

# TLV277x, TLV277xA

## FAMILY OF 2.7-V HIGH-SLEW-RATE RAIL-TO-RAIL OUTPUT OPERATIONAL AMPLIFIERS WITH SHUTDOWN

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- High Slew Rate . . . 10.5 V/ $\mu$ s Typ
- High-Gain Bandwidth . . . 5.1 MHz Typ
- Supply Voltage Range 2.5 V to 5.5 V
- Rail-to-Rail Output
- 360  $\mu$ V Input Offset Voltage
- Low Distortion Driving 600- $\Omega$   
0.005% THD+N
- 1 mA Supply Current (Per Channel)
- 17 nV/ $\sqrt{\text{Hz}}$  Input Noise Voltage
- 2 pA Input Bias Current
- Characterized From  $T_A = -55^\circ\text{C}$  to  $125^\circ\text{C}$
- Available in MSOP and SOT-23 Packages
- Micropower Shutdown Mode . . .  $I_{DD} < 1 \mu\text{A}$
- Available in Q-Temp Automotive  
High Reliability Automotive Applications  
Configuration Control / Print Support  
Qualification to Automotive Standards

### description

The TLV277x CMOS operational amplifier family combines high slew rate and bandwidth, rail-to-rail output swing, high output drive, and excellent dc precision. The device provides 10.5 V/ $\mu$ s of slew rate and 5.1 MHz of bandwidth while only consuming 1 mA of supply current per channel. This ac performance is much higher than current competitive CMOS amplifiers. The rail-to-rail output swing and high output drive make these devices a good choice for driving the analog input or reference of analog-to-digital converters. These devices also have low distortion while driving a 600- $\Omega$  load for use in telecom systems.

These amplifiers have a 360- $\mu$ V input offset voltage, a 17 nV/ $\sqrt{\text{Hz}}$  input noise voltage, and a 2-pA input bias current for measurement, medical, and industrial applications. The TLV277x family is also specified across an extended temperature range ( $-40^\circ\text{C}$  to  $125^\circ\text{C}$ ), making it useful for automotive systems, and the military temperature range ( $-55^\circ\text{C}$  to  $125^\circ\text{C}$ ), for military systems.

These devices operate from a 2.5-V to 5.5-V single supply voltage and are characterized at 2.7 V and 5 V. The single-supply operation and low power consumption make these devices a good solution for portable applications. The following table lists the packages available.

FAMILY PACKAGE TABLE

| DEVICE  | NUMBER OF CHANNELS | PACKAGE TYPES |      |      |        |       |      |      |      | SHUTDOWN | UNIVERSAL EVM BOARD                             |
|---------|--------------------|---------------|------|------|--------|-------|------|------|------|----------|-------------------------------------------------|
|         |                    | PDIP          | CDIP | SOIC | SOT-23 | TSSOP | MSOP | LCCC | CPAK |          |                                                 |
| TLV2770 | 1                  | 8             | —    | 8    | —      | —     | 8    | —    | —    | Yes      | Refer to the EVM Selection Guide (Lit# SLOU060) |
| TLV2771 | 1                  | —             | —    | 8    | 5      | —     | —    | —    | —    | —        |                                                 |
| TLV2772 | 2                  | 8             | 8    | 8    | —      | 8     | 8    | 20   | 10   | —        |                                                 |
| TLV2773 | 2                  | 14            | —    | 14   | —      | —     | 10   | —    | —    | Yes      |                                                 |
| TLV2774 | 4                  | 14            | —    | 14   | —      | 14    | —    | —    | —    | —        |                                                 |
| TLV2775 | 4                  | 16            | —    | 16   | —      | 16    | —    | —    | —    | Yes      |                                                 |

A SELECTION OF SINGLE-SUPPLY OPERATIONAL AMPLIFIER PRODUCTS<sup>†</sup>

| DEVICE  | V <sub>DD</sub> (V) | BW (MHz) | SLEW RATE (V/ $\mu$ s) | I <sub>DD</sub> (per channel) ( $\mu$ A) | RAIL-TO-RAIL |
|---------|---------------------|----------|------------------------|------------------------------------------|--------------|
| TLV277X | 2.5 – 6.0           | 5.1      | 10.5                   | 1000                                     | O            |
| TLV247X | 2.7 – 6.0           | 2.8      | 1.5                    | 600                                      | I/O          |
| TLV245X | 2.7 – 6.0           | 0.22     | 0.11                   | 23                                       | I/O          |
| TLV246X | 2.7 – 6.0           | 6.4      | 1.6                    | 550                                      | I/O          |

<sup>†</sup> All specifications measured at 5 V.



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.

This document contains information on products in more than one phase of development. The status of each device is indicated on the page(s) specifying its electrical characteristics.

  
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On products compliant to MIL-PRF-38535, all parameters are tested unless otherwise noted. On all other products, production processing does not necessarily include testing of all parameters.

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### TLV2770 and TLV2771 AVAILABLE OPTIONS

| T <sub>A</sub> | V <sub>IO</sub> max AT 25°C (mV) | PACKAGED DEVICES         |                  |                               |                 |
|----------------|----------------------------------|--------------------------|------------------|-------------------------------|-----------------|
|                |                                  | SMALL OUTLINE (D)        | SOT-23 (DBV)     | MSOP (DGK)                    | PLASTIC DIP (P) |
| 0°C to 70°C    | 2.5                              | TLV2770CD<br>TLV2771CD   | —<br>TLV2771CDBV | TLV2770CDGK <sup>†</sup><br>— | TLV2770CP<br>—  |
| –40°C to 125°C | 2.5                              | TLV2770ID<br>TLV2771ID   | —<br>TLV2771IDBV | TLV2770IDGK <sup>†</sup><br>— | TLV2770IP<br>—  |
|                | 1.6                              | TLV2770AID<br>TLV2771AID | —<br>—           | —<br>—                        | TLV2770AIP<br>— |

<sup>†</sup> This device is in the Product Preview stage of development. Please contact your local TI sales office for availability.

### TLV2772 and TLV2773 AVAILABLE OPTIONS

| T <sub>A</sub> | V <sub>IO</sub> max AT 25°C (mV) | PACKAGED DEVICES         |                  |                  |                 |                 |
|----------------|----------------------------------|--------------------------|------------------|------------------|-----------------|-----------------|
|                |                                  | SMALL OUTLINE (D)        | MSOP (DGK)       | MSOP (DGS)       | PLASTIC DIP (N) | PLASTIC DIP (P) |
| 0°C to 70°C    | 2.5                              | TLV2772CD<br>TLV2773CD   | TLV2772CDGK<br>— | —<br>TLV2773CDGS | —<br>TLV2773CN  | TLV2772CP<br>—  |
| –40°C to 125°C | 2.5                              | TLV2772ID<br>TLV2773ID   | TLV2772IDGK<br>— | —<br>TLV2773IDGS | —<br>TLV2773IN  | TLV2772IP<br>—  |
|                | 1.6                              | TLV2772AID<br>TLV2773AID | —<br>—           | —<br>—           | —<br>TLV2773AIN | TLV2772AIP<br>— |

### TLV2774 and TLV2775 AVAILABLE OPTIONS

| T <sub>A</sub> | V <sub>IO</sub> max AT 25°C (mV) | PACKAGED DEVICES         |                 |                 |                            |
|----------------|----------------------------------|--------------------------|-----------------|-----------------|----------------------------|
|                |                                  | SMALL OUTLINE (D)        | PLASTIC DIP (N) | PLASTIC DIP (P) | TSSOP (PW)                 |
| 0°C to 70°C    | 2.7                              | TLV2774CD<br>TLV2775CD   | —<br>TLV2775CN  | TLV2774CP<br>—  | TLV2774CPW<br>TLV2775CPW   |
| –40°C to 125°C | 2.7                              | TLV2774ID<br>TLV2775ID   | —<br>TLV2775IN  | TLV2774IP<br>—  | TLV2774IPW<br>TLV2775IPW   |
|                | 2.1                              | TLV2774AID<br>TLV2775AID | —<br>TLV2775AIN | TLV2774AIP<br>— | TLV2774AIPW<br>TLV2775AIPW |

### TLV2772M/Q AND TLV2772AM/Q AVAILABLE OPTIONS

| T <sub>A</sub> | V <sub>IO</sub> max AT 25°C (mV) | PACKAGED DEVICES        |                   |                  |                      |                          |
|----------------|----------------------------------|-------------------------|-------------------|------------------|----------------------|--------------------------|
|                |                                  | SMALL OUTLINE (D)       | CHIP CARRIER (FK) | CERAMIC DIP (JG) | CERAMIC FLATPACK (U) | TSSOP (PW)               |
| –40°C to 125°C | 2.5                              | TLV2772QD <sup>‡</sup>  | —                 | —                | —                    | TLV2772QPW <sup>‡</sup>  |
|                | 1.6                              | TLV2772AQD <sup>‡</sup> | —                 | —                | —                    | TLV2772AQPW <sup>‡</sup> |
| –55°C to 125°C | 2.5                              | TLV2772MD               | TLV2772MFK        | TLV2772MJG       | TLV2772MU            | —                        |
|                | 1.6                              | TLV2772AMD              | TLV2772AMFK       | TLV2772AMJG      | TLV2772AMU           | —                        |

<sup>‡</sup> Available in tape and reel

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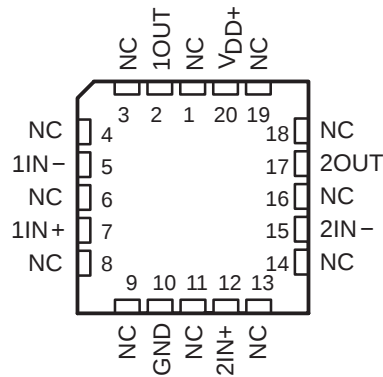
## **PACKAGE SYMBOLS**

| PACKAGE TYPE | PINS   | PART NUMBER | SYMBOL <sup>†</sup> |
|--------------|--------|-------------|---------------------|
| SOT23        | 5 Pin  | TLV2771CDBV | VAMC                |
|              |        | TLV2771IDBV | VAMI                |
| MSOP         | 8 Pin  | TLV2770CDGK | xxTIABO             |
|              |        | TLV2770IDGK | xxTIABP             |
|              |        | TLV2772CDGK | xxTIAAF             |
|              |        | TLV2772IDGK | xxTIAAG             |
|              | 10 Pin | TLV2773CDGS | xxTIABQ             |
|              |        | TLV2773IDGS | xxTIABR             |

<sup>†</sup> xx represents the device date code.

## **TLV277x PACKAGE PINOUT**

### **TLV2772M AND TLV2772AM FK PACKAGE (TOP VIEW)**



NC – No internal connection

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#### TLV277x PACKAGE PINOUTS<sup>(1)</sup>



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(1) SOT-23 may or may not be indicated

#### TYPICAL PIN 1 INDICATORS



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

|                                                                   |                              |
|-------------------------------------------------------------------|------------------------------|
| Supply voltage, $V_{DD}$ (see Note 1)                             | 7 V                          |
| Differential input voltage, $V_{ID}$ (see Note 2)                 | $\pm V_{DD}$                 |
| Input voltage range, $V_I$ (any input, see Note 1)                | -0.3 V to $V_{DD}$           |
| Input current, $I_I$ (any input)                                  | $\pm 4$ mA                   |
| Output current, $I_O$                                             | $\pm 50$ mA                  |
| Total current into $V_{DD+}$                                      | $\pm 50$ mA                  |
| Total current out of GND                                          | $\pm 50$ mA                  |
| Duration of short-circuit current (at or below) 25°C (see Note 3) | unlimited                    |
| Continuous total power dissipation                                | See Dissipation Rating Table |
| Operating free-air temperature range, $T_A$ : C suffix            | 0°C to 70°C                  |
| I suffix                                                          | -40°C to 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      | 260°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 GND.
  2. Differential voltages are at the noninverting input with respect to the inverting input. Excessive current flows when input is brought below GND - 0.3 V.
  3. The output may be shorted to either supply. Temperature and/or supply voltages must be limited to ensure that the maximum dissipation rating is not exceeded.

