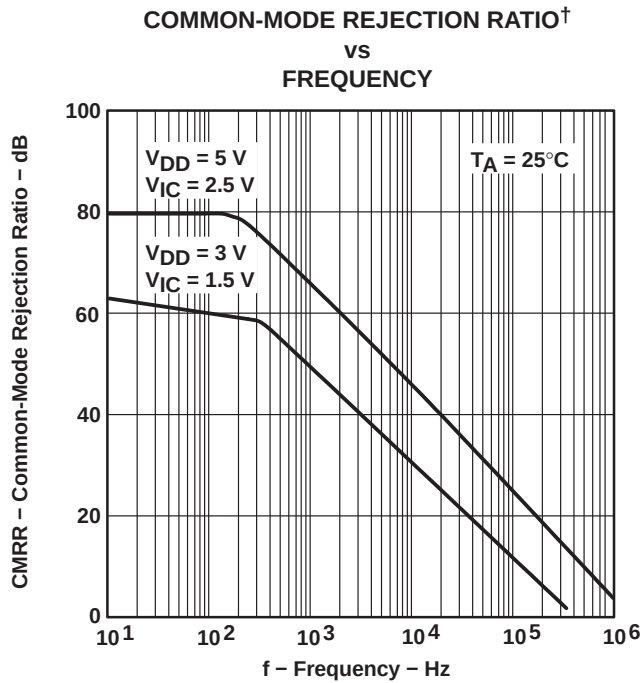


Figure 32

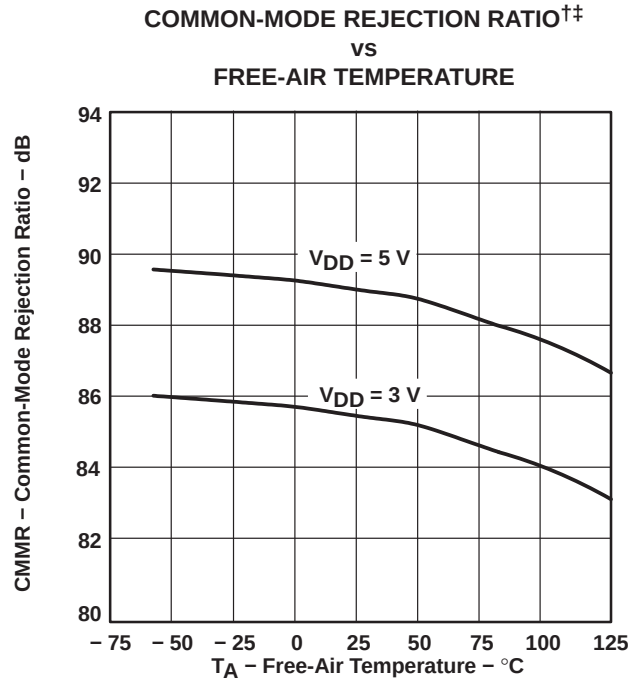


Figure 33

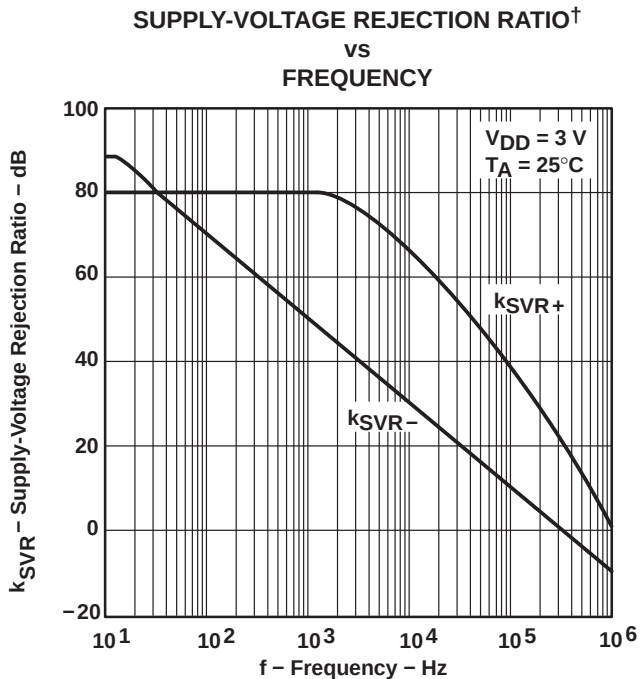


Figure 34

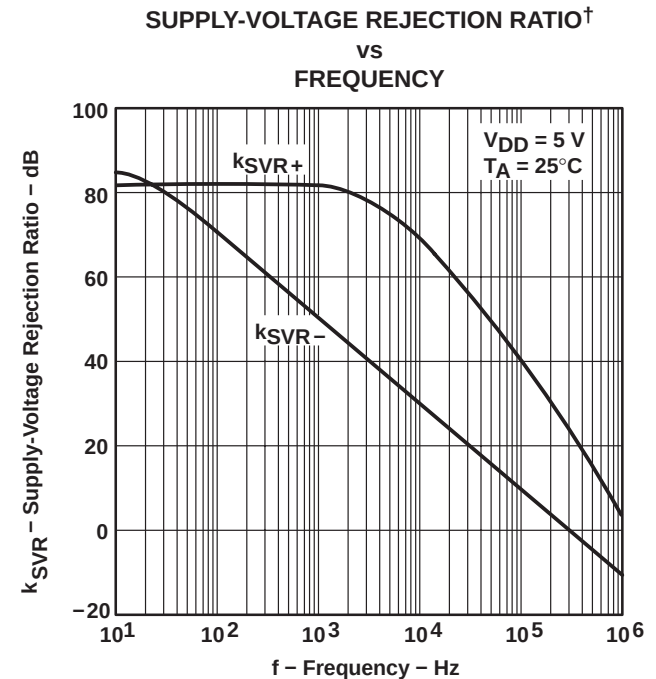


Figure 35

<sup>†</sup> For all curves where  $V_{DD} = 5\text{ V}$ , all loads are referenced to 2.5 V. For all curves where  $V_{DD} = 3\text{ V}$ , all loads are referenced to 1.5 V.

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

# TLV225x, TLV225xA

## Advanced LinCMOS™ RAIL-TO-RAIL

### VERY LOW-POWER OPERATIONAL AMPLIFIERS

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#### TYPICAL CHARACTERISTICS

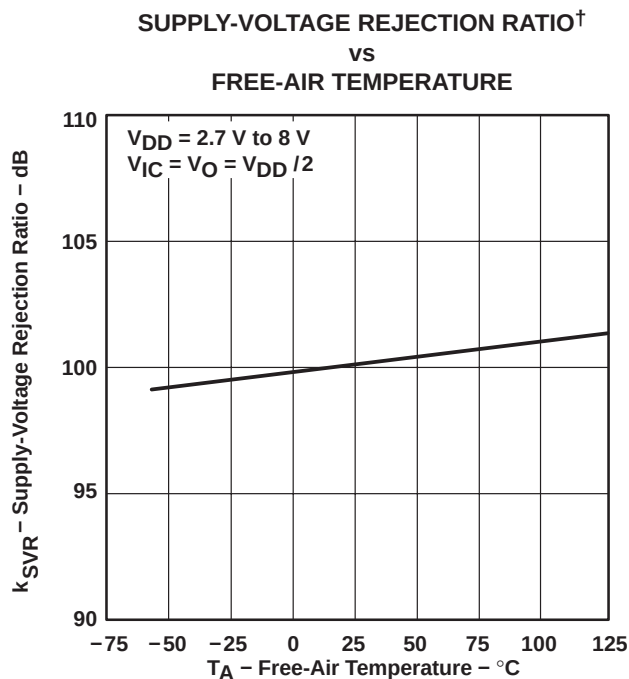


Figure 36

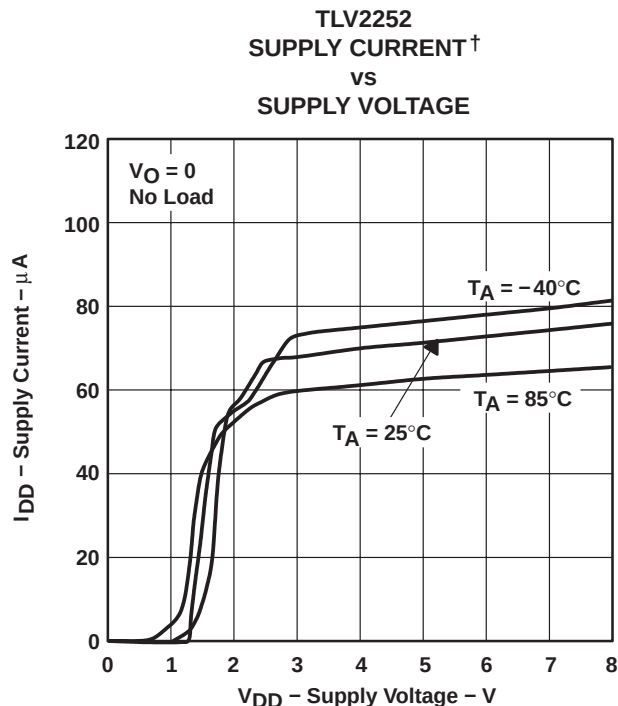


Figure 37

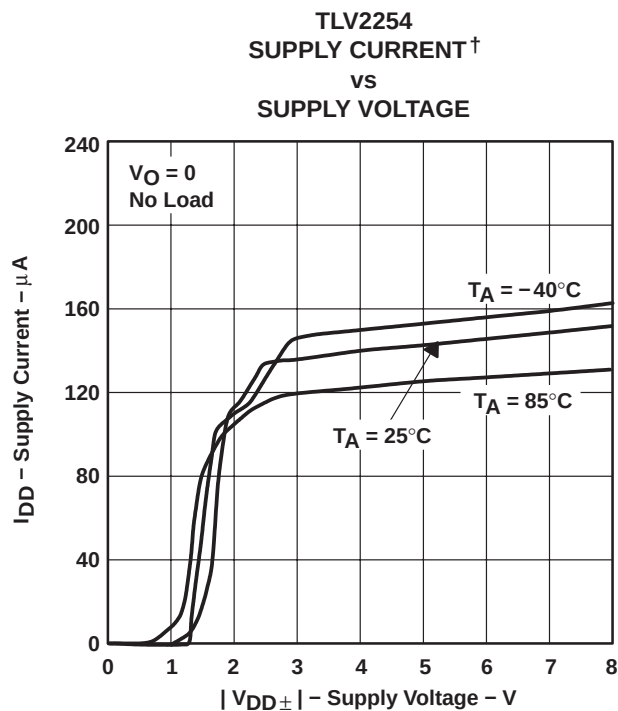


Figure 38

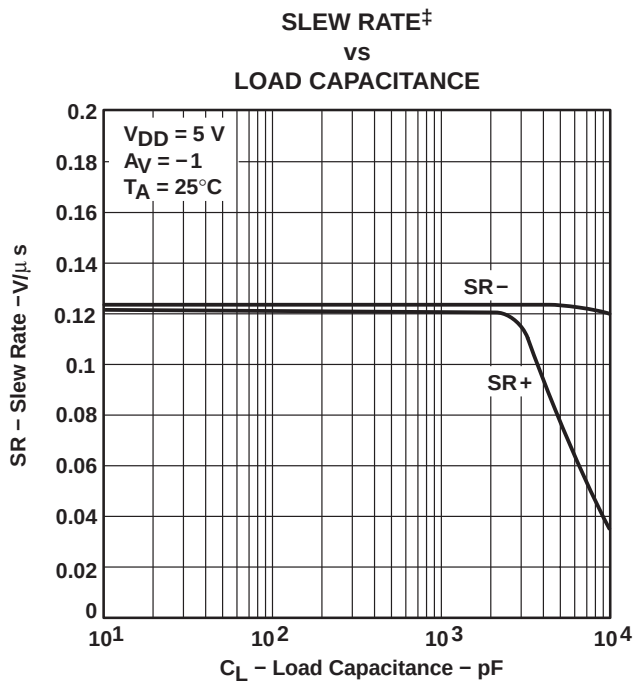


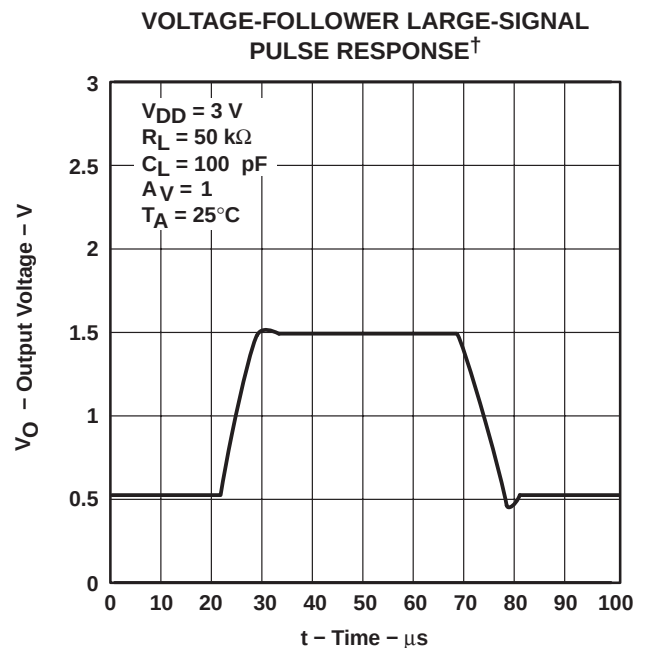
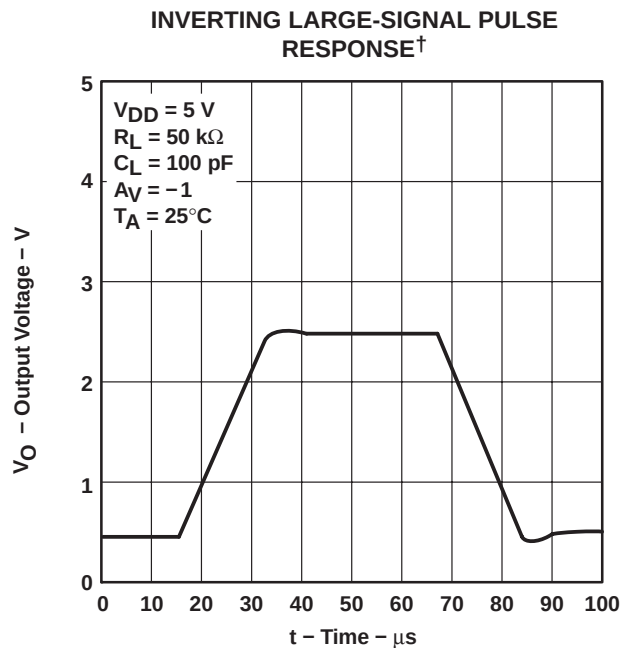
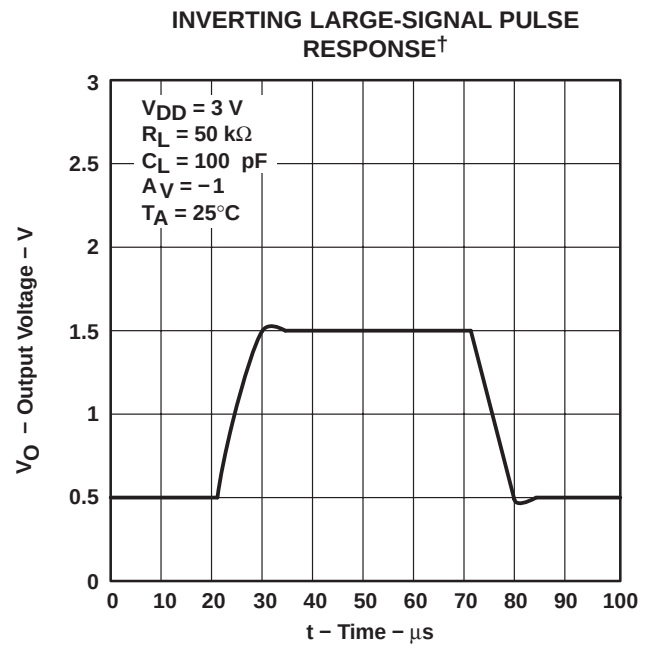
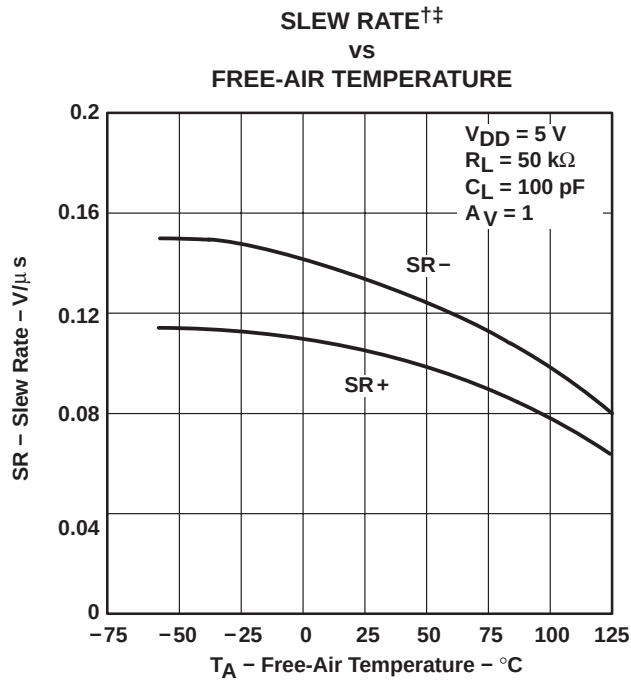
Figure 39

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

‡ For all curves where  $V_{DD} = 5 \text{ V}$ , all loads are referenced to 2.5 V. For all curves where  $V_{DD} = 3 \text{ V}$ , all loads are referenced to 1.5 V.



## TYPICAL CHARACTERISTICS



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

<sup>‡</sup> For all curves where  $V_{DD} = 5\text{ V}$ , all loads are referenced to 2.5 V. For all curves where  $V_{DD} = 3\text{ V}$ , all loads are referenced to 1.5 V.

# TLV225x, TLV225xA

## Advanced LinCMOS™ RAIL-TO-RAIL

### VERY LOW-POWER OPERATIONAL AMPLIFIERS

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#### TYPICAL CHARACTERISTICS

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

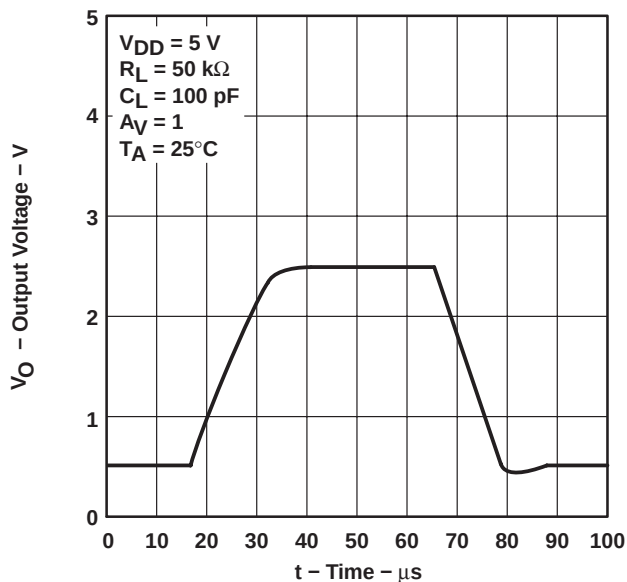


Figure 44

**INVERTING SMALL-SIGNAL PULSE RESPONSE†**

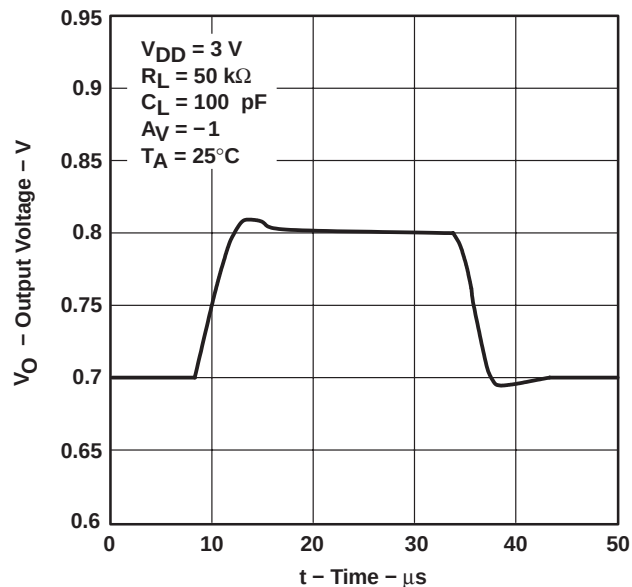


Figure 45

**INVERTING SMALL-SIGNAL PULSE RESPONSE†**

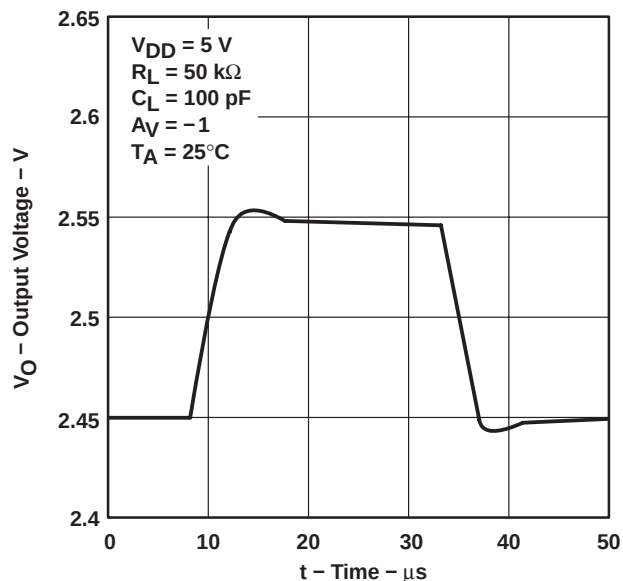


Figure 46

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

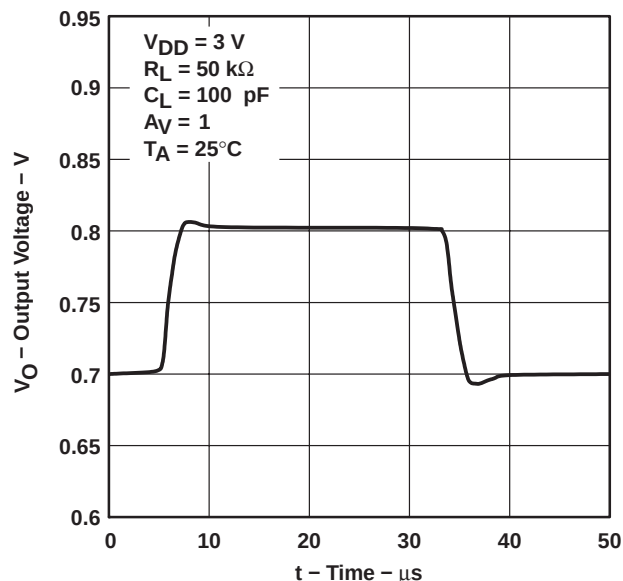


Figure 47

† For all curves where  $V_{DD} = 5$  V, all loads are referenced to 2.5 V. For all curves where  $V_{DD} = 3$  V, all loads are referenced to 1.5 V.