**DISSIPATION RATING TABLE**

| PACKAGE | $T_A \leq 25^\circ\text{C}$<br>POWER RATING | DERATING FACTOR<br>ABOVE $T_A = 25^\circ\text{C}$ | $T_A = 70^\circ\text{C}$<br>POWER RATING | $T_A = 85^\circ\text{C}$<br>POWER RATING | $T_A = 125^\circ\text{C}$<br>POWER RATING |
|---------|---------------------------------------------|---------------------------------------------------|------------------------------------------|------------------------------------------|-------------------------------------------|
| D       | 725 mW                                      | 5.8 mW/°C                                         | 464 mW                                   | 377 mW                                   | 145 mW                                    |
| DBV     | 437 mW                                      | 3.5 mW/°C                                         | 280 mW                                   | 227 mW                                   | 87 mW                                     |
| DGK     | 424 mW                                      | 3.4 mW/°C                                         | 271 mW                                   | 220 mW                                   | 85 mW                                     |
| DGS     | 424 mW                                      | 3.4 mW/°C                                         | 271 mW                                   | 220 mW                                   | 85 mW                                     |
| FK      | 1375 mW                                     | 11.0 mW/°C                                        | 672 mW                                   | 546 mW                                   | 210 mW                                    |
| JG      | 1050 mW                                     | 8.4 mW/°C                                         | 880 mW                                   | 714 mW                                   | 275 mW                                    |
| N       | 1150 mW                                     | 9.2 mW/°C                                         | 736 mW                                   | 598 mW                                   | 230 mW                                    |
| P       | 1000 mW                                     | 8.0 mW/°C                                         | 640 mW                                   | 520 mW                                   | 200 mW                                    |
| PW      | 700 mW                                      | 5.6 mW/°C                                         | 448 mW                                   | 364 mW                                   | 140 mW                                    |
| U       | 675 mW                                      | 5.4 mW/°C                                         | 432 mW                                   | 350 mW                                   | 135 mW                                    |

### recommended operating conditions

|                                       | C SUFFIX |                 | I SUFFIX |                 | Q SUFFIX |                 | M SUFFIX |                 | UNIT |
|---------------------------------------|----------|-----------------|----------|-----------------|----------|-----------------|----------|-----------------|------|
|                                       | MIN      | MAX             | MIN      | MAX             | MIN      | MAX             | MIN      | MAX             |      |
| Supply voltage, $V_{DD}$              | 2.5      | 6               | 2.5      | 6               | 2.5      | 6               | 2.5      | 6               | V    |
| Input voltage range, $V_I$            | GND      | $V_{DD+} - 1.3$ | GND      | $V_{DD+} - 1.3$ | GND      | $V_{DD+} - 1.3$ | GND      | $V_{DD+} - 1.3$ | V    |
| Common-mode input voltage, $V_{IC}$   | GND      | $V_{DD+} - 1.3$ | GND      | $V_{DD+} - 1.3$ | GND      | $V_{DD+} - 1.3$ | GND      | $V_{DD+} - 1.3$ | V    |
| Operating free-air temperature, $T_A$ | 0        | 70              | -40      | 125             | -40      | 125             | -55      | 125             | °C   |

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electrical characteristics at specified free-air temperature,  $V_{DD} = 2.7$  V (unless otherwise noted)

| PARAMETER      |                                                                    | TEST CONDITIONS                                   | $T_A^\dagger$                        | TLV277xC   |                  |     | UNIT             |
|----------------|--------------------------------------------------------------------|---------------------------------------------------|--------------------------------------|------------|------------------|-----|------------------|
|                |                                                                    |                                                   |                                      | MIN        | TYP              | MAX |                  |
| $V_{IO}$       | Input offset voltage                                               | $V_{IC} = 0$ ,<br>$R_S = 50\ \Omega$ ,<br>No load | $V_O = 0$ ,<br>$V_{DD} = \pm 1.35$ V | 25°C       | 0.48             | 2.5 | mV               |
|                |                                                                    |                                                   |                                      | Full range | 0.53             | 2.7 |                  |
|                |                                                                    |                                                   |                                      | 25°C       | 0.8              | 2.7 |                  |
|                |                                                                    |                                                   |                                      | Full range | 0.86             | 2.9 |                  |
| $\alpha_{VIO}$ | Temperature coefficient of input offset voltage                    |                                                   | 25°C to 125°C                        |            | 2                |     | $\mu V/^\circ C$ |
| $I_{IO}$       | Input offset current                                               | $V_{IC} = 0$ ,<br>$R_S = 50\ \Omega$              | $V_O = 0$ ,<br>$V_{DD} = \pm 1.35$ V | 25°C       | 1                | 60  | pA               |
|                |                                                                    |                                                   |                                      | Full range | 2                | 100 |                  |
| $I_{IB}$       | Input bias current                                                 |                                                   |                                      | 25°C       | 2                | 60  | pA               |
|                |                                                                    |                                                   |                                      | Full range | 6                | 100 |                  |
| $V_{OH}$       | High-level output voltage                                          | $I_{OH} = -0.675$ mA                              |                                      | 25°C       | 2.6              |     | V                |
|                |                                                                    |                                                   |                                      | Full range | 2.5              |     |                  |
|                |                                                                    | $I_{OH} = -2.2$ mA                                |                                      | 25°C       | 2.4              |     |                  |
|                |                                                                    |                                                   |                                      | Full range | 2.1              |     |                  |
| $V_{OL}$       | Low-level output voltage                                           | $V_{IC} = 1.35$ V, $I_{OL} = 0.675$ mA            |                                      | 25°C       | 0.1              |     | V                |
|                |                                                                    |                                                   |                                      | Full range | 0.2              |     |                  |
|                |                                                                    | $V_{IC} = 1.35$ V, $I_{OL} = 2.2$ mA              |                                      | 25°C       | 0.21             |     |                  |
|                |                                                                    |                                                   |                                      | Full range | 0.6              |     |                  |
| $A_{VD}$       | Large-signal differential voltage amplification                    | $V_{IC} = 1.35$ V,<br>$V_O = 0.6$ V to 2.1 V      | $R_L = 10$ k $\Omega$ ,              | 25°C       | 20               | 380 | V/mV             |
|                |                                                                    |                                                   |                                      | Full range | 13               |     |                  |
| $r_{i(d)}$     | Differential input resistance                                      |                                                   |                                      | 25°C       | 10 <sup>12</sup> |     | $\Omega$         |
| $c_{i(c)}$     | Common-mode input capacitance                                      | $f = 10$ kHz                                      |                                      | 25°C       | 8                |     | pF               |
| $z_o$          | Closed-loop output impedance                                       | $f = 100$ kHz, $A_V = 10$                         |                                      | 25°C       | 25               |     | $\Omega$         |
| CMRR           | Common-mode rejection ratio                                        | $V_{IC} = 0$ to 1.5 V,<br>$R_S = 50\ \Omega$      | $V_O = V_{DD}/2$ ,                   | 25°C       | 60               | 84  | dB               |
|                |                                                                    |                                                   |                                      | Full range | 60               | 82  |                  |
| $k_{SVR}$      | Supply voltage rejection ratio ( $\Delta V_{DD} / \Delta V_{IO}$ ) | $V_{DD} = 2.7$ V to 5 V,<br>No load               | $V_{IC} = V_{DD}/2$ ,                | 25°C       | 70               | 89  | dB               |
|                |                                                                    |                                                   |                                      | Full range | 70               | 84  |                  |
| $I_{DD}$       | Supply current (per channel)                                       | $V_O = V_{DD}/2$ ,<br>No load                     |                                      | 25°C       | 1                | 2   | mA               |
|                |                                                                    |                                                   |                                      | Full range |                  | 2   |                  |
| $I_{DD(SHDN)}$ | Supply current in shutdown (per channel)                           |                                                   |                                      | 25°C       | 0.8              | 1.5 | $\mu A$          |
|                |                                                                    |                                                   |                                      | Full range | 1.3              | 2   |                  |
| $V_{(ON)}$     | Turnon voltage level                                               | TLV2770                                           | $A_V = 5$                            | 25°C       | 1.47             |     | V                |
|                |                                                                    | TLV2773                                           |                                      |            | 1.43             |     |                  |
|                |                                                                    | TLV2775                                           |                                      |            | 1.40             |     |                  |
| $V_{(OFF)}$    | Turnoff voltage level                                              | TLV2770                                           | $A_V = 5$                            | 25°C       | 1.27             |     | V                |
|                |                                                                    | TLV2773                                           |                                      |            | 1.21             |     |                  |
|                |                                                                    | TLV2775                                           |                                      |            | 1.20             |     |                  |

$^\dagger$  Full range is 0°C to 70°C.

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operating characteristics at specified free-air temperature,  $V_{DD} = 2.7\text{ V}$  (unless otherwise noted)

| PARAMETER              |                                             | TEST CONDITIONS                                                                           |                         | T <sub>A</sub> <sup>†</sup> | TLV277xC |     |        | UNIT |
|------------------------|---------------------------------------------|-------------------------------------------------------------------------------------------|-------------------------|-----------------------------|----------|-----|--------|------|
|                        |                                             |                                                                                           |                         |                             | MIN      | TYP | MAX    |      |
| SR                     | Slew rate at unity gain                     | V <sub>O(PP)</sub> = 0.8 V, C <sub>L</sub> = 100 pF,<br>R <sub>L</sub> = 10 kΩ            |                         | 25°C                        | 5        | 9   | V/μs   |      |
|                        |                                             |                                                                                           |                         | Full range                  | 4.7      | 6   |        |      |
| V <sub>n</sub>         | Equivalent input noise voltage              | f = 1 kHz                                                                                 |                         | 25°C                        | 21       |     | nV/√Hz |      |
|                        |                                             | f = 10 kHz                                                                                |                         | 25°C                        | 17       |     |        |      |
| V <sub>N(PP)</sub>     | Peak-to-peak equivalent input noise voltage | f = 0.1 Hz to 1 Hz                                                                        |                         | 25°C                        | 0.33     |     | μV     |      |
|                        |                                             | f = 0.1 Hz to 10 Hz                                                                       |                         |                             | 0.86     |     |        |      |
| I <sub>n</sub>         | Equivalent input noise current              | f = 100 Hz                                                                                |                         | 25°C                        | 0.6      |     | fA/√Hz |      |
| THD + N                | Total harmonic distortion plus noise        | R <sub>L</sub> = 600 Ω,<br>f = 1 kHz                                                      | A <sub>V</sub> = 1      | 25°C                        | 0.0085%  |     |        |      |
|                        |                                             |                                                                                           | A <sub>V</sub> = 10     |                             | 0.025%   |     |        |      |
|                        |                                             |                                                                                           | A <sub>V</sub> = 100    |                             | 0.12%    |     |        |      |
| Gain-bandwidth product |                                             | f = 10 kHz,<br>C <sub>L</sub> = 100 pF                                                    | R <sub>L</sub> = 600 Ω, | 25°C                        | 4.8      |     | MHz    |      |
| t <sub>s</sub>         | Settling time                               | A <sub>V</sub> = −1,<br>Step = 1 V,<br>R <sub>L</sub> = 600 Ω,<br>C <sub>L</sub> = 100 pF | 0.1%                    | 25°C                        | 0.186    |     | μs     |      |
|                        |                                             |                                                                                           | 0.01%                   | 25°C                        | 0.3      |     |        |      |
| φ <sub>m</sub>         | Phase margin at unity gain                  | R <sub>L</sub> = 600 Ω, C <sub>L</sub> = 100 pF                                           |                         | 25°C                        | 46°      |     |        |      |
|                        | Gain margin                                 |                                                                                           |                         | 25°C                        | 12       |     | dB     |      |

$^\dagger$  Full range is 0°C to 70°C.