## TYPICAL CHARACTERISTICS

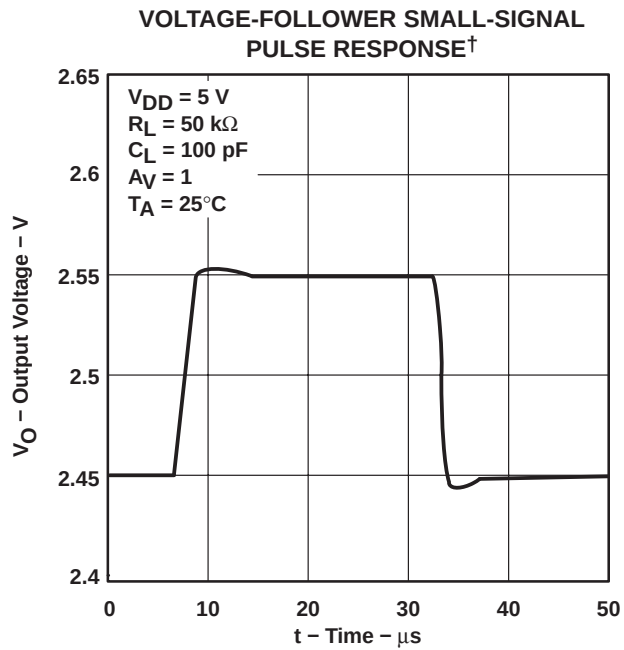


Figure 48

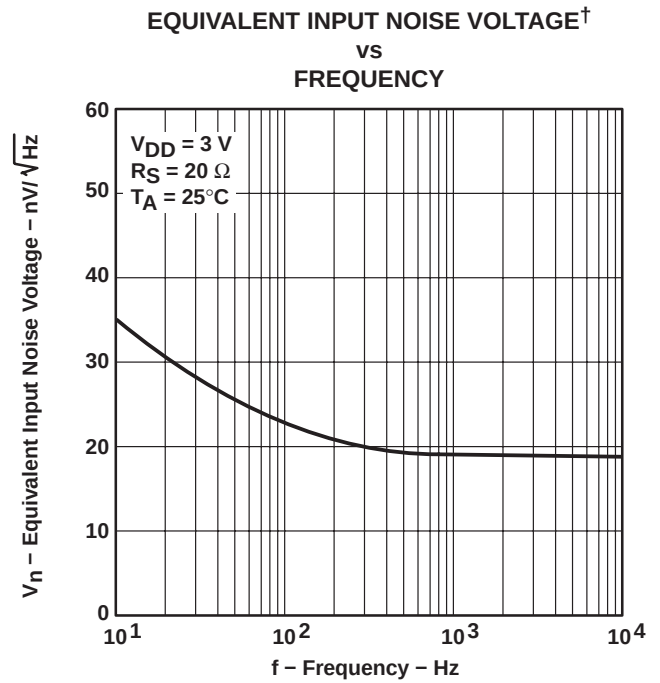


Figure 49

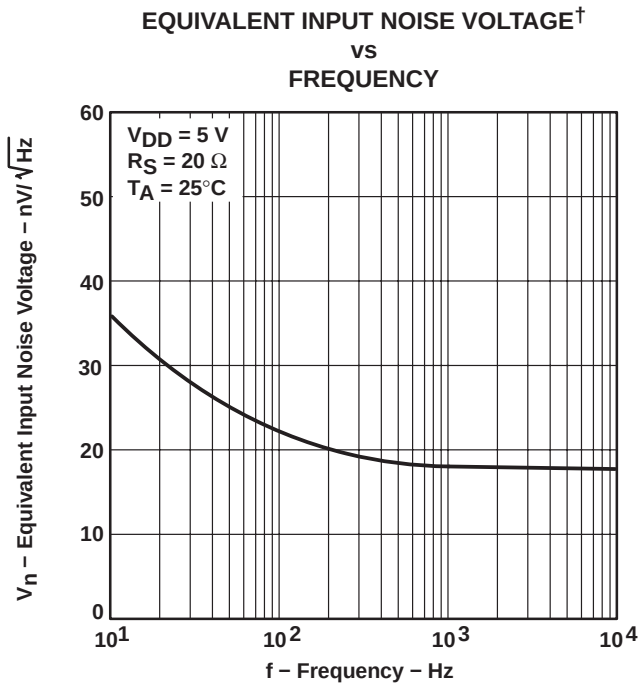


Figure 50

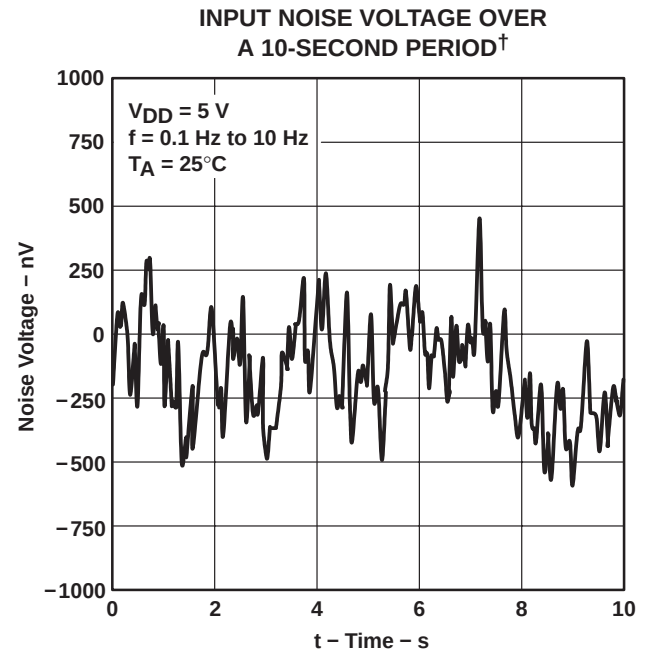


Figure 51

† For all curves where  $V_{DD} = 5\text{ V}$ , all loads are referenced to 2.5 V. For all curves where  $V_{DD} = 3\text{ V}$ , all loads are referenced to 1.5 V.

# TLV225x, TLV225xA

## Advanced LinCMOS™ RAIL-TO-RAIL

### VERY LOW-POWER OPERATIONAL AMPLIFIERS

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#### TYPICAL CHARACTERISTICS

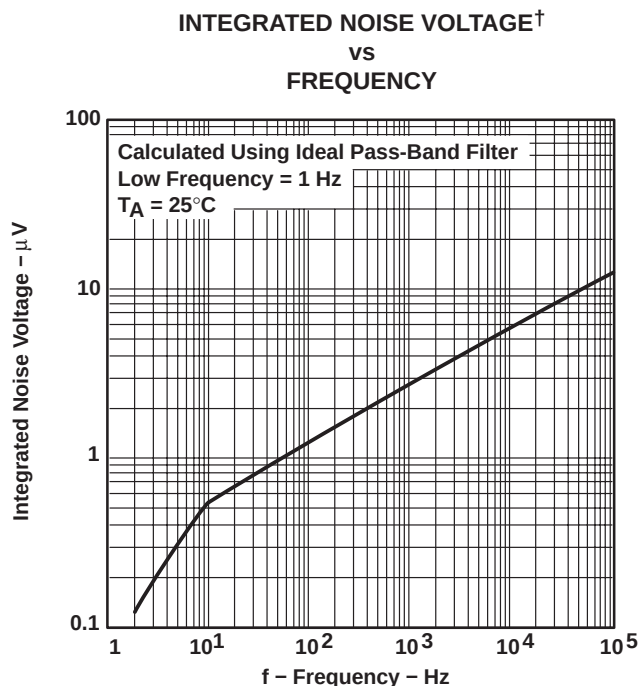


Figure 52

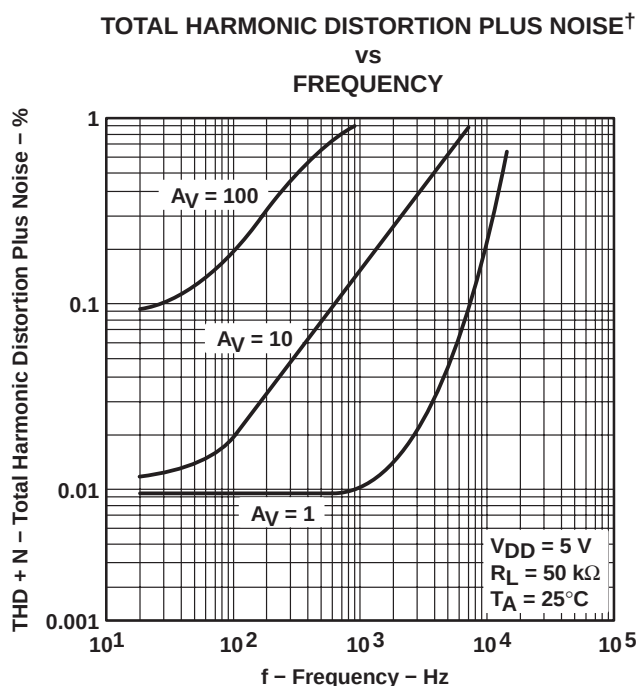


Figure 53

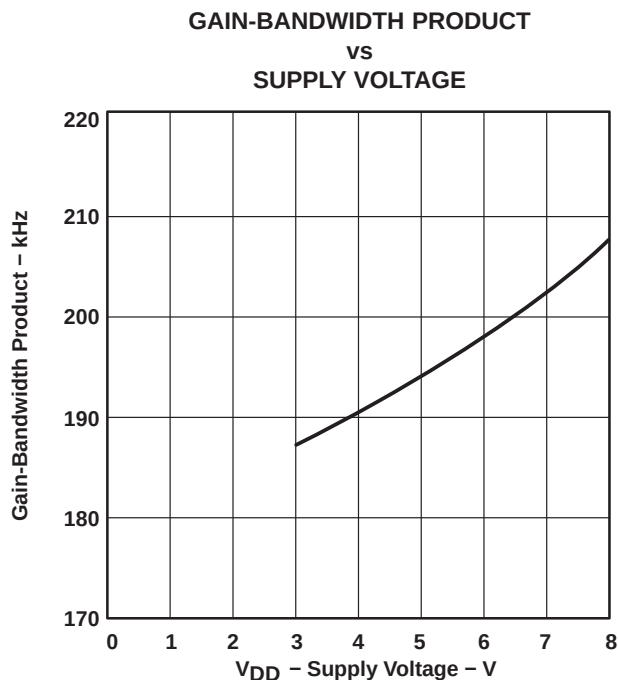


Figure 54

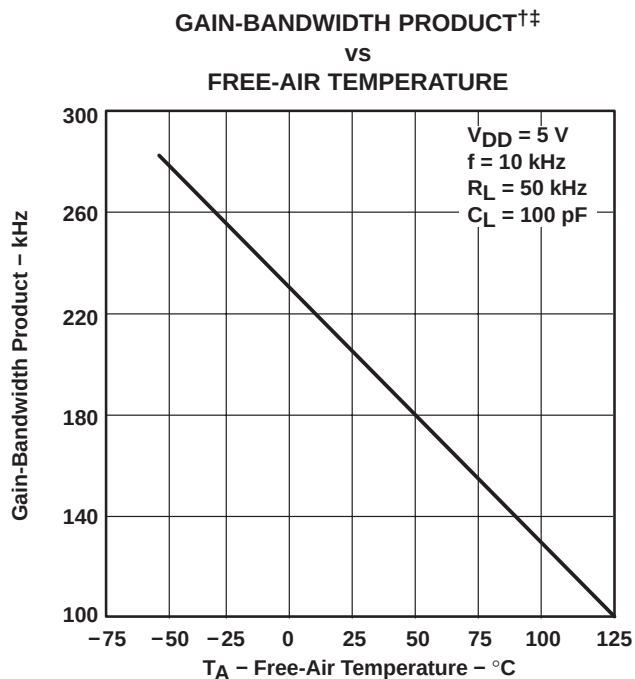
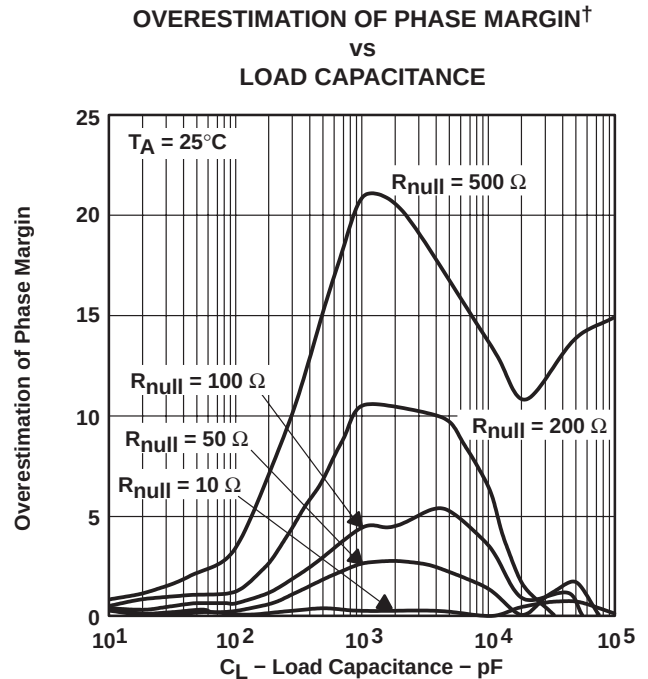
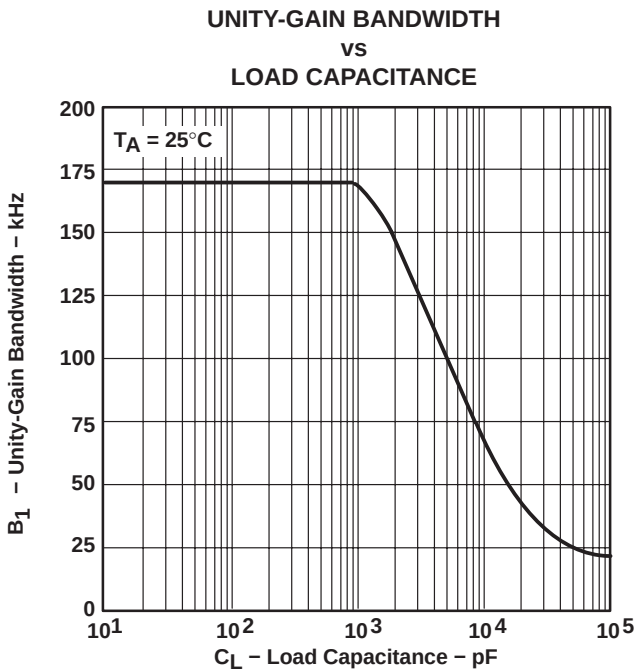
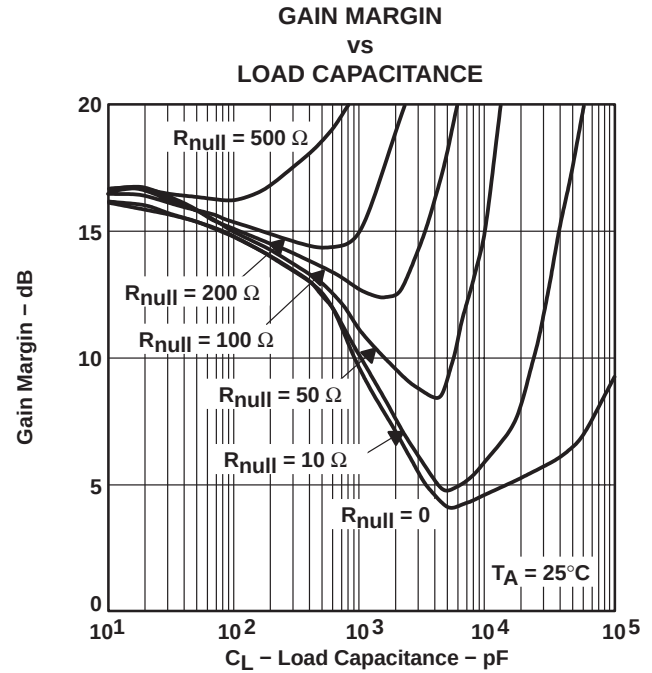
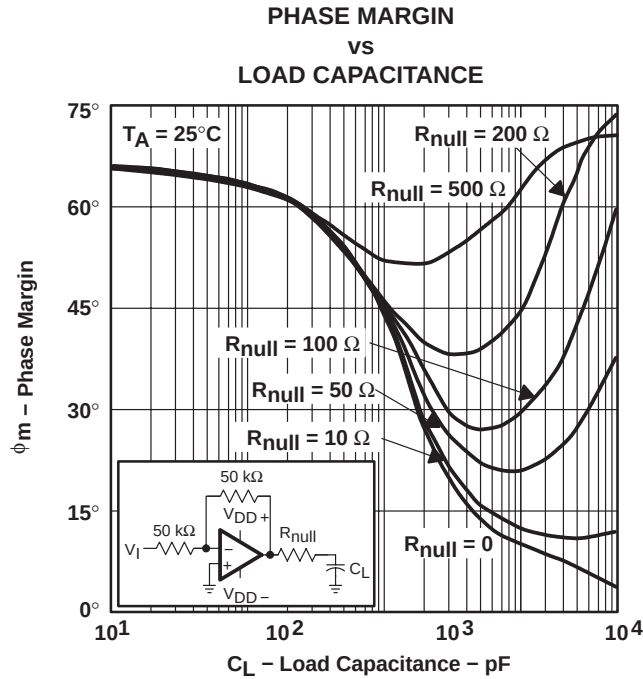


Figure 55

<sup>†</sup> For all curves where  $V_{DD} = 5\text{ V}$ , all loads are referenced to 2.5 V. For all curves where  $V_{DD} = 3\text{ V}$ , all loads are referenced to 1.5 V.

## TYPICAL CHARACTERISTICS



† See application information

† For all curves where  $V_{DD} = 5\text{ V}$ , all loads are referenced to  $2.5\text{ V}$ . For all curves where  $V_{DD} = 3\text{ V}$ , all loads are referenced to  $1.5\text{ V}$ .

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

# TLV225x, TLV225xA

## Advanced LinCMOS™ RAIL-TO-RAIL

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#### APPLICATION INFORMATION

##### driving large capacitive loads

The TLV2252 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 55 and Figure 56 show the effects of adding series resistances of 10  $\Omega$ , 50  $\Omega$ , 100  $\Omega$ , 200  $\Omega$ , and 500  $\Omega$ . The addition of this series resistor has two effects: the first adds a zero to the transfer function and the second 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, 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.

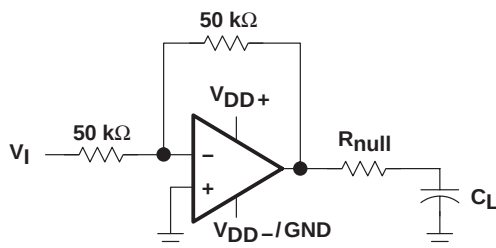


Figure 60. Series-Resistance Circuit

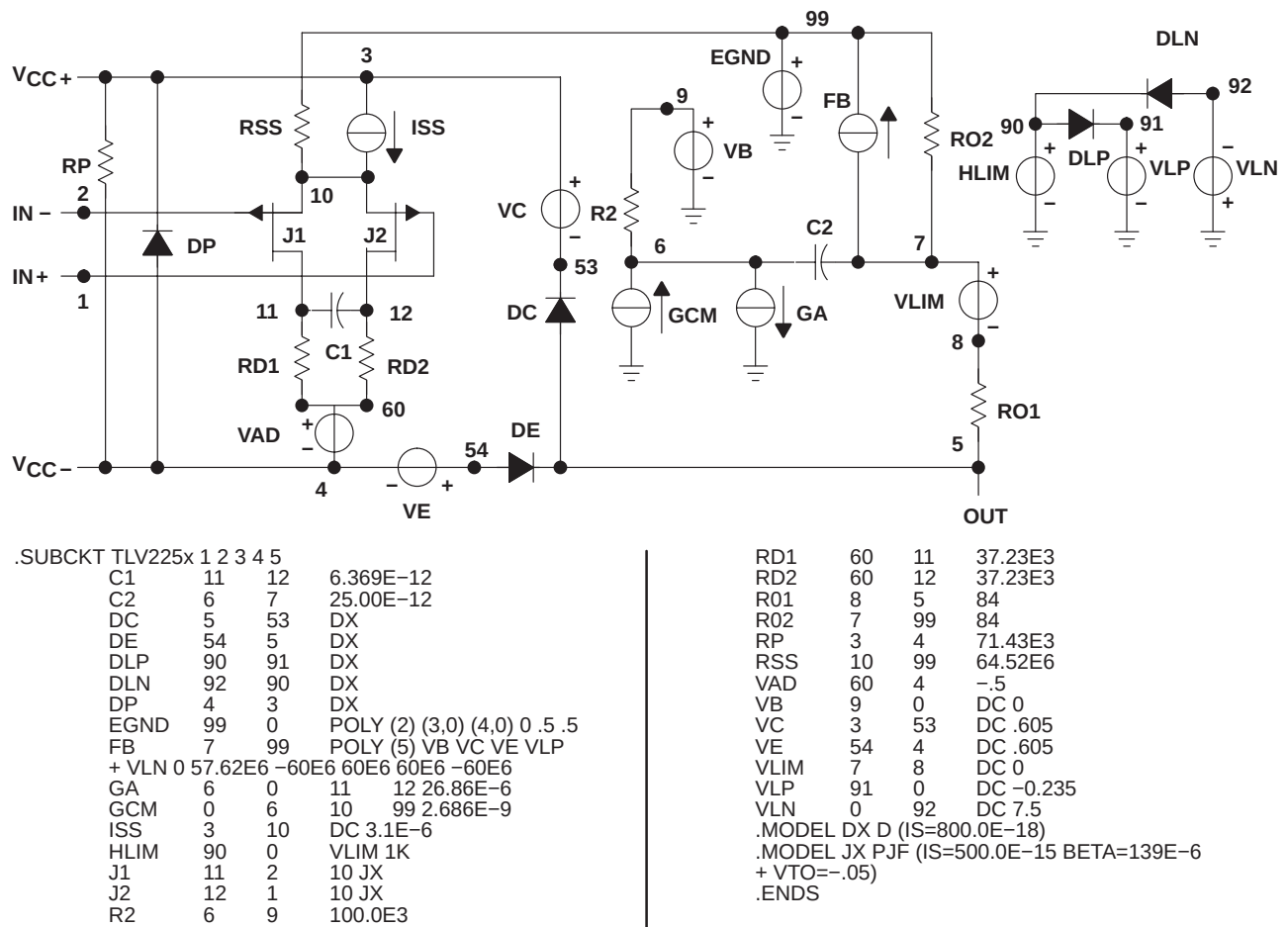
## APPLICATION INFORMATION

### 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 TLV2252 typical electrical and operating characteristics at  $T_A = 25^\circ\text{C}$ . Using this information, output simulations of the following key parameters can be generated to a tolerance of 20% (in most cases):

- Maximum positive output voltage swing
- Maximum negative output voltage swing
- Slew rate
- Quiescent power dissipation
- Input bias current
- Open-loop voltage amplification
- Unity-gain frequency
- Common-mode rejection ratio
- Phase margin
- DC output resistance
- AC output resistance
- Short-circuit output current limit

NOTE 5: G. R. Boyle, B. M. Cohn, D. O. Pederson, and J. E. Solomon, "Macromodeling of Integrated Circuit Operational Amplifiers," *IEEE Journal of Solid-State Circuits*, SC-9, 353 (1974).



**Figure 61. Boyle Macromodel and Subcircuit**

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

## PACKAGING INFORMATION

| Orderable Device | Status<br>(1) | Package Type | Package<br>Drawing | Pins | Package<br>Qty | Eco Plan<br>(2)     | Lead finish/<br>Ball material<br>(6) | MSL Peak Temp<br>(3) | Op Temp (°C) | Device Marking<br>(4/5) | Samples                 |
|------------------|---------------|--------------|--------------------|------|----------------|---------------------|--------------------------------------|----------------------|--------------|-------------------------|-------------------------|
| 5962-9550401QPA  | ACTIVE        | CDIP         | JG                 | 8    | 1              | Non-RoHS<br>& Green | SNPB                                 | N / A for Pkg Type   | -55 to 125   | 9550401QPA<br>TLV2262M  | <a href="#">Samples</a> |
| 5962-9550403QHA  | ACTIVE        | CFP          | U                  | 10   | 1              | Non-RoHS<br>& Green | SNPB                                 | N / A for Pkg Type   | -55 to 125   | 9550403QHA<br>TLV2262AM | <a href="#">Samples</a> |
| 5962-9550403QPA  | ACTIVE        | CDIP         | JG                 | 8    | 1              | Non-RoHS<br>& Green | SNPB                                 | N / A for Pkg Type   | -55 to 125   | 9550403QPA<br>TLV2262AM | <a href="#">Samples</a> |
| 5962-9566601QPA  | ACTIVE        | CDIP         | JG                 | 8    | 1              | Non-RoHS<br>& Green | SNPB                                 | N / A for Pkg Type   | -55 to 125   | 9566601QPA<br>TLV2252M  | <a href="#">Samples</a> |
| 5962-9566603QPA  | ACTIVE        | CDIP         | JG                 | 8    | 1              | Non-RoHS<br>& Green | SNPB                                 | N / A for Pkg Type   | -55 to 125   | 9566603QPA<br>TLV2252AM | <a href="#">Samples</a> |
| TLV2252AID       | ACTIVE        | SOIC         | D                  | 8    | 75             | RoHS & Green        | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 125   | V2252A                  | <a href="#">Samples</a> |
| TLV2252AIDG4     | ACTIVE        | SOIC         | D                  | 8    | 75             | RoHS & Green        | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 125   | V2252A                  | <a href="#">Samples</a> |
| TLV2252AIDR      | ACTIVE        | SOIC         | D                  | 8    | 2500           | RoHS & Green        | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 125   | V2252A                  | <a href="#">Samples</a> |
| TLV2252AIDRG4    | ACTIVE        | SOIC         | D                  | 8    | 2500           | RoHS & Green        | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 125   | V2252A                  | <a href="#">Samples</a> |
| TLV2252AIP       | ACTIVE        | PDIP         | P                  | 8    | 50             | RoHS & Green        | NIPDAU                               | N / A for Pkg Type   | -40 to 125   | TLV2252AI               | <a href="#">Samples</a> |
| TLV2252AIPW      | ACTIVE        | TSSOP        | PW                 | 8    | 150            | RoHS & Green        | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 125   | TY252A                  | <a href="#">Samples</a> |
| TLV2252AIPWG4    | ACTIVE        | TSSOP        | PW                 | 8    | 150            | RoHS & Green        | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 125   | TY252A                  | <a href="#">Samples</a> |
| TLV2252AIPWR     | ACTIVE        | TSSOP        | PW                 | 8    | 2000           | RoHS & Green        | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 125   | TY252A                  | <a href="#">Samples</a> |
| TLV2252AMJGB     | ACTIVE        | CDIP         | JG                 | 8    | 1              | Non-RoHS<br>& Green | SNPB                                 | N / A for Pkg Type   | -55 to 125   | 9566603QPA<br>TLV2252AM | <a href="#">Samples</a> |
| TLV2252AQDRG4    | ACTIVE        | SOIC         | D                  | 8    | 2500           | RoHS & Green        | NIPDAU                               | Level-1-260C-UNLIM   |              | V2252A                  | <a href="#">Samples</a> |
| TLV2252ID        | ACTIVE        | SOIC         | D                  | 8    | 75             | RoHS & Green        | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 125   | V2252I                  | <a href="#">Samples</a> |
| TLV2252IDR       | ACTIVE        | SOIC         | D                  | 8    | 2500           | RoHS & Green        | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 125   | V2252I                  | <a href="#">Samples</a> |
| TLV2252IDRG4     | ACTIVE        | SOIC         | D                  | 8    | 2500           | RoHS & Green        | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 125   | V2252I                  | <a href="#">Samples</a> |
| TLV2252IP        | ACTIVE        | PDIP         | P                  | 8    | 50             | RoHS & Green        | NIPDAU                               | N / A for Pkg Type   | -40 to 125   | TLV2252IP               | <a href="#">Samples</a> |