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

| PARAMETER              |                                                                      | TEST CONDITIONS                                           | T <sub>A</sub> <sup>†</sup>                      | TLV277xC                  |                  |     | UNIT  |   |
|------------------------|----------------------------------------------------------------------|-----------------------------------------------------------|--------------------------------------------------|---------------------------|------------------|-----|-------|---|
|                        |                                                                      |                                                           |                                                  | MIN                       | TYP              | MAX |       |   |
| V <sub>IO</sub>        | Input offset voltage                                                 | V <sub>IC</sub> = 0,<br>R <sub>S</sub> = 50 Ω,<br>No load | V <sub>O</sub> = 0,<br>V <sub>DD</sub> = ±2.5 V, | 25°C                      | 0.5              | 2.5 | mV    |   |
|                        |                                                                      |                                                           |                                                  | Full range                | 0.6              | 2.7 |       |   |
|                        |                                                                      |                                                           |                                                  | 25°C                      | 0.7              | 2.5 |       |   |
|                        |                                                                      |                                                           |                                                  | Full range                | 0.78             | 2.7 |       |   |
| α <sub>VIO</sub>       | Temperature coefficient of input offset voltage                      | V <sub>IC</sub> = 0,<br>R <sub>S</sub> = 50 Ω             | V <sub>O</sub> = 0,<br>V <sub>DD</sub> = ±2.5 V  | 25°C to 125°C             | 2                |     | μV/°C |   |
| I <sub>IO</sub>        | Input offset current                                                 |                                                           |                                                  | 25°C                      | 1                | 60  | pA    |   |
|                        |                                                                      |                                                           |                                                  | Full range                | 2                | 100 |       |   |
| I <sub>IB</sub>        | Input bias current                                                   |                                                           |                                                  | 25°C                      | 2                | 60  | pA    |   |
|                        |                                                                      |                                                           |                                                  | Full range                | 6                | 100 |       |   |
| V <sub>OH</sub>        | High-level output voltage                                            |                                                           |                                                  | I <sub>OH</sub> = −1.3 mA | 25°C             | 4.9 |       | V |
|                        |                                                                      |                                                           |                                                  | I <sub>OH</sub> = −4.2 mA | Full range       | 4.8 |       |   |
|                        |                                                                      |                                                           |                                                  |                           | 25°C             | 4.7 |       |   |
|                        |                                                                      | Full range                                                | 4.4                                              |                           |                  |     |       |   |
| V <sub>OL</sub>        | Low-level output voltage                                             | V <sub>IC</sub> = 2.5 V, I <sub>OL</sub> = 1.3 mA         | 25°C                                             | 0.1                       |                  | V   |       |   |
|                        |                                                                      | V <sub>IC</sub> = 2.5 V, I <sub>OL</sub> = 4.2 mA         | Full range                                       | 0.2                       |                  |     |       |   |
|                        |                                                                      |                                                           | 25°C                                             | 0.21                      |                  |     |       |   |
|                        |                                                                      |                                                           | Full range                                       | 0.6                       |                  |     |       |   |
| A <sub>VD</sub>        | Large-signal differential voltage amplification                      | V <sub>IC</sub> = 2.5 V,<br>V <sub>O</sub> = 1 V to 4 V   | R <sub>L</sub> = 10 kΩ,                          | 25°C                      | 20               | 450 | V/mV  |   |
|                        |                                                                      |                                                           |                                                  | Full range                | 13               |     |       |   |
| r <sub>i(d)</sub>      | Differential input resistance                                        |                                                           |                                                  | 25°C                      | 10 <sup>12</sup> |     | Ω     |   |
| c <sub>i(c)</sub>      | Common-mode input capacitance                                        | f = 10 kHz                                                |                                                  | 25°C                      | 8                |     | pF    |   |
| z <sub>O</sub>         | Closed-loop output impedance                                         | f = 100 kHz,                                              | A <sub>V</sub> = 10                              | 25°C                      | 20               |     | Ω     |   |
| CMRR                   | Common-mode rejection ratio                                          | V <sub>IC</sub> = 0 to 3.7 V,<br>R <sub>S</sub> = 50 Ω    | V <sub>O</sub> = V <sub>DD</sub> /2,             | 25°C                      | 70               | 96  | dB    |   |
|                        |                                                                      |                                                           |                                                  | Full range                | 70               | 93  |       |   |
| k <sub>SVR</sub>       | Supply voltage rejection ratio (ΔV <sub>DD</sub> /ΔV <sub>IO</sub> ) | V <sub>DD</sub> = 2.7 V to 5 V,<br>No load                | V <sub>IC</sub> = V <sub>DD</sub> /2,            | 25°C                      | 70               | 89  | dB    |   |
|                        |                                                                      |                                                           |                                                  | Full range                | 70               | 84  |       |   |
| I <sub>DD</sub>        | Supply current (per channel)                                         | V <sub>O</sub> = V <sub>DD</sub> /2,                      | No load                                          | 25°C                      | 1                | 2   | mA    |   |
|                        |                                                                      |                                                           |                                                  | Full range                | 2                |     |       |   |
| I <sub>DD</sub> (SHDN) | Supply current in shutdown (per channel)                             |                                                           |                                                  | 25°C                      | 0.8              | 1.5 | μA    |   |
|                        |                                                                      |                                                           |                                                  | Full range                | 1.3              | 2   |       |   |
| V <sub>(ON)</sub>      | Turnon voltage level                                                 | A <sub>V</sub> = 5                                        | 25°C                                             | 2.59                      |                  |     | V     |   |
|                        |                                                                      |                                                           |                                                  | 2.47                      |                  |     |       |   |
|                        |                                                                      |                                                           |                                                  | 2.48                      |                  |     |       |   |
| V <sub>(OFF)</sub>     | Turnoff voltage level                                                | A <sub>V</sub> = 5                                        | 25°C                                             | 2.41                      |                  |     | V     |   |
|                        |                                                                      |                                                           |                                                  | 2.32                      |                  |     |       |   |
|                        |                                                                      |                                                           |                                                  | 2.29                      |                  |     |       |   |

<sup>†</sup> Full range is 0°C to 70°C.

**TLV277x, TLV277xA**  
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operating characteristics at specified free-air temperature,  $V_{DD} = 5\text{ V}$  (unless otherwise noted)

| PARAMETER              |                                             |      | TEST CONDITIONS                                                                           |                                                                        | T <sub>A</sub> <sup>†</sup> | TLV277xC   |     |        | UNIT |
|------------------------|---------------------------------------------|------|-------------------------------------------------------------------------------------------|------------------------------------------------------------------------|-----------------------------|------------|-----|--------|------|
|                        |                                             |      |                                                                                           |                                                                        |                             | MIN        | TYP | MAX    |      |
| SR                     | Slew rate at unity gain                     |      | V <sub>O(PP)</sub> = 2 V,<br>R <sub>L</sub> = 10 kΩ                                       |                                                                        | C <sub>L</sub> = 100 pF,    | 25°C       | 5   | 10.5   | V/μs |
|                        |                                             |      |                                                                                           |                                                                        |                             | Full range | 4.7 | 6      |      |
| V <sub>n</sub>         | Equivalent input noise voltage              |      | f = 1 kHz                                                                                 | 25°C                                                                   |                             | 17         |     | nV/√Hz |      |
|                        |                                             |      | f = 10 kHz                                                                                | 25°C                                                                   |                             | 12         |     |        |      |
| V <sub>N(PP)</sub>     | Peak-to-peak equivalent input noise voltage |      | f = 0.1 Hz to 1 Hz                                                                        | 25°C                                                                   |                             | 0.33       |     | μV     |      |
|                        |                                             |      | f = 0.1 Hz to 10 Hz                                                                       |                                                                        |                             | 0.86       |     |        |      |
| I <sub>n</sub>         | Equivalent input noise current              |      | f = 100 Hz                                                                                | 25°C                                                                   |                             | 0.6        |     | fA/√Hz |      |
| THD + N                | Total harmonic distortion plus noise        |      | R <sub>L</sub> = 600 Ω,<br>f = 1 kHz                                                      | A <sub>V</sub> = 1                                                     | 25°C                        | 0.005%     |     |        |      |
|                        |                                             |      |                                                                                           | A <sub>V</sub> = 10                                                    |                             | 0.016%     |     |        |      |
|                        |                                             |      |                                                                                           | A <sub>V</sub> = 100                                                   |                             | 0.095%     |     |        |      |
| Gain-bandwidth product |                                             |      | f = 10 kHz,<br>C <sub>L</sub> = 100 pF                                                    | R <sub>L</sub> = 600 Ω,                                                | 25°C                        | 5.1        |     | MHz    |      |
| t <sub>s</sub>         | Settling time                               |      | A <sub>V</sub> = -1,<br>Step = 2 V,<br>R <sub>L</sub> = 600 Ω,<br>C <sub>L</sub> = 100 pF | 0.1%                                                                   | 25°C                        | 0.335      |     | μs     |      |
|                        |                                             |      |                                                                                           | 0.01%                                                                  | 25°C                        | 0.6        |     |        |      |
| φ <sub>m</sub>         | Phase margin at unity gain                  |      | R <sub>L</sub> = 600 Ω,<br>C <sub>L</sub> = 100 pF                                        |                                                                        | 25°C                        | 46°        |     |        |      |
| Gain margin            |                                             | 25°C |                                                                                           |                                                                        | 12                          |            | dB  |        |      |
| t <sub>(ON)</sub>      | Amplifier turnon time                       |      | TLV2770                                                                                   | A <sub>V</sub> = 5,<br>R <sub>L</sub> = Open,<br>Measured to 50% point | 25°C                        | 1.2        |     | μs     |      |
|                        |                                             |      |                                                                                           |                                                                        |                             | TLV2773    | 2.4 |        |      |
|                        |                                             |      |                                                                                           |                                                                        |                             | TLV2775    | 1.9 |        |      |
| t <sub>(OFF)</sub>     | Amplifier turnoff time                      |      | TLV2770                                                                                   | A <sub>V</sub> = 5<br>R <sub>L</sub> = Open,<br>Measured to 50% point  | 25°C                        | 335        |     | ns     |      |
|                        |                                             |      |                                                                                           |                                                                        |                             | TLV2773    | 444 |        |      |
|                        |                                             |      |                                                                                           |                                                                        |                             | TLV2775    | 345 |        |      |

$^\dagger$  Full range is 0°C to 70°C.

# TLV277x, TLV277xA

## FAMILY OF 2.7-V HIGH-SLEW-RATE RAIL-TO-RAIL OUTPUT

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electrical characteristics at specified free-air temperature,  $V_{DD} = 2.7\text{ V}$  (unless otherwise noted)

| PARAMETER      |                                                                  | TEST CONDITIONS                                                                                  | $T_A^\dagger$ | TLV277xI         |     |     | TLV277xAI        |     |     | UNIT                         |
|----------------|------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|---------------|------------------|-----|-----|------------------|-----|-----|------------------------------|
|                |                                                                  |                                                                                                  |               | MIN              | TYP | MAX | MIN              | TYP | MAX |                              |
| $V_{IO}$       | Input offset voltage                                             | TLV2770/1/2<br>$V_{IC} = 0, V_O = 0,$<br>$R_S = 50\ \Omega$                                      | 25°C          | 0.48             | 2.5 |     | 0.48             | 1.6 |     | mV                           |
|                |                                                                  |                                                                                                  | Full range    | 0.53             | 2.7 |     | 0.53             | 1.9 |     |                              |
|                | TLV2773/4/5                                                      | $V_{DD} = \pm 1.35\text{ V},$<br>No load                                                         | 25°C          | 0.8              | 2.7 |     | 0.8              | 2.1 |     |                              |
|                |                                                                  |                                                                                                  | Full range    | 0.86             | 2.9 |     | 0.86             | 2.2 |     |                              |
| $\alpha_{VIO}$ | Temperature coefficient of input offset voltage                  |                                                                                                  | 25°C to 125°C | 2                |     |     | 2                |     |     | $\mu\text{V}/^\circ\text{C}$ |
| $I_{IO}$       | Input offset current                                             | $V_{IC} = 0, V_O = 0,$<br>$R_S = 50\ \Omega$                                                     | 25°C          | 1                | 60  |     | 1                | 60  |     | pA                           |
|                |                                                                  |                                                                                                  | Full range    | 2                | 125 |     | 2                | 125 |     |                              |
| $I_{IB}$       | Input bias current                                               |                                                                                                  | 25°C          | 2                | 60  |     | 2                | 60  |     | pA                           |
|                |                                                                  |                                                                                                  | Full range    | 6                | 350 |     | 6                | 350 |     |                              |
| $V_{OH}$       | High-level output voltage                                        | $I_{OH} = -0.675\text{ mA}$                                                                      | 25°C          | 2.6              |     |     | 2.6              |     |     | V                            |
|                |                                                                  |                                                                                                  | Full range    | 2.5              |     |     | 2.5              |     |     |                              |
|                |                                                                  | $I_{OH} = -2.2\text{ mA}$                                                                        | 25°C          | 2.4              |     |     | 2.4              |     |     |                              |
|                |                                                                  |                                                                                                  | Full range    | 2.1              |     |     | 2.1              |     |     |                              |
| $V_{OL}$       | Low-level output voltage                                         | $V_{IC} = 1.35\text{ V},$<br>$I_{OL} = 0.675\text{ mA}$                                          | 25°C          | 0.1              |     |     | 0.1              |     |     | V                            |
|                |                                                                  |                                                                                                  | Full range    | 0.2              |     |     | 0.2              |     |     |                              |
|                |                                                                  | $V_{IC} = 1.35\text{ V},$<br>$I_{OL} = 2.2\text{ mA}$                                            | 25°C          | 0.21             |     |     | 0.21             |     |     |                              |
|                |                                                                  |                                                                                                  | Full range    | 0.6              |     |     | 0.6              |     |     |                              |
| $A_{VD}$       | Large-signal differential voltage amplification                  | $V_{IC} = 1.35\text{ V},$<br>$R_L = 10\text{ k}\Omega,$<br>$V_O = 0.6\text{ V to } 2.1\text{ V}$ | 25°C          | 20               | 380 |     | 20               | 380 |     | V/mV                         |
|                |                                                                  |                                                                                                  | Full range    | 13               |     |     | 13               |     |     |                              |
| $r_{i(d)}$     | Differential input resistance                                    |                                                                                                  | 25°C          | 10 <sup>12</sup> |     |     | 10 <sup>12</sup> |     |     | $\Omega$                     |
| $c_{i(c)}$     | Common-mode input capacitance                                    | $f = 10\text{ kHz},$                                                                             | 25°C          | 8                |     |     | 8                |     |     | pF                           |
| $z_o$          | Closed-loop output impedance                                     | $f = 100\text{ kHz},$<br>$A_V = 10$                                                              | 25°C          | 25               |     |     | 25               |     |     | $\Omega$                     |
| CMRR           | Common-mode rejection ratio                                      | $V_{IC} = 0\text{ to } 1.5\text{ V},$<br>$V_O = V_{DD}/2,$<br>$R_S = 50\ \Omega$                 | 25°C          | 60               | 84  |     | 60               | 84  |     | dB                           |
|                |                                                                  |                                                                                                  | Full range    | 60               | 82  |     | 60               | 82  |     |                              |
| $k_{SVR}$      | Supply voltage rejection ratio ( $\Delta V_{DD}/\Delta V_{IO}$ ) | $V_{DD} = 2.7\text{ V to } 5\text{ V},$<br>$V_{IC} = V_{DD}/2,$<br>No load                       | 25°C          | 70               | 89  |     | 70               | 89  |     | dB                           |
|                |                                                                  |                                                                                                  | Full range    | 70               | 84  |     | 70               | 84  |     |                              |
| $I_{DD}$       | Supply current (per channel)                                     | $V_O = V_{DD}/2,$<br>No load                                                                     | 25°C          | 1                | 2   |     | 1                | 2   |     | mA                           |
|                |                                                                  |                                                                                                  | Full range    |                  | 2   |     |                  | 2   |     |                              |
| $I_{DD(SHDN)}$ | Supply current in shutdown (per channel)                         |                                                                                                  | 25°C          | 0.8              | 1.5 |     | 0.8              | 1.5 |     | $\mu\text{A}$                |
|                |                                                                  |                                                                                                  | Full range    | 1.3              | 2   |     | 1.3              | 2   |     |                              |

<sup>†</sup> Full range is  $-40^\circ\text{C}$  to  $125^\circ\text{C}$ .