| Orderable Device | Status<br>(1) | Package Type | Package<br>Drawing | Pins | Package<br>Qty | Eco Plan<br>(2)     | Lead finish/<br>Ball material<br>(6) | MSL Peak Temp<br>(3) | Op Temp (°C) | Device Marking<br>(4/5) | Samples                 |
|------------------|---------------|--------------|--------------------|------|----------------|---------------------|--------------------------------------|----------------------|--------------|-------------------------|-------------------------|
| TLV2252MJGB      | ACTIVE        | CDIP         | JG                 | 8    | 1              | Non-RoHS<br>& Green | SNPB                                 | N / A for Pkg Type   | -55 to 125   | 9566601QPA<br>TLV2252M  | <a href="#">Samples</a> |
| TLV2254AID       | ACTIVE        | SOIC         | D                  | 14   | 50             | RoHS & Green        | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 125   | V2254AI                 | <a href="#">Samples</a> |
| TLV2254AIDR      | ACTIVE        | SOIC         | D                  | 14   | 2500           | RoHS & Green        | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 125   | V2254AI                 | <a href="#">Samples</a> |
| TLV2254AIN       | ACTIVE        | PDIP         | N                  | 14   | 25             | RoHS & Green        | NIPDAU                               | N / A for Pkg Type   | -40 to 125   | TLV2254AIN              | <a href="#">Samples</a> |
| TLV2254AIPW      | ACTIVE        | TSSOP        | PW                 | 14   | 90             | RoHS & Green        | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 125   | TY2254A                 | <a href="#">Samples</a> |
| TLV2254AIPWR     | ACTIVE        | TSSOP        | PW                 | 14   | 2000           | RoHS & Green        | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 125   | TY2254A                 | <a href="#">Samples</a> |
| TLV2254AIPWRG4   | ACTIVE        | TSSOP        | PW                 | 14   | 2000           | RoHS & Green        | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 125   | TY2254A                 | <a href="#">Samples</a> |
| TLV2254AQD       | ACTIVE        | SOIC         | D                  | 14   | 50             | RoHS & Green        | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 125   | TLV2254A                | <a href="#">Samples</a> |
| TLV2254ID        | ACTIVE        | SOIC         | D                  | 14   | 50             | RoHS & Green        | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 125   | TLV2254I                | <a href="#">Samples</a> |
| TLV2254IDG4      | ACTIVE        | SOIC         | D                  | 14   | 50             | RoHS & Green        | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 125   | TLV2254I                | <a href="#">Samples</a> |
| TLV2254IDR       | ACTIVE        | SOIC         | D                  | 14   | 2500           | RoHS & Green        | NIPDAU                               | Level-1-260C-UNLIM   | -40 to 125   | TLV2254I                | <a href="#">Samples</a> |
| TLV2254IN        | ACTIVE        | PDIP         | N                  | 14   | 25             | RoHS & Green        | NIPDAU                               | N / A for Pkg Type   | -40 to 125   | TLV2254IN               | <a href="#">Samples</a> |
| TLV2262AMJGB     | ACTIVE        | CDIP         | JG                 | 8    | 1              | Non-RoHS<br>& Green | SNPB                                 | N / A for Pkg Type   | -55 to 125   | 9550403QPA<br>TLV2262AM | <a href="#">Samples</a> |
| TLV2262AMUB      | ACTIVE        | CFP          | U                  | 10   | 1              | Non-RoHS<br>& Green | SNPB                                 | N / A for Pkg Type   | -55 to 125   | 9550403QHA<br>TLV2262AM | <a href="#">Samples</a> |
| TLV2262MJGB      | ACTIVE        | CDIP         | JG                 | 8    | 1              | Non-RoHS<br>& Green | SNPB                                 | N / A for Pkg Type   | -55 to 125   | 9550401QPA<br>TLV2262M  | <a href="#">Samples</a> |

<sup>(1)</sup> 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.

<sup>(2)</sup> **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

**RoHS Exempt:** TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

**Green:** TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of  $\leq 1000$ ppm threshold. Antimony trioxide based flame retardants must also meet the  $\leq 1000$ ppm threshold requirement.

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

<sup>(4)</sup> There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

<sup>(5)</sup> Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

<sup>(6)</sup> Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

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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 TLV2252, TLV2252A, TLV2252AM, TLV2252M, TLV2254A, TLV2262AM, TLV2262M :**

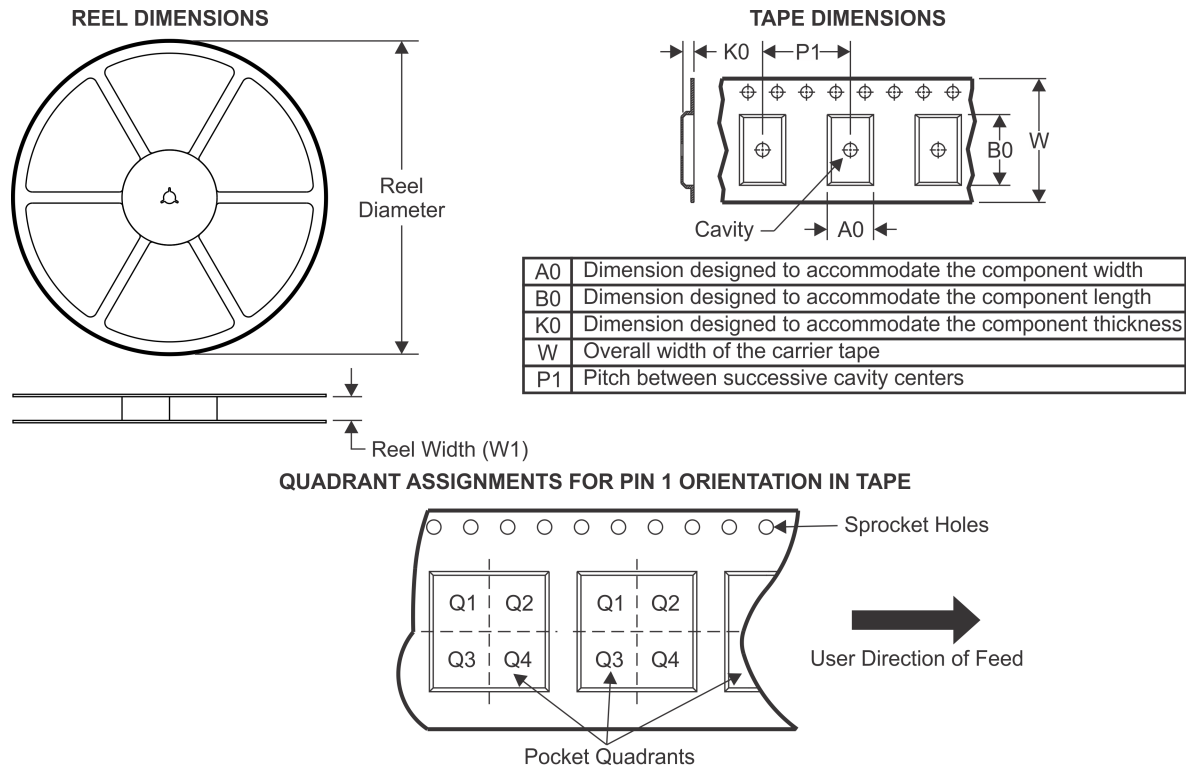
- Catalog : [TLV2252A](#), [TLV2252](#), [TLV2262A](#), [TLV2262](#)
- Automotive : [TLV2252-Q1](#), [TLV2252A-Q1](#), [TLV2252A-Q1](#), [TLV2252-Q1](#), [TLV2262A-Q1](#)
- Enhanced Product : [TLV2252A-EP](#), [TLV2252A-EP](#), [TLV2254A-EP](#)
- Military : [TLV2252M](#), [TLV2252AM](#)

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product

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

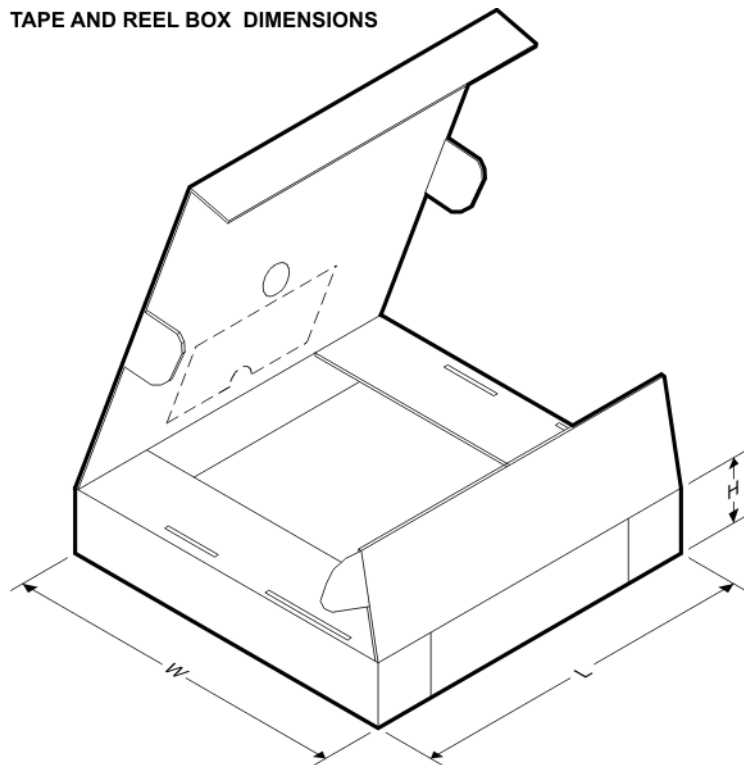
## TAPE AND REEL INFORMATION



\*All dimensions are nominal

| Device       | Package Type | Package Drawing | Pins | SPQ  | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|--------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| TLV2252AIDR  | SOIC         | D               | 8    | 2500 | 330.0              | 12.4               | 6.4     | 5.2     | 2.1     | 8.0     | 12.0   | Q1            |
| TLV2252AIPWR | TSSOP        | PW              | 8    | 2000 | 330.0              | 12.4               | 7.0     | 3.6     | 1.6     | 8.0     | 12.0   | Q1            |
| TLV2252IDR   | SOIC         | D               | 8    | 2500 | 330.0              | 12.4               | 6.4     | 5.2     | 2.1     | 8.0     | 12.0   | Q1            |
| TLV2254AIDR  | SOIC         | D               | 14   | 2500 | 330.0              | 16.4               | 6.5     | 9.0     | 2.1     | 8.0     | 16.0   | Q1            |
| TLV2254AIPWR | TSSOP        | PW              | 14   | 2000 | 330.0              | 12.4               | 6.9     | 5.6     | 1.6     | 8.0     | 12.0   | Q1            |
| TLV2254IDR   | SOIC         | D               | 14   | 2500 | 330.0              | 16.4               | 6.5     | 9.0     | 2.1     | 8.0     | 16.0   | Q1            |

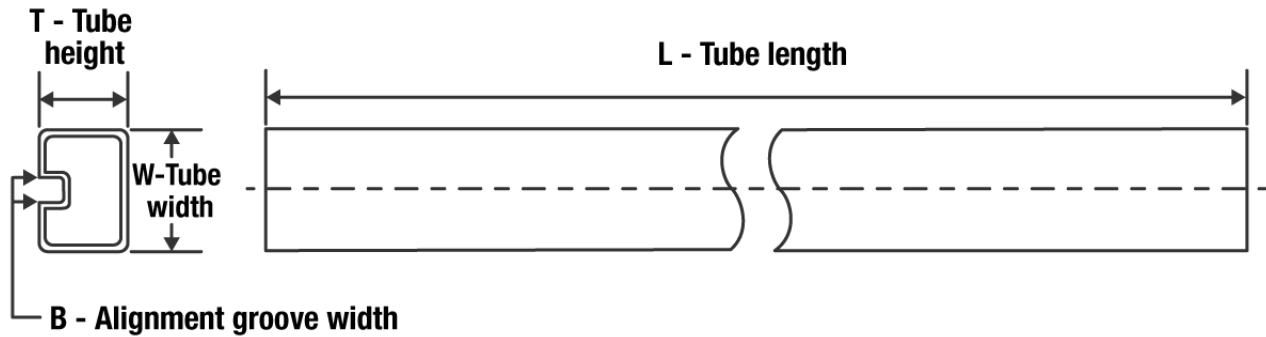
## TAPE AND REEL BOX DIMENSIONS



\*All dimensions are nominal

| Device       | Package Type | Package Drawing | Pins | SPQ  | Length (mm) | Width (mm) | Height (mm) |
|--------------|--------------|-----------------|------|------|-------------|------------|-------------|
| TLV2252AIDR  | SOIC         | D               | 8    | 2500 | 340.5       | 336.1      | 25.0        |
| TLV2252AIPWR | TSSOP        | PW              | 8    | 2000 | 853.0       | 449.0      | 35.0        |
| TLV2252IDR   | SOIC         | D               | 8    | 2500 | 340.5       | 336.1      | 25.0        |
| TLV2254AIDR  | SOIC         | D               | 14   | 2500 | 350.0       | 350.0      | 43.0        |
| TLV2254AIPWR | TSSOP        | PW              | 14   | 2000 | 853.0       | 449.0      | 35.0        |
| TLV2254IDR   | SOIC         | D               | 14   | 2500 | 350.0       | 350.0      | 43.0        |

## TUBE



\*All dimensions are nominal

| Device        | Package Name | Package Type | Pins | SPQ | L (mm) | W (mm) | T (μm) | B (mm) |
|---------------|--------------|--------------|------|-----|--------|--------|--------|--------|
| TLV2252AID    | D            | SOIC         | 8    | 75  | 507    | 8      | 3940   | 4.32   |
| TLV2252AID    | D            | SOIC         | 8    | 75  | 505.46 | 6.76   | 3810   | 4      |
| TLV2252AIDG4  | D            | SOIC         | 8    | 75  | 507    | 8      | 3940   | 4.32   |
| TLV2252AIDG4  | D            | SOIC         | 8    | 75  | 505.46 | 6.76   | 3810   | 4      |
| TLV2252AIP    | P            | PDIP         | 8    | 50  | 506    | 13.97  | 11230  | 4.32   |
| TLV2252AIPW   | PW           | TSSOP        | 8    | 150 | 530    | 10.2   | 3600   | 3.5    |
| TLV2252AIPWG4 | PW           | TSSOP        | 8    | 150 | 530    | 10.2   | 3600   | 3.5    |
| TLV2252ID     | D            | SOIC         | 8    | 75  | 505.46 | 6.76   | 3810   | 4      |
| TLV2252ID     | D            | SOIC         | 8    | 75  | 507    | 8      | 3940   | 4.32   |
| TLV2252IP     | P            | PDIP         | 8    | 50  | 506    | 13.97  | 11230  | 4.32   |
| TLV2254AID    | D            | SOIC         | 14   | 50  | 505.46 | 6.76   | 3810   | 4      |
| TLV2254AIN    | N            | PDIP         | 14   | 25  | 506    | 13.97  | 11230  | 4.32   |
| TLV2254AIPW   | PW           | TSSOP        | 14   | 90  | 530    | 10.2   | 3600   | 3.5    |
| TLV2254AQD    | D            | SOIC         | 14   | 50  | 505.46 | 6.76   | 3810   | 4      |
| TLV2254ID     | D            | SOIC         | 14   | 50  | 505.46 | 6.76   | 3810   | 4      |
| TLV2254IDG4   | D            | SOIC         | 14   | 50  | 505.46 | 6.76   | 3810   | 4      |
| TLV2254IN     | N            | PDIP         | 14   | 25  | 506    | 13.97  | 11230  | 4.32   |