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**electrical characteristics at specified free-air temperature,  $V_{DD} = 2.7$  V (unless otherwise noted)**  
**(continued)**

| PARAMETER          |                       | TEST CONDITIONS | T <sub>A</sub> <sup>†</sup> | TLV277xI |      |     | TLV277xAI |      |     | UNIT |   |
|--------------------|-----------------------|-----------------|-----------------------------|----------|------|-----|-----------|------|-----|------|---|
|                    |                       |                 |                             | MIN      | TYP  | MAX | MIN       | TYP  | MAX |      |   |
| V <sub>(ON)</sub>  | Turnon voltage level  | TLV2770         | A <sub>V</sub> = 5          | 25°C     | 1.47 |     |           | 1.47 |     |      | V |
|                    |                       | TLV2773         |                             |          | 1.43 |     |           | 1.43 |     |      |   |
|                    |                       | TLV2775         |                             |          | 1.40 |     |           | 1.4  |     |      |   |
| V <sub>(OFF)</sub> | Turnoff voltage level | TLV2770         | A <sub>V</sub> = 5          | 25°C     | 1.27 |     |           | 1.27 |     |      | V |
|                    |                       | TLV2773         |                             |          | 1.21 |     |           | 1.21 |     |      |   |
|                    |                       | TLV2775         |                             |          | 1.20 |     |           | 1.2  |     |      |   |

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

**operating characteristics at specified free-air temperature,  $V_{DD} = 2.7$  V (unless otherwise noted)**

| PARAMETER              |                                             | TEST CONDITIONS                                                                               |                      | T <sub>A</sub> <sup>†</sup> | TLV277xI |     |     | TLV277xAI |     |     | UNIT   |
|------------------------|---------------------------------------------|-----------------------------------------------------------------------------------------------|----------------------|-----------------------------|----------|-----|-----|-----------|-----|-----|--------|
|                        |                                             |                                                                                               |                      |                             | MIN      | TYP | MAX | MIN       | TYP | MAX |        |
| SR                     | Slew rate at unity gain                     | V <sub>O(PP)</sub> = 0.8 V, C <sub>L</sub> = 100 pF, R <sub>L</sub> = 10 kΩ                   |                      | 25°C                        | 5        | 9   |     | 5         | 9   |     | V/μs   |
|                        |                                             |                                                                                               |                      | Full range                  | 4.7      | 6   |     | 4.7       | 6   |     |        |
| V <sub>n</sub>         | Equivalent input noise voltage              | f = 1 kHz                                                                                     |                      | 25°C                        | 21       |     |     | 21        |     |     | nV/√Hz |
|                        |                                             | f = 10 kHz                                                                                    |                      | 25°C                        | 17       |     |     | 17        |     |     |        |
| V <sub>N(PP)</sub>     | Peak-to-peak equivalent input noise voltage | f = 0.1 Hz to 1 Hz                                                                            |                      | 25°C                        | 0.33     |     |     | 0.33      |     |     | μV     |
|                        |                                             | f = 0.1 Hz to 10 Hz                                                                           |                      | 25°C                        | 0.86     |     |     | 0.86      |     |     | μV     |
| I <sub>n</sub>         | Equivalent input noise current              | f = 100 Hz                                                                                    |                      | 25°C                        | 0.6      |     |     | 0.6       |     |     | fA/√Hz |
| THD + N                | Total harmonic distortion plus noise        | R <sub>L</sub> = 600 Ω, f = 1 kHz                                                             | A <sub>V</sub> = 1   | 25°C                        | 0.0085%  |     |     | 0.0085%   |     |     |        |
|                        |                                             |                                                                                               | A <sub>V</sub> = 10  |                             | 0.025%   |     |     | 0.025%    |     |     |        |
|                        |                                             |                                                                                               | A <sub>V</sub> = 100 |                             | 0.12%    |     |     | 0.12%     |     |     |        |
| Gain-bandwidth product |                                             | f = 10 kHz, R <sub>L</sub> = 600 Ω, C <sub>L</sub> = 100 pF                                   |                      | 25°C                        | 4.8      |     |     | 4.8       |     |     | MHz    |
| t <sub>s</sub>         | Settling time                               | A <sub>V</sub> = −1, Step = 0.85 V to 1.85 V, R <sub>L</sub> = 600 Ω, C <sub>L</sub> = 100 pF | 0.1%                 | 25°C                        | 0.186    |     |     | 0.186     |     |     | μs     |
|                        |                                             |                                                                                               | 0.01%                | 25°C                        | 3.92     |     |     | 3.92      |     |     |        |
| φ <sub>m</sub>         | Phase margin at unity gain                  | R <sub>L</sub> = 600 Ω, C <sub>L</sub> = 100 pF                                               |                      | 25°C                        | 46°      |     |     | 46°       |     |     |        |
| Gain margin            |                                             |                                                                                               |                      | 25°C                        | 12       |     |     | 12        |     |     | dB     |

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

# TLV277x, TLV277xA

## FAMILY OF 2.7-V HIGH-SLEW-RATE RAIL-TO-RAIL OUTPUT OPERATIONAL AMPLIFIERS WITH SHUTDOWN

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

| PARAMETER              |                                                                      | TEST CONDITIONS                                                                                           | T <sub>A</sub> <sup>†</sup> | TLV277xI         |     |          | TLV277xAI        |       |     | UNIT |
|------------------------|----------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------|-----------------------------|------------------|-----|----------|------------------|-------|-----|------|
|                        |                                                                      |                                                                                                           |                             | MIN              | TYP | MAX      | MIN              | TYP   | MAX |      |
| V <sub>IO</sub>        | Input offset voltage                                                 | V <sub>IC</sub> = 0, No load<br>V <sub>O</sub> = 0,<br>R <sub>S</sub> = 50 Ω,<br>V <sub>DD</sub> = ±2.5 V | 25°C                        | 0.5 2.5          |     | 0.5 1.6  |                  | mV    |     |      |
|                        |                                                                      |                                                                                                           | Full range                  | 0.6 2.7          |     | 0.6 1.9  |                  |       |     |      |
|                        |                                                                      |                                                                                                           | 25°C                        | 0.7 2.5          |     | 0.7 2.1  |                  |       |     |      |
|                        |                                                                      |                                                                                                           | Full range                  | 0.78 2.7         |     | 0.78 2.2 |                  |       |     |      |
| α <sub>VIO</sub>       | Temperature coefficient of input offset voltage                      | V <sub>IC</sub> = 0,<br>V <sub>O</sub> = 0,<br>R <sub>S</sub> = 50 Ω,<br>V <sub>DD</sub> = ±2.5 V         | 25°C to 125°C               | 2                |     | 2        |                  | μV/°C |     |      |
| I <sub>IO</sub>        | Input offset current                                                 |                                                                                                           | 25°C                        | 1 60             |     | 1 60     |                  | pA    |     |      |
| I <sub>IB</sub>        | Input bias current                                                   |                                                                                                           | Full range                  | 2 125            |     | 2 125    |                  |       |     |      |
|                        |                                                                      |                                                                                                           | 25°C                        | 2 60             |     | 2 60     |                  | pA    |     |      |
|                        |                                                                      |                                                                                                           | Full range                  | 6 350            |     | 6 350    |                  |       |     |      |
|                        |                                                                      |                                                                                                           |                             |                  |     |          |                  |       |     |      |
| V <sub>OH</sub>        | High-level output voltage                                            | I <sub>OH</sub> = −1.3 mA                                                                                 | 25°C                        | 4.9              |     | 4.9      |                  | V     |     |      |
|                        |                                                                      |                                                                                                           | Full range                  | 4.8              |     | 4.8      |                  |       |     |      |
|                        |                                                                      | I <sub>OH</sub> = −4.2 mA                                                                                 | 25°C                        | 4.7              |     | 4.7      |                  |       |     |      |
|                        |                                                                      |                                                                                                           | Full range                  | 4.4              |     | 4.4      |                  |       |     |      |
| V <sub>OL</sub>        | Low-level output voltage                                             | V <sub>IC</sub> = 2.5 V,<br>I <sub>OL</sub> = 1.3 mA                                                      | 25°C                        | 0.1              |     | 0.1      |                  | V     |     |      |
|                        |                                                                      |                                                                                                           | Full range                  | 0.2              |     | 0.2      |                  |       |     |      |
|                        |                                                                      | V <sub>IC</sub> = 2.5 V,<br>I <sub>OL</sub> = 4.2 mA                                                      | 25°C                        | 0.21             |     | 0.21     |                  |       |     |      |
|                        |                                                                      |                                                                                                           | Full range                  | 0.6              |     | 0.6      |                  |       |     |      |
| A <sub>VD</sub>        | Large-signal differential voltage amplification                      | V <sub>IC</sub> = 2.5 V,<br>R <sub>L</sub> = 10 kΩ,<br>V <sub>O</sub> = 1 V to 4 V                        | 25°C                        | 20               | 450 | 20       | 450              | V/mV  |     |      |
|                        |                                                                      |                                                                                                           | Full range                  | 13               |     | 13       |                  |       |     |      |
| r <sub>i(d)</sub>      | Differential 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                                                                                                | 25°C                        | 8                |     |          | 8                | pF    |     |      |
| z <sub>o</sub>         | Closed-loop output impedance                                         | f = 100 kHz,<br>A <sub>V</sub> = 10                                                                       | 25°C                        | 20               |     |          | 20               | Ω     |     |      |
| CMRR                   | Common-mode rejection ratio                                          | V <sub>IC</sub> = 0 to 3.7 V,<br>V <sub>O</sub> = V <sub>DD</sub> /2,<br>R <sub>S</sub> = 50 Ω            | 25°C                        | 60               | 96  | 70       | 96               | dB    |     |      |
|                        |                                                                      |                                                                                                           | Full range                  | 60               | 93  | 70       | 93               |       |     |      |
| k <sub>SVR</sub>       | Supply voltage rejection ratio (ΔV <sub>DD</sub> /ΔV <sub>IO</sub> ) | V <sub>DD</sub> = 2.7 V to 5 V,<br>V <sub>IC</sub> = V <sub>DD</sub> /2,<br>No load                       | 25°C                        | 70               | 89  | 70       | 89               | dB    |     |      |
|                        |                                                                      |                                                                                                           | Full range                  | 70               | 84  | 70       | 84               |       |     |      |
| I <sub>DD</sub>        | Supply current (per channel)                                         | V <sub>O</sub> = V <sub>DD</sub> /2,<br>No load                                                           | 25°C                        | 1                | 2   | 1        | 2                | mA    |     |      |
|                        |                                                                      |                                                                                                           | Full range                  | 2                |     | 2        |                  |       |     |      |
| I <sub>DD</sub> (SHDN) | Supply current shutdown (per channel)                                |                                                                                                           | 25°C                        | 0.8              | 1.5 | 0.8      | 1.5              | μA    |     |      |
|                        |                                                                      |                                                                                                           | Full range                  | 1.3              | 2   | 1.3      | 2                |       |     |      |

<sup>†</sup> Full range is  $-40^\circ\text{C}$  to  $125^\circ\text{C}$ .