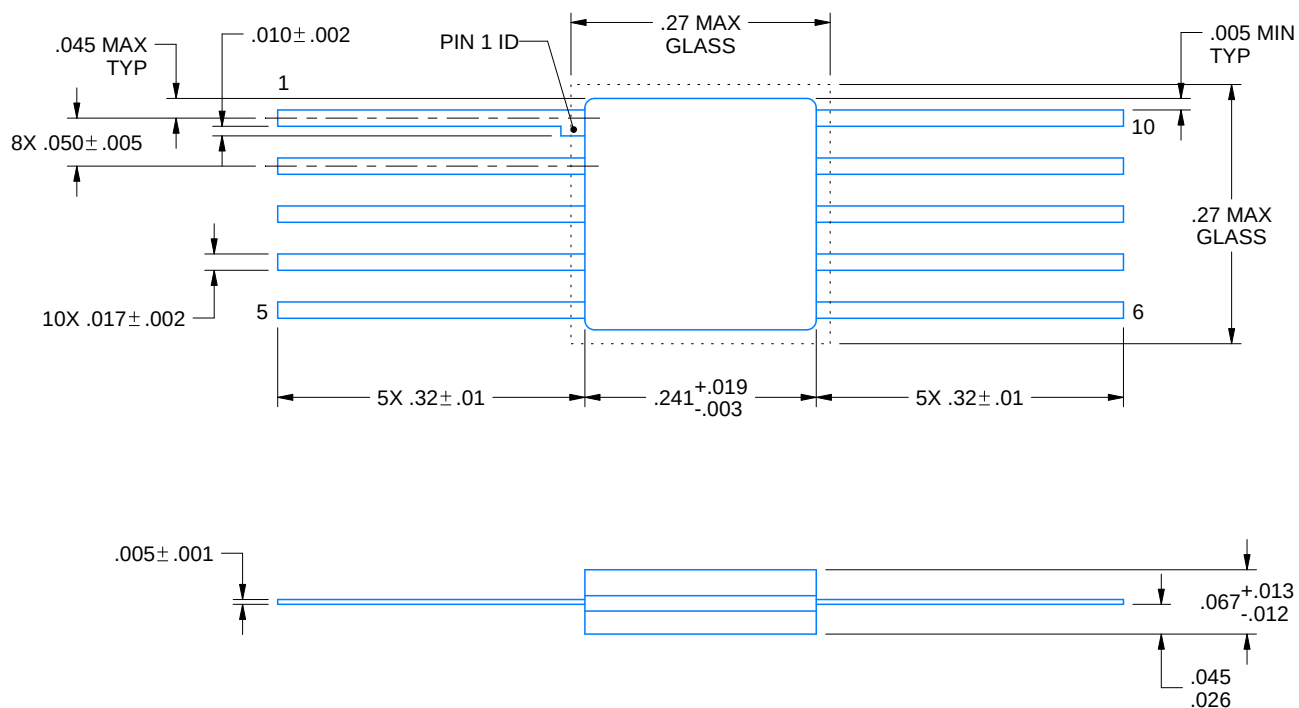
U0010A



## PACKAGE OUTLINE

CFP - 2.03 mm max height

CERAMIC FLATPACK



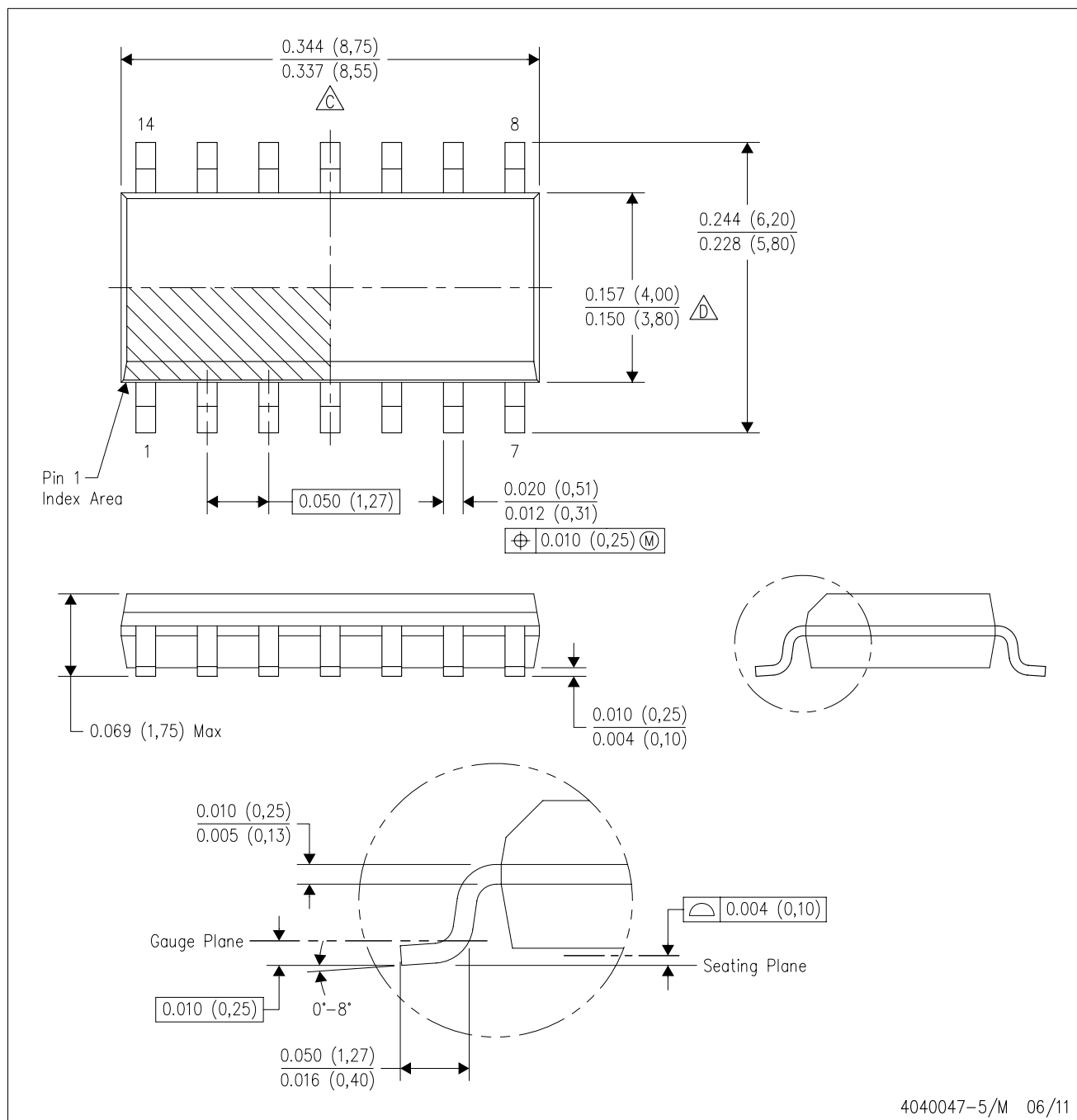
4225582/A 01/2020

### NOTES:

1. All linear dimensions are in inches. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.

D (R-PDSO-G14)

PLASTIC SMALL OUTLINE



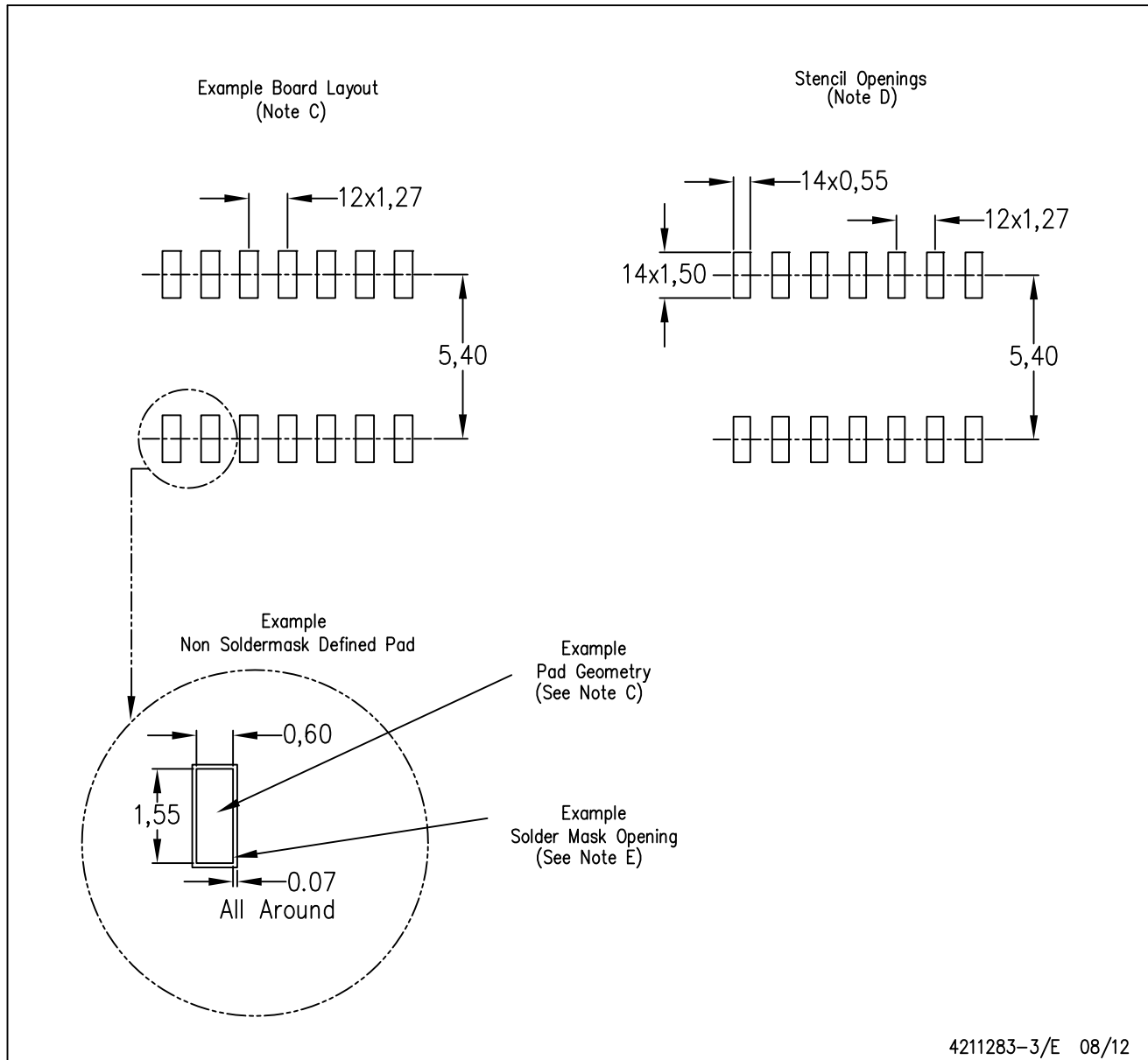
NOTES:

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



D (R-PDSO-G14)