**TLV277x, TLV277xA**  
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**electrical characteristics at specified free-air temperature,  $V_{DD} = 5\text{ V}$  (unless otherwise noted) (continued)**

| PARAMETER          |                       | TEST CONDITIONS | T <sub>A</sub> <sup>†</sup> | TLV277xI |      |     | TLV277xAI |      |     | UNIT |   |
|--------------------|-----------------------|-----------------|-----------------------------|----------|------|-----|-----------|------|-----|------|---|
|                    |                       |                 |                             | MIN      | TYP  | MAX | MIN       | TYP  | MAX |      |   |
| V <sub>(ON)</sub>  | Turnon voltage level  | TLV2770         | A <sub>V</sub> = 5          | 25°C     | 2.59 |     |           | 2.59 |     |      | V |
|                    |                       | TLV2773         |                             |          | 2.47 |     |           | 2.47 |     |      |   |
|                    |                       | TLV2775         |                             |          | 2.48 |     |           | 2.48 |     |      |   |
| V <sub>(OFF)</sub> | Turnoff voltage level | TLV2770         | A <sub>V</sub> = 5          | 25°C     | 2.41 |     |           | 2.41 |     |      | V |
|                    |                       | TLV2773         |                             |          | 2.32 |     |           | 2.32 |     |      |   |
|                    |                       | TLV2775         |                             |          | 2.29 |     |           | 2.29 |     |      |   |

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

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

| PARAMETER              |                                             |                                                                                                      | TEST CONDITIONS                                                        |            | T <sub>A</sub> <sup>†</sup> | TLV277xI |     |        | TLV277xAI |     |        | UNIT |
|------------------------|---------------------------------------------|------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------|------------|-----------------------------|----------|-----|--------|-----------|-----|--------|------|
|                        |                                             |                                                                                                      |                                                                        |            |                             | MIN      | TYP | MAX    | MIN       | TYP | MAX    |      |
| SR                     | Slew rate at unity gain                     | V <sub>O(PP)</sub> = 1.5 V, C <sub>L</sub> = 100 pF,<br>R <sub>L</sub> = 10 kΩ                       |                                                                        | 25°C       | 5                           | 10.5     |     | 5      | 10.5      |     | V/μs   |      |
|                        |                                             |                                                                                                      |                                                                        | Full range | 4.7                         | 6        |     | 4.7    | 6         |     |        |      |
| V <sub>n</sub>         | Equivalent input noise voltage              | f = 1 kHz                                                                                            |                                                                        | 25°C       | 17                          |          |     | 17     |           |     | nV/√Hz |      |
|                        |                                             | f = 10 kHz                                                                                           |                                                                        | 25°C       | 12                          |          |     | 12     |           |     |        |      |
| V <sub>N(PP)</sub>     | Peak-to-peak equivalent input noise voltage | f = 0.1 Hz to 1 Hz                                                                                   |                                                                        | 25°C       | 0.33                        |          |     | 0.33   |           |     | μV     |      |
|                        |                                             | f = 0.1 Hz to 10 Hz                                                                                  |                                                                        | 25°C       | 0.86                        |          |     | 0.86   |           |     | μV     |      |
| I <sub>n</sub>         | Equivalent input noise current              | f = 100 Hz                                                                                           |                                                                        | 25°C       | 0.6                         |          |     | 0.6    |           |     | fA/√Hz |      |
| THD + N                | Total harmonic distortion plus noise        | R <sub>L</sub> = 600 Ω,<br>f = 1 kHz                                                                 | A <sub>V</sub> = 1                                                     | 25°C       | 0.005%                      |          |     | 0.005% |           |     |        |      |
|                        |                                             |                                                                                                      | A <sub>V</sub> = 10                                                    |            | 0.016%                      |          |     | 0.016% |           |     |        |      |
|                        |                                             |                                                                                                      | A <sub>V</sub> = 100                                                   |            | 0.095%                      |          |     | 0.095% |           |     |        |      |
| Gain-bandwidth product |                                             | f = 10 kHz, R <sub>L</sub> = 600 Ω,<br>C <sub>L</sub> = 100 pF                                       |                                                                        | 25°C       | 5.1                         |          |     | 5.1    |           |     | MHz    |      |
| t <sub>s</sub>         | Settling time                               | A <sub>V</sub> = −1,<br>Step = 1.5 V to 3.5 V,<br>R <sub>L</sub> = 600 Ω,<br>C <sub>L</sub> = 100 pF | 0.1%                                                                   | 25°C       | 0.134                       |          |     | 0.134  |           |     | μs     |      |
|                        |                                             |                                                                                                      | 0.01%                                                                  | 25°C       | 1.97                        |          |     | 1.97   |           |     |        |      |
| φ <sub>m</sub>         | Phase margin at unity gain                  | R <sub>L</sub> = 600 Ω, C <sub>L</sub> = 100 pF                                                      |                                                                        | 25°C       | 46°                         |          |     | 46°    |           |     |        |      |
| Gain margin            |                                             |                                                                                                      |                                                                        | 25°C       | 12                          |          |     | 12     |           |     | dB     |      |
| t <sub>(ON)</sub>      | Amplifier turnon time                       | TLV2770                                                                                              | A <sub>V</sub> = 5,<br>R <sub>L</sub> = Open,<br>Measured to 50% point | 25°C       | 1.2                         |          |     | 1.2    |           |     | μs     |      |
|                        |                                             | TLV2773                                                                                              |                                                                        |            | 2.4                         |          |     | 2.4    |           |     |        |      |
|                        |                                             | TLV2775                                                                                              |                                                                        |            | 1.9                         |          |     | 1.9    |           |     |        |      |
| t <sub>(OFF)</sub>     | Amplifier turnoff time                      | TLV2770                                                                                              | A <sub>V</sub> = 5,<br>R <sub>L</sub> = Open,<br>Measured to 50% point | 25°C       | 335                         |          |     | 335    |           |     | ns     |      |
|                        |                                             | TLV2773                                                                                              |                                                                        |            | 444                         |          |     | 444    |           |     |        |      |
|                        |                                             | TLV2775                                                                                              |                                                                        |            | 345                         |          |     | 345    |           |     |        |      |

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

# TLV277x, TLV277xA

## FAMILY OF 2.7-V HIGH-SLEW-RATE RAIL-TO-RAIL OUTPUT OPERATIONAL AMPLIFIERS WITH SHUTDOWN

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electrical characteristics at specified free-air temperature,  $V_{DD} = 2.7\text{ V}$  (unless otherwise noted)

| PARAMETER                                                                  | TEST CONDITIONS                                                                                            | $T_A^\dagger$ | TLV2772Q<br>TLV2772M |             |     | TLV2772AQ<br>TLV2772AM |             |     | UNIT                         |
|----------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------|---------------|----------------------|-------------|-----|------------------------|-------------|-----|------------------------------|
|                                                                            |                                                                                                            |               | MIN                  | TYP         | MAX | MIN                    | TYP         | MAX |                              |
| $V_{IO}$ Input offset voltage                                              | $V_{DD} = \pm 1.35\text{ V}$ ,<br>$V_{IC} = 0$ ,<br>$R_S = 50\ \Omega$<br>$V_O = 0$                        | 25°C          |                      | 0.44        | 2.5 |                        | 0.44        | 1.6 | mV                           |
|                                                                            |                                                                                                            | Full range    |                      | 0.47        | 2.7 |                        | 0.47        | 1.9 |                              |
| $\alpha_{VIO}$ Temperature coefficient of input offset voltage             |                                                                                                            | 25°C to 125°C |                      | 2           |     |                        | 2           |     | $\mu\text{V}/^\circ\text{C}$ |
| $I_{IO}$ Input offset current                                              |                                                                                                            | 25°C          |                      | 1           | 60  |                        | 1           | 60  | pA                           |
|                                                                            |                                                                                                            | Full range    |                      | 2           | 125 |                        | 2           | 125 |                              |
| $I_{IB}$ Input bias current                                                |                                                                                                            | 25°C          |                      | 2           | 60  |                        | 2           | 60  | pA                           |
|                                                                            |                                                                                                            | Full range    |                      | 6           | 350 |                        | 6           | 350 |                              |
| $V_{ICR}$ Common-mode input voltage range                                  | CMRR > 60 dB, $R_S = 50\ \Omega$                                                                           | 25°C          | 0 to 1.4             | -0.3 to 1.7 |     | 0 to 1.4               | -0.3 to 1.7 |     | V                            |
|                                                                            |                                                                                                            | Full range    | 0 to 1.4             | -0.3 to 1.7 |     | 0 to 1.4               | -0.3 to 1.7 |     |                              |
| $V_{OH}$ High-level output voltage                                         | $I_{OH} = -0.675\text{ mA}$                                                                                | 25°C          |                      | 2.6         |     |                        | 2.6         |     | V                            |
|                                                                            |                                                                                                            | Full range    |                      | 2.45        |     |                        | 2.45        |     |                              |
|                                                                            | $I_{OH} = -2.2\text{ mA}$                                                                                  | 25°C          |                      | 2.4         |     |                        | 2.4         |     |                              |
|                                                                            |                                                                                                            | Full range    |                      | 2.1         |     |                        | 2.1         |     |                              |
| $V_{OL}$ Low-level output voltage                                          | $V_{IC} = 1.35\text{ V}$ , $I_{OL} = 0.675\text{ mA}$                                                      | 25°C          |                      | 0.1         |     |                        | 0.1         |     | V                            |
|                                                                            |                                                                                                            | Full range    |                      | 0.2         |     |                        | 0.2         |     |                              |
|                                                                            | $V_{IC} = 1.35\text{ V}$ , $I_{OL} = 2.2\text{ mA}$                                                        | 25°C          |                      | 0.21        |     |                        | 0.21        |     |                              |
|                                                                            |                                                                                                            | Full range    |                      | 0.6         |     |                        | 0.6         |     |                              |
| $A_{VD}$ Large-signal differential voltage amplification                   | $V_{IC} = 1.35\text{ V}$ ,<br>$V_O = 0.6\text{ V to } 2.1\text{ V}$<br>$R_L = 10\text{ k}\Omega,^\ddagger$ | 25°C          | 20                   | 380         |     | 20                     | 380         |     | V/mV                         |
|                                                                            |                                                                                                            | Full range    | 13                   |             |     | 13                     |             |     |                              |
| $r_{i(d)}$ Differential input resistance                                   |                                                                                                            | 25°C          |                      | $10^{12}$   |     |                        | $10^{12}$   |     | $\Omega$                     |
| $C_{i(c)}$ Common-mode input capacitance                                   | $f = 10\text{ kHz}$ ,                                                                                      | 25°C          |                      | 8           |     |                        | 8           |     | pF                           |
| $z_o$ Closed-loop output impedance                                         | $f = 100\text{ kHz}$ , $A_V = 10$                                                                          | 25°C          |                      | 25          |     |                        | 25          |     | $\Omega$                     |
| CMRR Common-mode rejection ratio                                           | $V_{IC} = V_{ICR}(\text{min})$ ,<br>$R_S = 50\ \Omega$ , $V_O = 1.5\text{ V}$                              | 25°C          | 60                   | 84          |     | 60                     | 84          |     | dB                           |
|                                                                            |                                                                                                            | Full range    | 60                   | 82          |     | 60                     | 82          |     |                              |
| $k_{SVR}$ Supply voltage rejection ratio ( $\Delta V_{DD}/\Delta V_{IO}$ ) | $V_{DD} = 2.7\text{ V to } 5\text{ V}$ , $V_{IC} = V_{DD}/2$ ,<br>No load                                  | 25°C          | 70                   | 89          |     | 70                     | 89          |     | dB                           |
|                                                                            |                                                                                                            | Full range    | 70                   | 84          |     | 70                     | 84          |     |                              |
| $I_{DD}$ Supply current (per channel)                                      | $V_O = 1.5\text{ V}$ , No load                                                                             | 25°C          |                      | 1           | 2   |                        | 1           | 2   | mA                           |
|                                                                            |                                                                                                            | Full range    |                      | 2           |     |                        | 2           |     |                              |