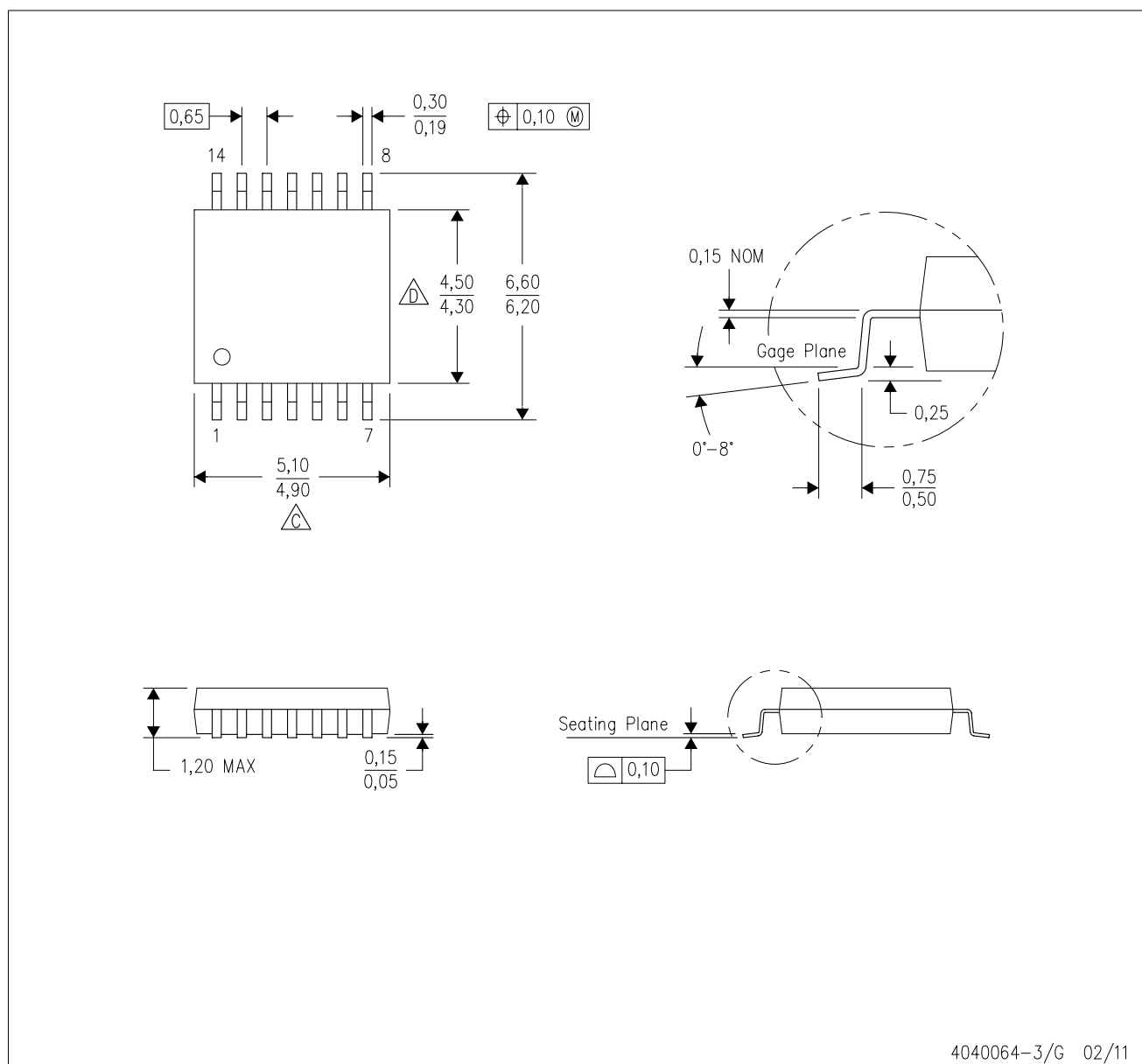
PLASTIC SMALL OUTLINE



- 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.

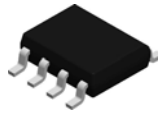
PW (R-PDSO-G14)

PLASTIC SMALL OUTLINE



4040064-3/G 02/11

- NOTES:
- A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
  - B. This drawing is subject to change without notice.
  - C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0,15 each side.
  - D. Body width does not include interlead flash. Interlead flash shall not exceed 0,25 each side.
  - E. Falls within JEDEC MO-153

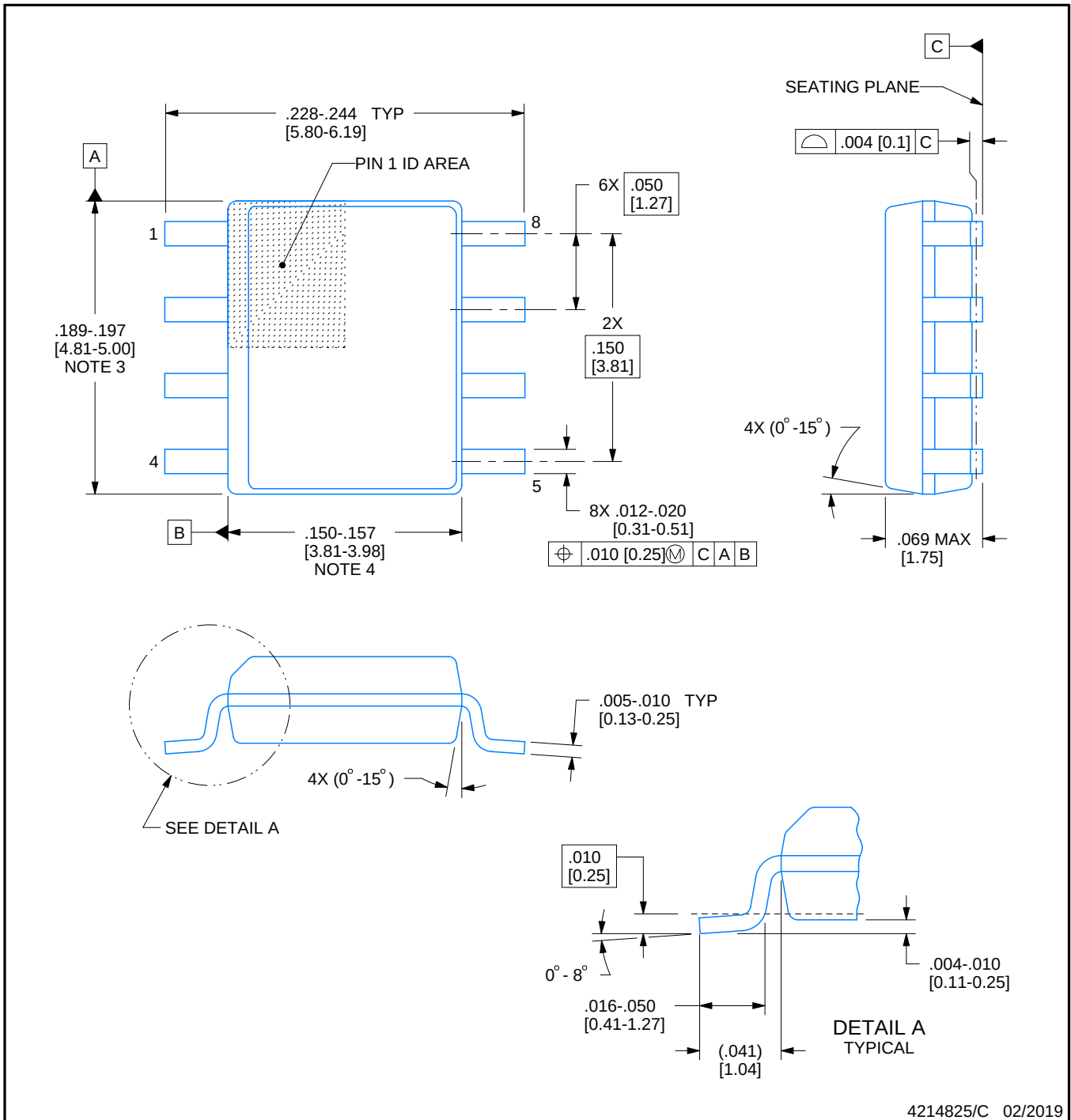


**D0008A**

# PACKAGE OUTLINE

**SOIC - 1.75 mm max height**

SMALL OUTLINE INTEGRATED CIRCUIT



4214825/C 02/2019

## NOTES:

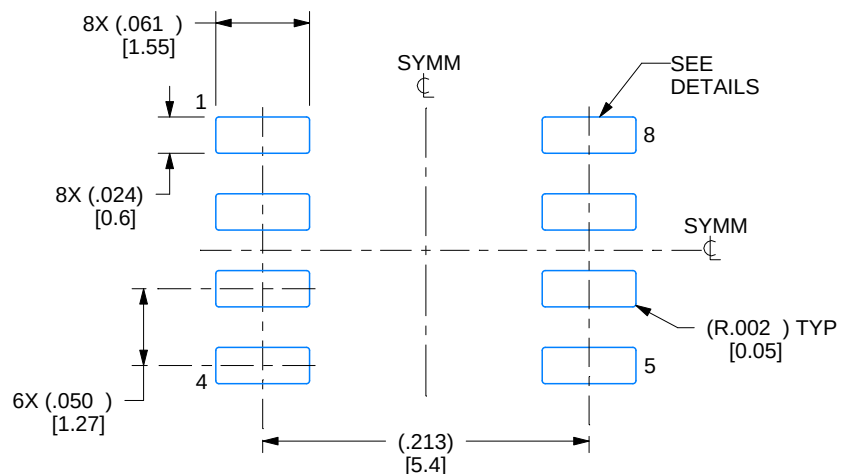
1. Linear dimensions are in inches [millimeters]. Dimensions in parenthesis are for reference only. Controlling dimensions are in inches. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed .006 [0.15] per side.
4. This dimension does not include interlead flash.
5. Reference JEDEC registration MS-012, variation AA.

# EXAMPLE BOARD LAYOUT

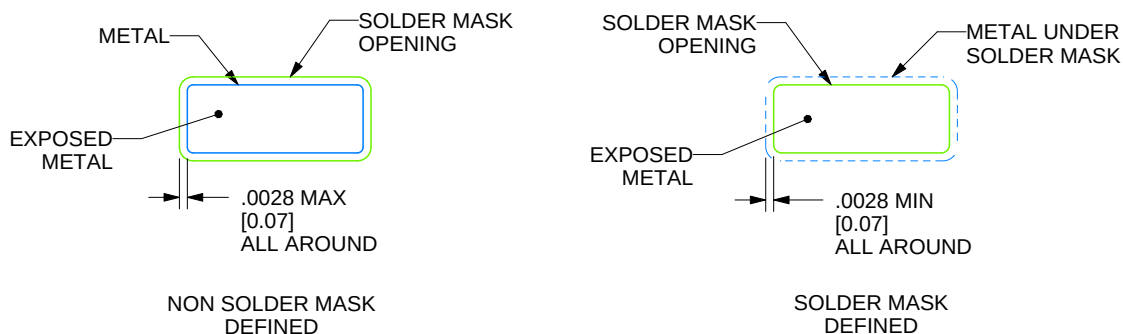
D0008A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



LAND PATTERN EXAMPLE  
EXPOSED METAL SHOWN  
SCALE:8X



SOLDER MASK DETAILS

4214825/C 02/2019

NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.

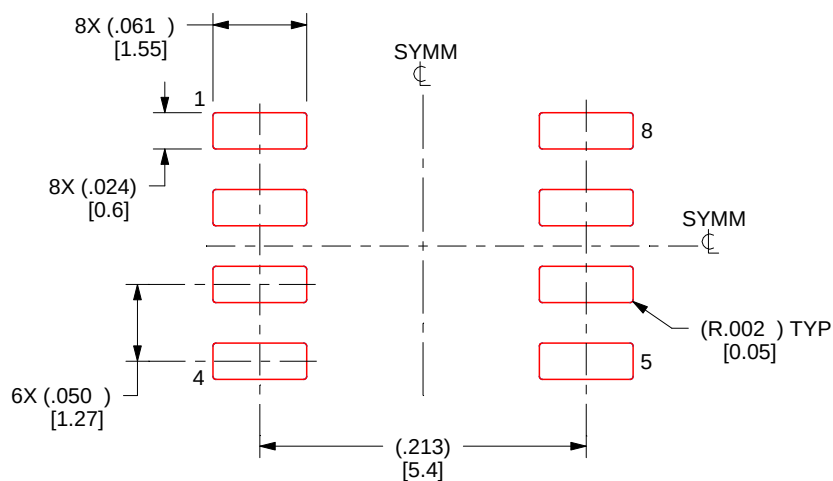
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

## EXAMPLE STENCIL DESIGN

D0008A

SOIC - 1.75 mm max height

SMALL OUTLINE INTEGRATED CIRCUIT



SOLDER PASTE EXAMPLE  
BASED ON .005 INCH [0.125 MM] THICK STENCIL  
SCALE:8X

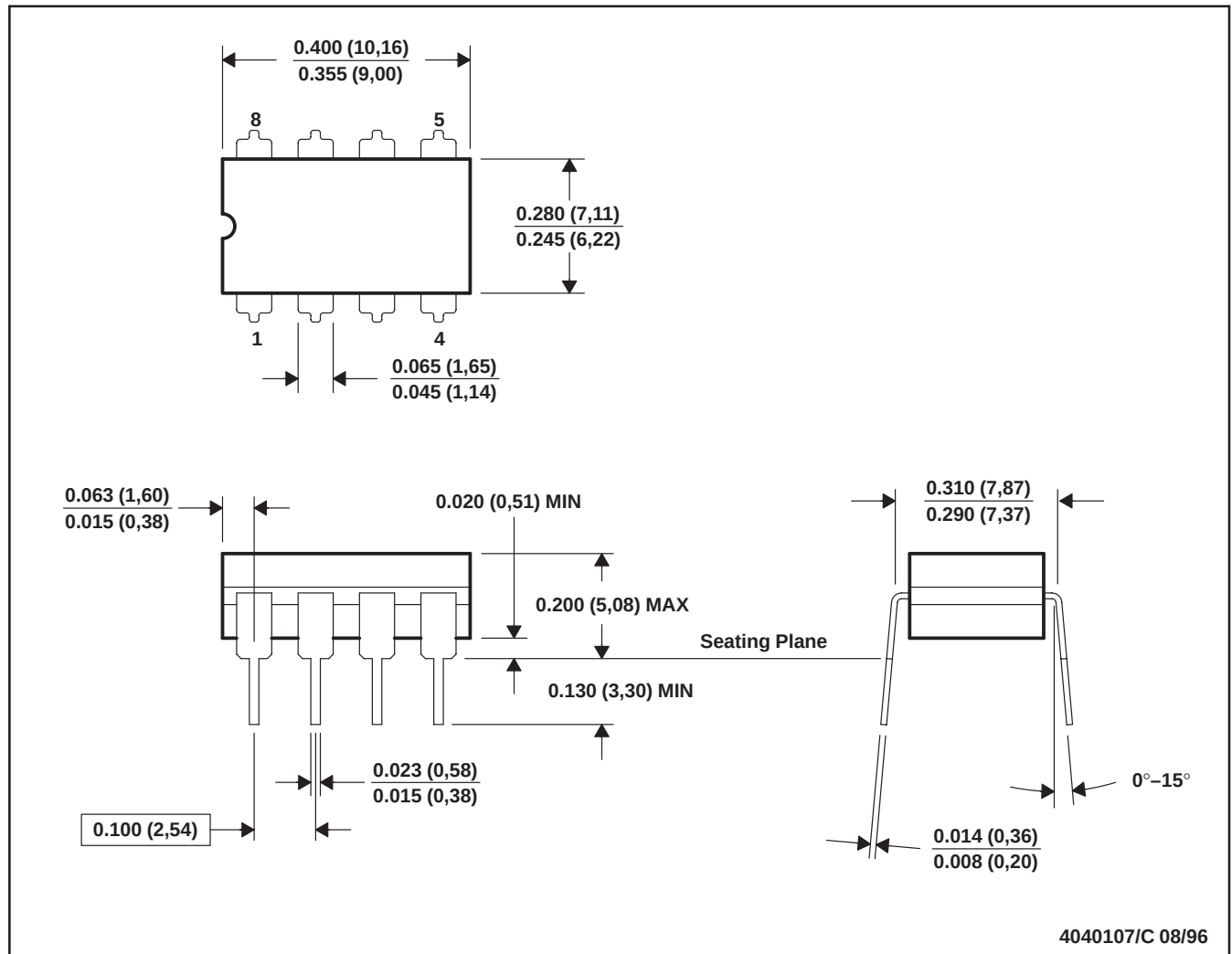
4214825/C 02/2019

NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

## JG (R-GDIP-T8)

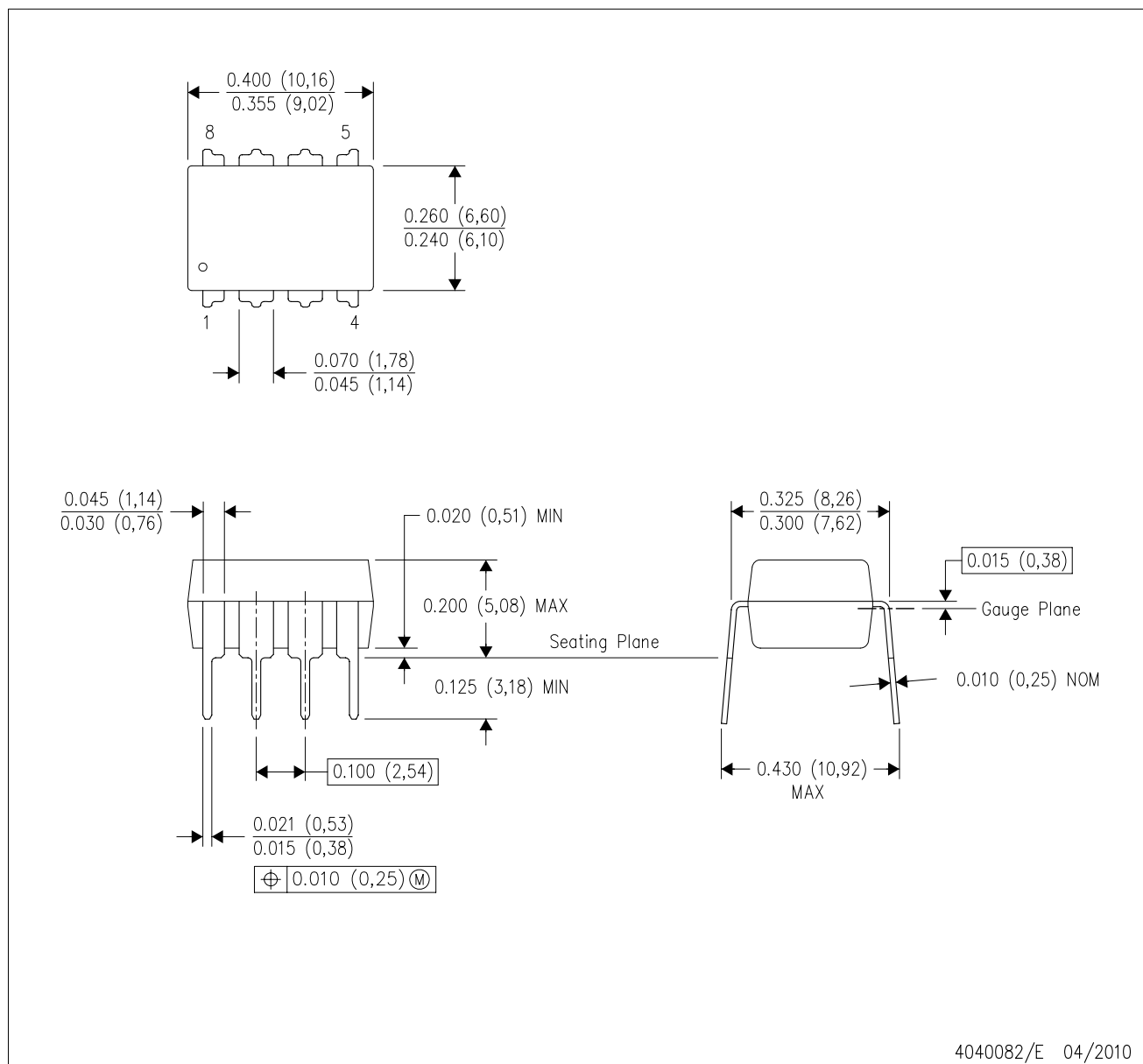
## CERAMIC DUAL-IN-LINE



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

P (R-PDIP-T8)

PLASTIC DUAL-IN-LINE PACKAGE

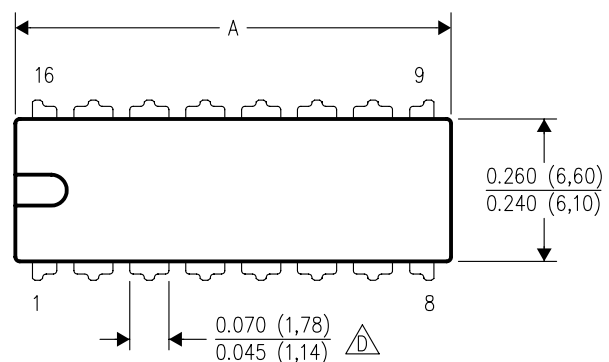


- NOTES:
- A. All linear dimensions are in inches (millimeters).
  - B. This drawing is subject to change without notice.
  - C. Falls within JEDEC MS-001 variation BA.

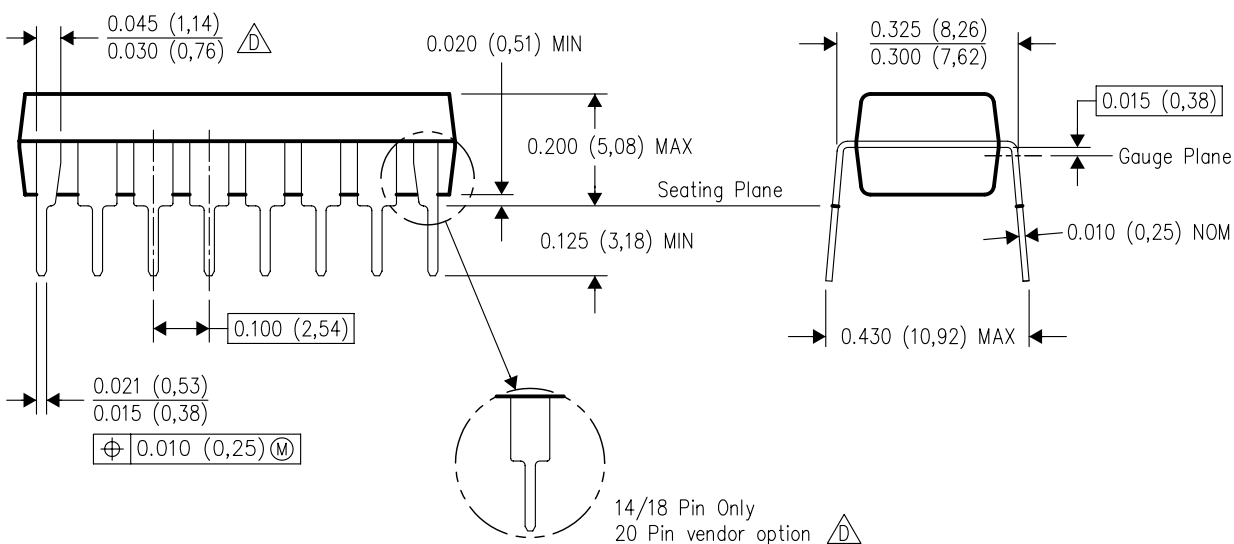
N (R-PDIP-T\*\*)

16 PINS SHOWN

## PLASTIC DUAL-IN-LINE PACKAGE



| PINS **<br>DIM      | 14               | 16               | 18               | 20               |
|---------------------|------------------|------------------|------------------|------------------|
| A MAX               | 0.775<br>(19,69) | 0.775<br>(19,69) | 0.920<br>(23,37) | 1.060<br>(26,92) |
| A MIN               | 0.745<br>(18,92) | 0.745<br>(18,92) | 0.850<br>(21,59) | 0.940<br>(23,88) |
| MS-001<br>VARIATION | AA               | BB               | AC               | AD               |



4040049/E 12/2002

NOTES:

- A. All linear dimensions are in inches (millimeters).  
B. This drawing is subject to change without notice.
-  Falls within JEDEC MS-001, except 18 and 20 pin minimum body length (Dim A).  
 The 20 pin end lead shoulder width is a vendor option, either half or full width.



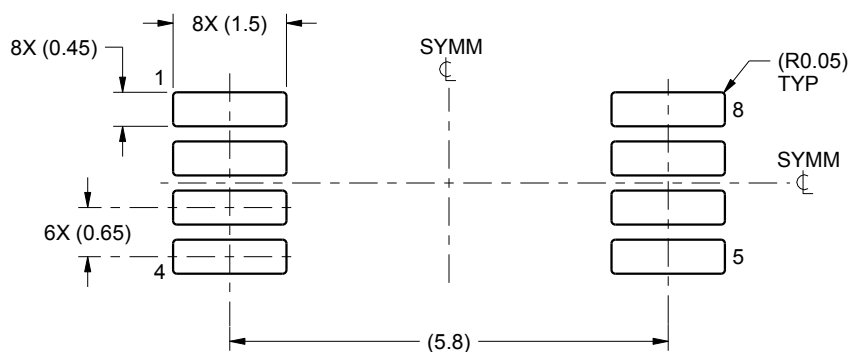


# EXAMPLE BOARD LAYOUT

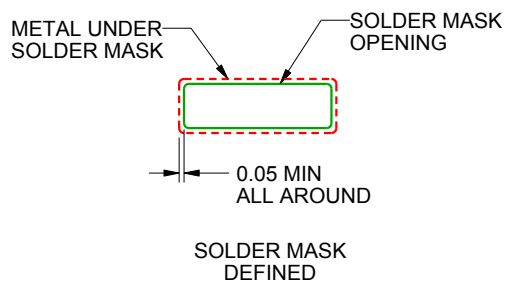
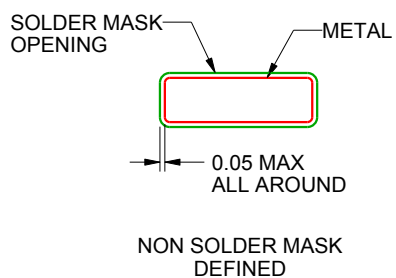
PW0008A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



LAND PATTERN EXAMPLE  
SCALE:10X



SOLDER MASK DETAILS  
NOT TO SCALE

4221848/A 02/2015

NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.

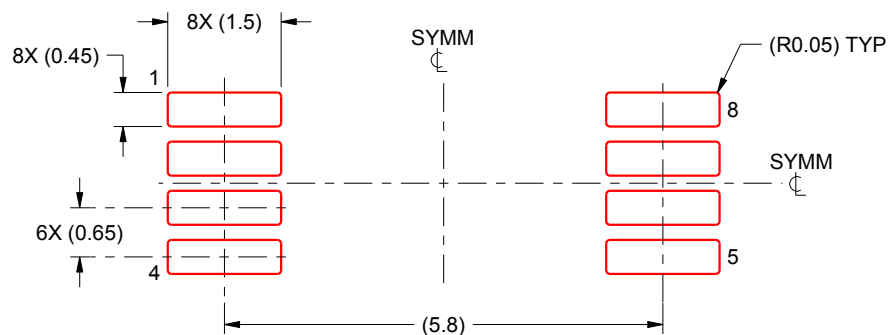
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.

## EXAMPLE STENCIL DESIGN

PW0008A

TSSOP - 1.2 mm max height

SMALL OUTLINE PACKAGE



SOLDER PASTE EXAMPLE  
BASED ON 0.125 mm THICK STENCIL  
SCALE:10X

4221848/A 02/2015

NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

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