$^\dagger$  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 1.35 V

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operating characteristics at specified free-air temperature,  $V_{DD} = 2.7\text{ V}$  (unless otherwise noted)

| PARAMETER                                               | TEST CONDITIONS                                                                                  | $T_A^\dagger$                       | TLV2772Q<br>TLV2772M |         |     | TLV2772AQ<br>TLV2772AM |         |     | UNIT                   |
|---------------------------------------------------------|--------------------------------------------------------------------------------------------------|-------------------------------------|----------------------|---------|-----|------------------------|---------|-----|------------------------|
|                                                         |                                                                                                  |                                     | MIN                  | TYP     | MAX | MIN                    | TYP     | MAX |                        |
| SR      Slew rate at unity gain                         | $V_{O(PP)} = 0.8\text{ V}$ , $C_L = 100\text{ pF}$ ,<br>$R_L = 10\text{ k}\Omega$                | 25°C                                | 5                    | 9       |     | 5                      | 9       |     | V/ $\mu\text{s}$       |
|                                                         |                                                                                                  | Full range                          | 4.7                  | 6       |     | 4.7                    | 6       |     |                        |
| $V_n$ Equivalent input noise voltage                    | $f = 1\text{ kHz}$                                                                               | 25°C                                |                      | 21      |     |                        | 21      |     | nV/ $\sqrt{\text{Hz}}$ |
|                                                         | $f = 10\text{ kHz}$                                                                              | 25°C                                |                      | 17      |     |                        | 17      |     |                        |
| $V_{N(PP)}$ Peak-to-peak equivalent input noise voltage | $f = 0.1\text{ Hz to }1\text{ Hz}$                                                               | 25°C                                |                      | 0.33    |     |                        | 0.33    |     | $\mu\text{V}$          |
|                                                         | $f = 0.1\text{ Hz to }10\text{ Hz}$                                                              | 25°C                                |                      | 0.86    |     |                        | 0.86    |     | $\mu\text{V}$          |
| $I_n$ Equivalent input noise current                    | $f = 100\text{ Hz}$                                                                              | 25°C                                |                      | 0.6     |     |                        | 0.6     |     | fA/ $\sqrt{\text{Hz}}$ |
| THD + N      Total harmonic distortion plus noise       | $R_L = 600\text{ }\Omega$ ,<br>$f = 1\text{ kHz}$                                                | $A_V = 1$                           |                      | 0.0085% |     |                        | 0.0085% |     |                        |
|                                                         |                                                                                                  | $A_V = 10$                          |                      | 0.025%  |     |                        | 0.025%  |     |                        |
|                                                         |                                                                                                  | $A_V = 100$                         |                      | 0.12%   |     |                        | 0.12%   |     |                        |
| Gain-bandwidth product                                  | $f = 10\text{ kHz}$ ,<br>$C_L = 100\text{ pF}$                                                   | $R_L = 600\text{ }\Omega$ ,<br>25°C |                      | 4.8     |     |                        | 4.8     |     | MHz                    |
| $t_s$ Settling time                                     | $A_V = -1$ ,<br>Step = 0.85 V to 1.85 V,<br>$R_L = 600\text{ }\Omega$ ,<br>$C_L = 100\text{ pF}$ | 0.1%                                | 25°C                 | 0.186   |     |                        | 0.186   |     | $\mu\text{s}$          |
|                                                         |                                                                                                  | 0.01%                               | 25°C                 | 3.92    |     |                        | 3.92    |     |                        |
| $\phi_m$ Phase margin at unity gain                     | $R_L = 600\text{ }\Omega$ ,<br>$C_L = 100\text{ pF}$                                             | 25°C                                |                      | 46°     |     |                        | 46°     |     |                        |
| Gain margin                                             |                                                                                                  | 25°C                                |                      | 12      |     |                        | 12      |     | 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.

# TLV277x, TLV277xA

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

| PARAMETER                                                                  | TEST CONDITIONS                                                                      | $T_A^\dagger$ | TLV2772Q<br>TLV2772M |             |     | TLV2772AQ<br>TLV2772AM |             |     | UNIT                         |
|----------------------------------------------------------------------------|--------------------------------------------------------------------------------------|---------------|----------------------|-------------|-----|------------------------|-------------|-----|------------------------------|
|                                                                            |                                                                                      |               | MIN                  | TYP         | MAX | MIN                    | TYP         | MAX |                              |
| $V_{IO}$ Input offset voltage                                              | $V_{DD} = \pm 2.5\text{ V}$ ,<br>$V_{IC} = 0$ ,<br>$V_O = 0$ ,<br>$R_S = 50\ \Omega$ | 25°C          |                      | 0.36        | 2.5 |                        | 0.36        | 1.6 | mV                           |
|                                                                            |                                                                                      | Full range    |                      | 0.4         | 2.7 |                        | 0.4         | 1.9 |                              |
| $\alpha_{VIO}$ Temperature coefficient of input offset voltage             |                                                                                      | 25°C to 125°C |                      | 2           |     |                        | 2           |     | $\mu\text{V}/^\circ\text{C}$ |
| $I_{IO}$ Input offset current                                              |                                                                                      | 25°C          |                      | 1           | 60  |                        | 1           | 60  | pA                           |
|                                                                            |                                                                                      | Full range    |                      | 2           | 125 |                        | 2           | 125 |                              |
| $I_{IB}$ Input bias current                                                |                                                                                      | 25°C          |                      | 2           | 60  |                        | 2           | 60  | pA                           |
|                                                                            |                                                                                      | Full range    |                      | 6           | 350 |                        | 6           | 350 |                              |
| $V_{ICR}$ Common-mode input voltage range                                  | CMRR > 60 dB, $R_S = 50\ \Omega$                                                     | 25°C          | 0 to 3.7             | -0.3 to 3.8 |     | 0 to 3.7               | -0.3 to 3.8 |     | V                            |
|                                                                            |                                                                                      | Full range    | 0 to 3.7             | -0.3 to 3.8 |     | 0 to 3.7               | -0.3 to 3.8 |     |                              |
| $V_{OH}$ High-level output voltage                                         | $I_{OH} = -1.3\text{ mA}$                                                            | 25°C          |                      | 4.9         |     |                        | 4.9         |     | V                            |
|                                                                            |                                                                                      | Full range    |                      | 4.8         |     |                        | 4.8         |     |                              |
|                                                                            | $I_{OH} = -4.2\text{ mA}$                                                            | 25°C          |                      | 4.7         |     |                        | 4.7         |     |                              |
|                                                                            |                                                                                      | Full range    |                      | 4.4         |     |                        | 4.4         |     |                              |
| $V_{OL}$ Low-level output voltage                                          | $V_{IC} = 2.5\text{ V}$ , $I_{OL} = 1.3\text{ mA}$                                   | 25°C          |                      | 0.1         |     |                        | 0.1         |     | V                            |
|                                                                            |                                                                                      | Full range    |                      | 0.2         |     |                        | 0.2         |     |                              |
|                                                                            | $V_{IC} = 2.5\text{ V}$ , $I_{OL} = 4.2\text{ mA}$                                   | 25°C          |                      | 0.21        |     |                        | 0.21        |     |                              |
|                                                                            |                                                                                      | Full range    |                      | 0.6         |     |                        | 0.6         |     |                              |
| $A_{VD}$ Large-signal differential voltage amplification                   | $V_{IC} = 2.5\text{ V}$ , $V_O = 1\text{ V to }4\text{ V}$                           | 25°C          | 20                   | 450         |     | 20                     | 450         |     | V/mV                         |
|                                                                            |                                                                                      | Full range    | 13                   |             |     | 13                     |             |     |                              |
| $r_{i(d)}$ Differential input resistance                                   |                                                                                      | 25°C          |                      | $10^{12}$   |     |                        | $10^{12}$   |     | $\Omega$                     |
| $C_{i(c)}$ Common-mode input capacitance                                   | $f = 10\text{ kHz}$                                                                  | 25°C          |                      | 8           |     |                        | 8           |     | pF                           |
| $z_o$ Closed-loop output impedance                                         | $f = 100\text{ kHz}$ , $A_V = 10$                                                    | 25°C          |                      | 20          |     |                        | 20          |     | $\Omega$                     |
| CMRR Common-mode rejection ratio                                           | $V_{IC} = V_{ICR}(\text{min})$ , $R_S = 50\ \Omega$                                  | 25°C          | 60                   | 96          |     | 60                     | 96          |     | dB                           |
|                                                                            | $V_O = 3.7\text{ V}$                                                                 | Full range    | 60                   | 93          |     | 60                     | 93          |     |                              |
| $k_{SVR}$ Supply voltage rejection ratio ( $\Delta V_{DD}/\Delta V_{IO}$ ) | $V_{DD} = 2.7\text{ V to }5\text{ V}$ , No load                                      | 25°C          | 70                   | 89          |     | 70                     | 89          |     | dB                           |
|                                                                            |                                                                                      | Full range    | 70                   | 84          |     | 70                     | 84          |     |                              |
| $I_{DD}$ Supply current (per channel)                                      | $V_O = 1.5\text{ V}$ , No load                                                       | 25°C          |                      | 1           | 2   |                        | 1           | 2   | mA                           |
|                                                                            |                                                                                      | Full range    |                      |             | 2   |                        |             | 2   |                              |

$^\dagger$  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

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

| PARAMETER                                               | TEST CONDITIONS                                                                                | $T_A^\dagger$                                                              | TLV2772Q<br>TLV2772M |        |     | TLV2772AQ<br>TLV2772AM |        |     | UNIT                   |
|---------------------------------------------------------|------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------|----------------------|--------|-----|------------------------|--------|-----|------------------------|
|                                                         |                                                                                                |                                                                            | MIN                  | TYP    | MAX | MIN                    | TYP    | MAX |                        |
| SR      Slew rate at unity gain                         | $V_{O(PP)} = 1.5\text{ V}$ , $C_L = 100\text{ pF}$ ,<br>$R_L = 10\text{ k}\Omega$              | 25°C                                                                       | 5                    | 10.5   |     | 5                      | 10.5   |     | V/ $\mu\text{s}$       |
|                                                         |                                                                                                | Full range                                                                 | 4.7                  | 6      |     | 4.7                    | 6      |     |                        |
| $V_n$ Equivalent input noise voltage                    | $f = 1\text{ kHz}$                                                                             | 25°C                                                                       |                      | 17     |     |                        | 17     |     | nV/ $\sqrt{\text{Hz}}$ |
|                                                         | $f = 10\text{ kHz}$                                                                            | 25°C                                                                       |                      | 12     |     |                        | 12     |     |                        |
| $V_{N(PP)}$ Peak-to-peak equivalent input noise voltage | $f = 0.1\text{ Hz to }1\text{ Hz}$                                                             | 25°C                                                                       |                      | 0.33   |     |                        | 0.33   |     | $\mu\text{V}$          |
|                                                         | $f = 0.1\text{ Hz to }10\text{ Hz}$                                                            | 25°C                                                                       |                      | 0.86   |     |                        | 0.86   |     | $\mu\text{V}$          |
| $I_n$ Equivalent input noise current                    | $f = 100\text{ Hz}$                                                                            | 25°C                                                                       |                      | 0.6    |     |                        | 0.6    |     | fA/ $\sqrt{\text{Hz}}$ |
| THD + N      Total harmonic distortion plus noise       | $R_L = 600\text{ }\Omega$ ,<br>$f = 1\text{ kHz}$                                              | $A_V = 1$                                                                  |                      | 0.005% |     |                        | 0.005% |     |                        |
|                                                         |                                                                                                | $A_V = 10$                                                                 |                      | 0.016% |     |                        | 0.016% |     |                        |
|                                                         |                                                                                                | $A_V = 100$                                                                |                      | 0.095% |     |                        | 0.095% |     |                        |
|                                                         | Gain-bandwidth product                                                                         | $f = 10\text{ kHz}$ ,<br>$C_L = 100\text{ pF}$ , $R_L = 600\text{ }\Omega$ | 25°C                 | 5.1    |     |                        | 5.1    |     | MHz                    |
| $t_s$ Settling time                                     | $A_V = -1$ ,<br>Step = 1.5 V to 3.5 V,<br>$R_L = 600\text{ }\Omega$ ,<br>$C_L = 100\text{ pF}$ | 0.1%                                                                       | 25°C                 | 0.134  |     |                        | 0.134  |     | $\mu\text{s}$          |
|                                                         |                                                                                                | 0.01%                                                                      | 25°C                 | 1.97   |     |                        | 1.97   |     |                        |
| $\phi_m$ Phase margin at unity gain                     | $R_L = 600\text{ }\Omega$ , $C_L = 100\text{ pF}$                                              | 25°C                                                                       |                      | 46°    |     |                        | 46°    |     |                        |
| Gain margin                                             |                                                                                                | 25°C                                                                       |                      | 12     |     |                        | 12     |     | 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.

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**TYPICAL CHARACTERISTICS**

**Table of Graphs**

|                 |                                                                  |                                                              | <b>FIGURE</b>     |
|-----------------|------------------------------------------------------------------|--------------------------------------------------------------|-------------------|
| $V_{IO}$        | Input offset voltage                                             | Distribution<br>vs Common-mode input voltage<br>Distribution | 1,2<br>3,4<br>5,6 |
| $I_{IB}/I_{IO}$ | Input bias and input offset currents                             | vs Free-air temperature                                      | 7                 |
| $V_{OH}$        | High-level output voltage                                        | vs High-level output current                                 | 8,9               |
| $V_{OL}$        | Low-level output voltage                                         | vs Low-level output current                                  | 10,11             |
| $V_{O(PP)}$     | Maximum peak-to-peak output voltage                              | vs Frequency                                                 | 12,13             |
| $I_{OS}$        | Short-circuit output current                                     | vs Supply voltage<br>vs Free-air temperature                 | 14<br>15          |
| $V_O$           | Output voltage                                                   | vs Differential input voltage                                | 16                |
| $A_{VD}$        | Large-signal differential voltage amplification and phase margin | vs Frequency                                                 | 17,18             |
| $A_{VD}$        | Differential voltage amplification                               | vs Load resistance<br>vs Free-air temperature                | 19<br>20,21       |
| $z_o$           | Output impedance                                                 | vs Frequency                                                 | 22,23             |
| CMRR            | Common-mode rejection ratio                                      | vs Frequency<br>vs Free-air temperature                      | 24<br>25          |
| $k_{SVR}$       | Supply-voltage rejection ratio                                   | vs Frequency                                                 | 26,27             |
| $I_{DD}$        | Supply current (per channel)                                     | vs Supply voltage                                            | 28                |
| SR              | Slew rate                                                        | vs Load capacitance<br>vs Free-air temperature               | 29<br>30          |
| $V_O$           | Voltage-follower small-signal pulse response                     |                                                              | 31,32             |
| $V_O$           | Voltage-follower large-signal pulse response                     |                                                              | 33,34             |
| $V_O$           | Inverting small-signal pulse response                            |                                                              | 35,36             |
| $V_O$           | Inverting large-signal pulse response                            |                                                              | 37,38             |
| $V_n$           | Equivalent input noise voltage                                   | vs Frequency                                                 | 39,40             |
|                 | Noise voltage (referred to input)                                | Over a 10-second period                                      | 41                |
| THD + N         | Total harmonic distortion plus noise                             | vs Frequency                                                 | 42,43             |
|                 | Gain-bandwidth product                                           | vs Supply voltage                                            | 44                |
| $B_1$           | Unity-gain bandwidth                                             | vs Load capacitance                                          | 45                |
| $\phi_m$        | Phase margin                                                     | vs Load capacitance                                          | 46                |
|                 | Gain margin                                                      | vs Load capacitance                                          | 47                |
|                 | Amplifier with shutdown pulse turnon/off characteristics         |                                                              | 48 – 50           |
|                 | Supply current with shutdown pulse turnon/off characteristics    |                                                              | 51 – 53           |
|                 | Shutdown supply current                                          | vs Free-air temperature                                      | 54                |
|                 | Shutdown forward/reverse isolation                               | vs Frequency                                                 | 55, 56            |

# TLV277x, TLV277xA FAMILY OF 2.7-V HIGH-SLEW-RATE RAIL-TO-RAIL OUTPUT OPERATIONAL AMPLIFIERS WITH SHUTDOWN

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## TYPICAL CHARACTERISTICS

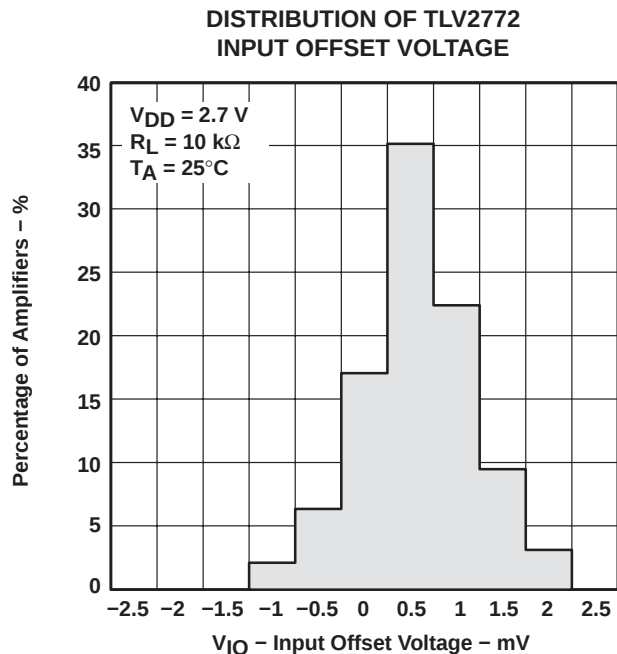


Figure 1

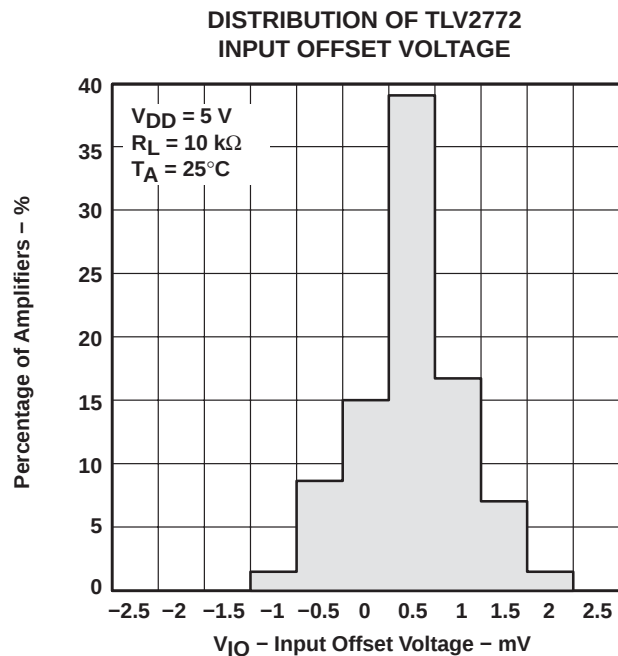


Figure 2

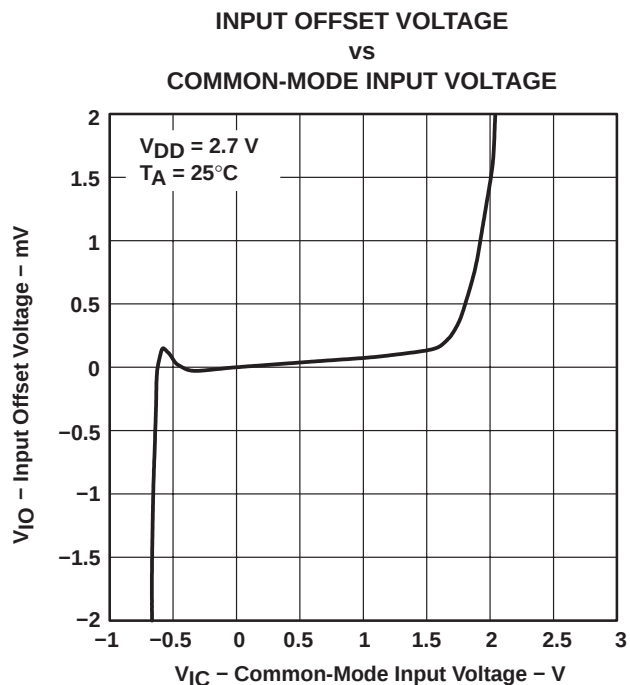


Figure 3

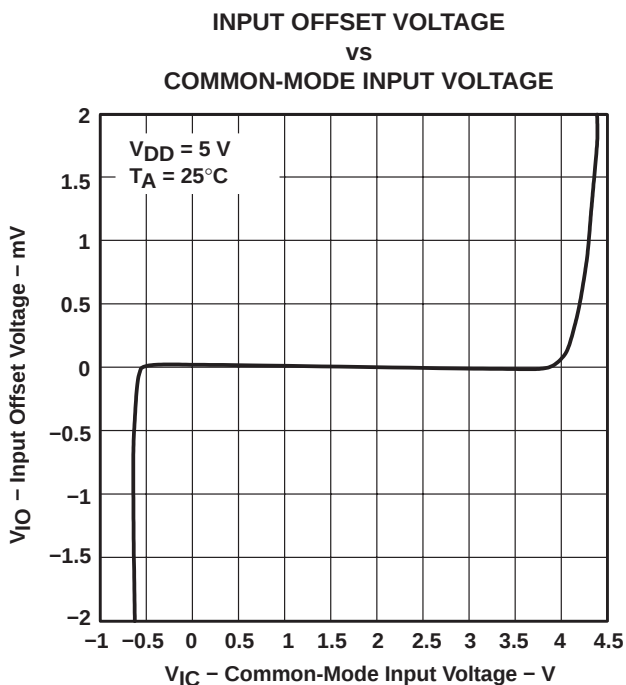


Figure 4

# TLV277x, TLV277xA

## FAMILY OF 2.7-V HIGH-SLEW-RATE RAIL-TO-RAIL OUTPUT OPERATIONAL AMPLIFIERS WITH SHUTDOWN

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### TYPICAL CHARACTERISTICS



Figure 5



Figure 6



Figure 7



Figure 8

# TLV277x, TLV277xA FAMILY OF 2.7-V HIGH-SLEW-RATE RAIL-TO-RAIL OUTPUT OPERATIONAL AMPLIFIERS WITH SHUTDOWN

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## TYPICAL CHARACTERISTICS



Figure 9

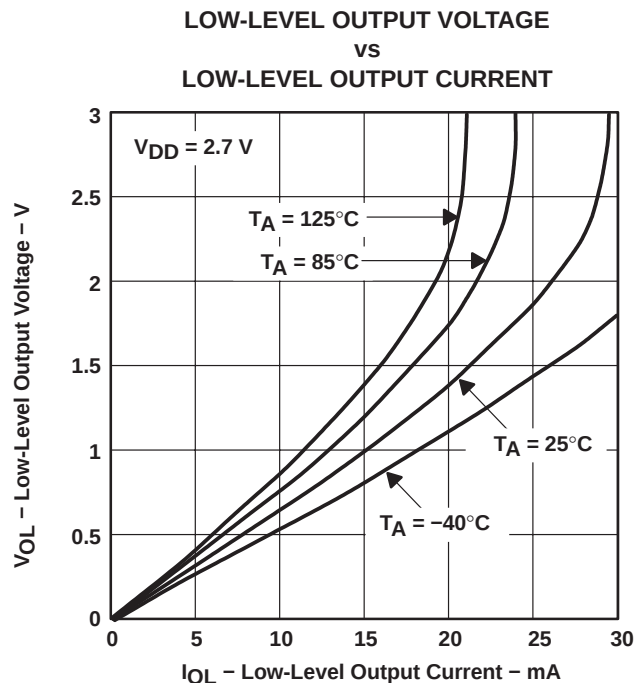


Figure 10



Figure 11



Figure 12

# TLV277x, TLV277xA

## FAMILY OF 2.7-V HIGH-SLEW-RATE RAIL-TO-RAIL OUTPUT OPERATIONAL AMPLIFIERS WITH SHUTDOWN

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### TYPICAL CHARACTERISTICS



Figure 13



Figure 14



Figure 15



Figure 16

**TLV277x, TLV277xA**  
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**TYPICAL CHARACTERISTICS**

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

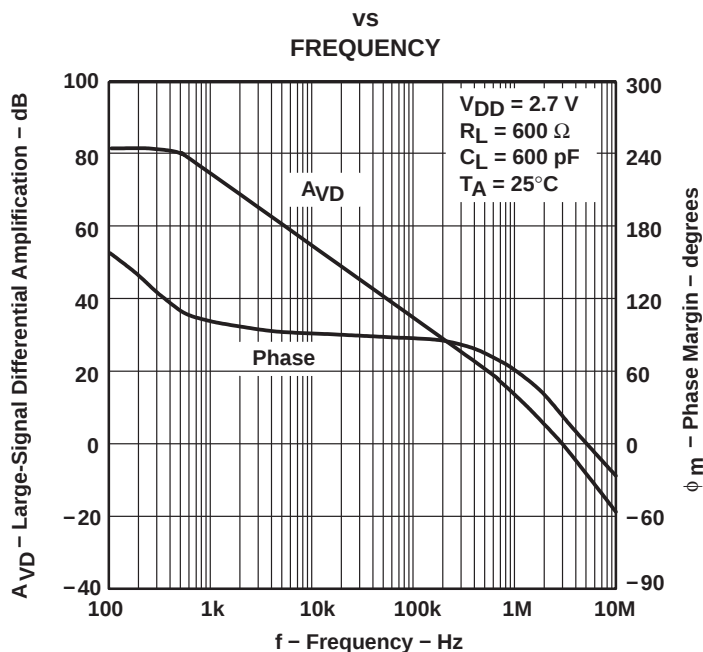


Figure 17

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

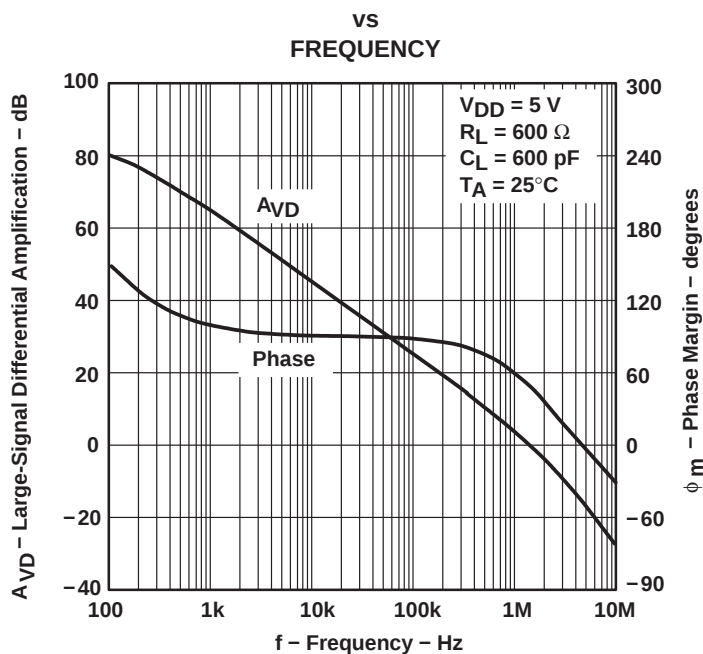


Figure 18

# TLV277x, TLV277xA

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### TYPICAL CHARACTERISTICS

DIFFERENTIAL VOLTAGE AMPLIFICATION  
vs  
LOAD RESISTANCE



Figure 19

DIFFERENTIAL VOLTAGE AMPLIFICATION  
vs  
FREE-AIR TEMPERATURE



Figure 20

DIFFERENTIAL VOLTAGE AMPLIFICATION  
vs  
FREE-AIR TEMPERATURE



Figure 21

OUTPUT IMPEDANCE  
vs  
FREQUENCY

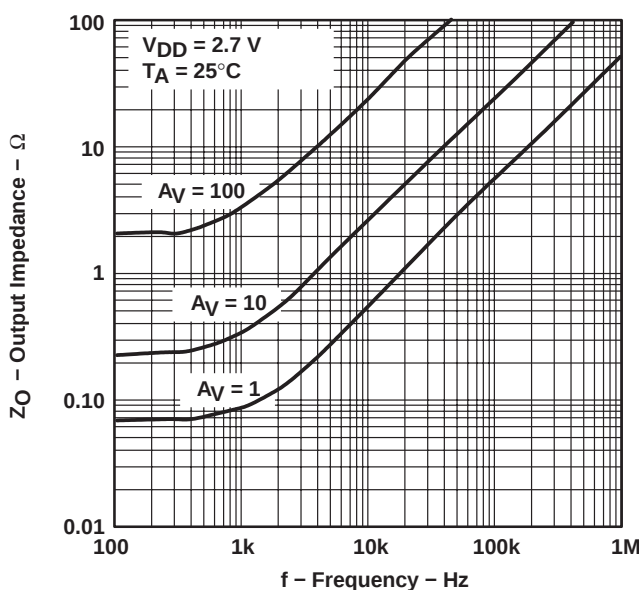


Figure 22

# TLV277x, TLV277xA

## FAMILY OF 2.7-V HIGH-SLEW-RATE RAIL-TO-RAIL OUTPUT OPERATIONAL AMPLIFIERS WITH SHUTDOWN

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### TYPICAL CHARACTERISTICS



Figure 23



Figure 24



Figure 25



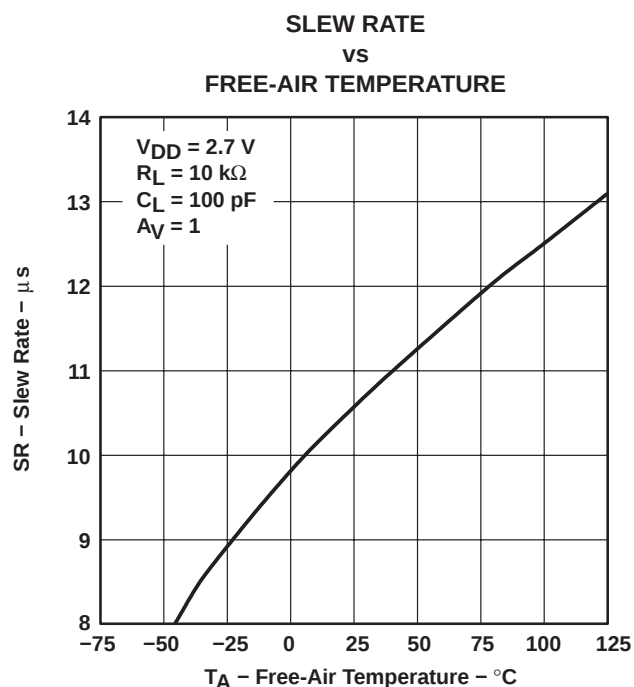
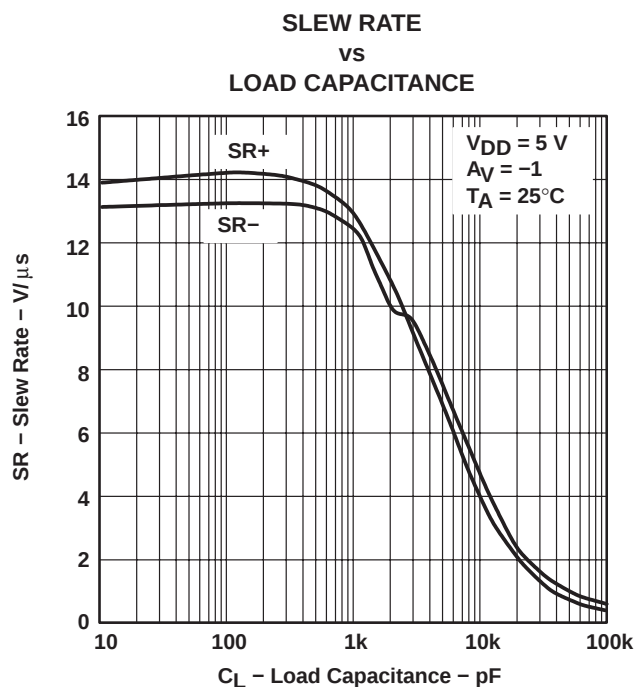
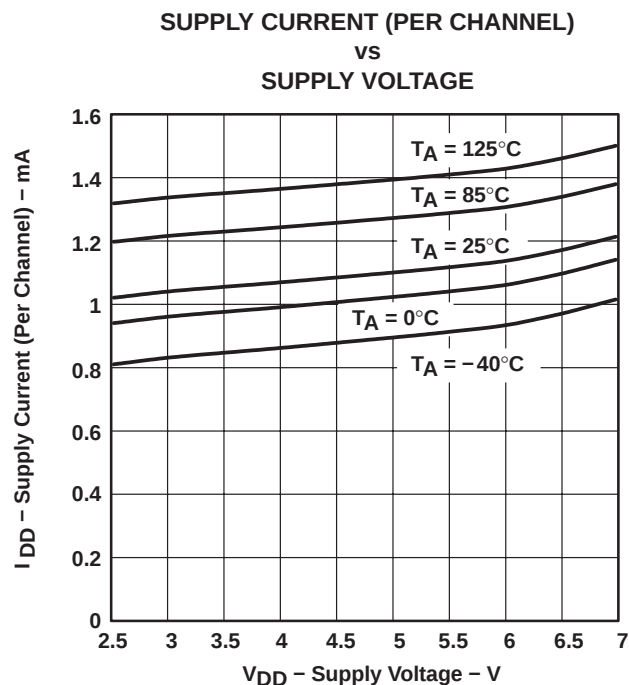
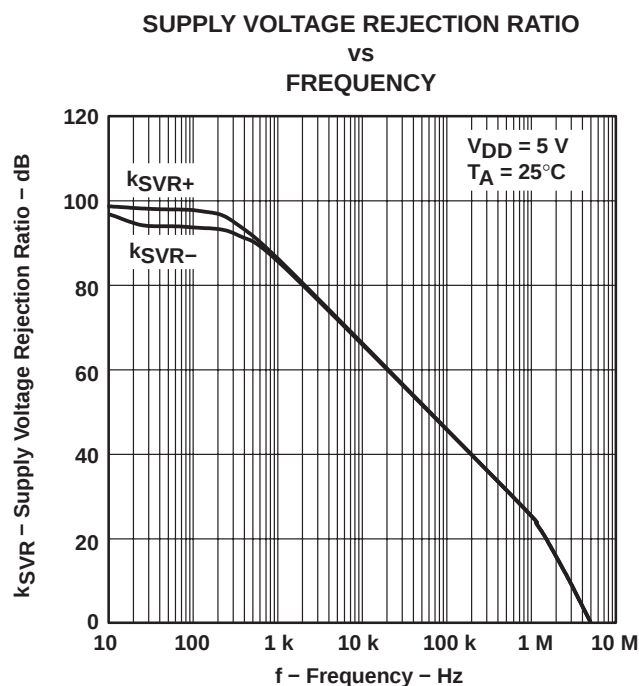
Figure 26

# TLV277x, TLV277xA

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### TYPICAL CHARACTERISTICS



# TLV277x, TLV277xA FAMILY OF 2.7-V HIGH-SLEW-RATE RAIL-TO-RAIL OUTPUT OPERATIONAL AMPLIFIERS WITH SHUTDOWN

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## TYPICAL CHARACTERISTICS

VOLTAGE-FOLLOWER  
SMALL-SIGNAL PULSE RESPONSE



Figure 31

VOLTAGE-FOLLOWER  
SMALL-SIGNAL PULSE RESPONSE

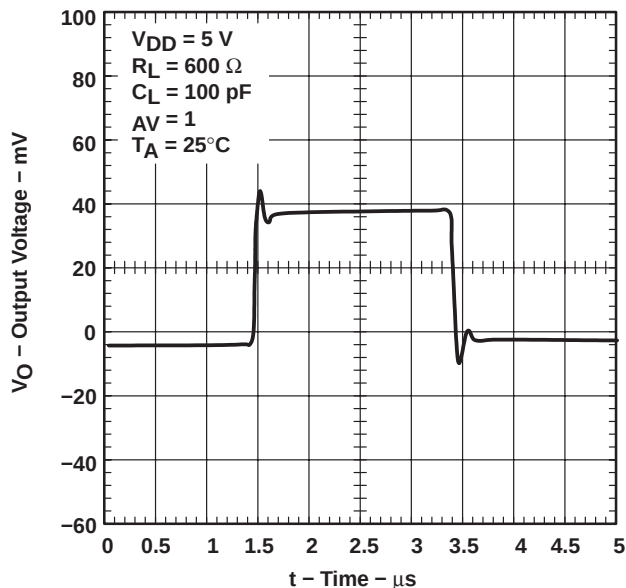


Figure 32

VOLTAGE-FOLLOWER  
LARGE-SIGNAL PULSE RESPONSE



Figure 33

VOLTAGE-FOLLOWER  
LARGE-SIGNAL PULSE RESPONSE



Figure 34

# TLV277x, TLV277xA

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### TYPICAL CHARACTERISTICS

INVERTING SMALL-SIGNAL  
PULSE RESPONSE



Figure 35

INVERTING SMALL-SIGNAL  
PULSE RESPONSE



Figure 36

INVERTING LARGE-SIGNAL  
PULSE RESPONSE



Figure 37

INVERTING LARGE-SIGNAL  
PULSE RESPONSE

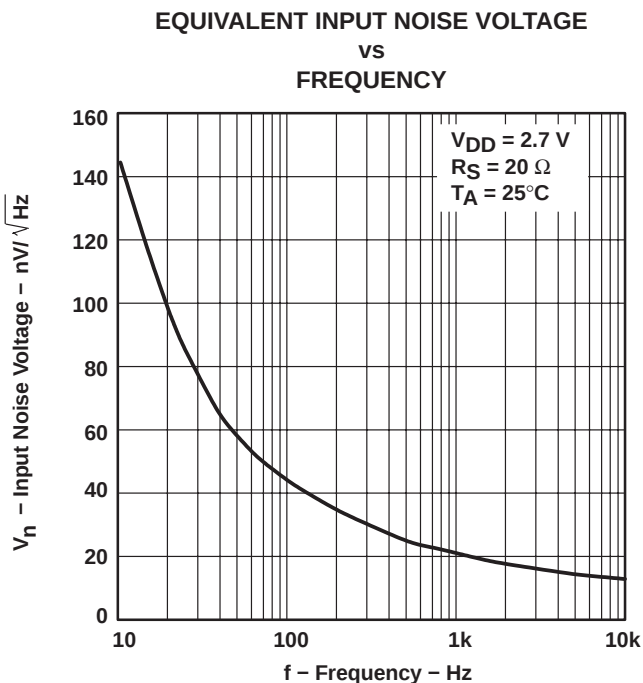


Figure 38

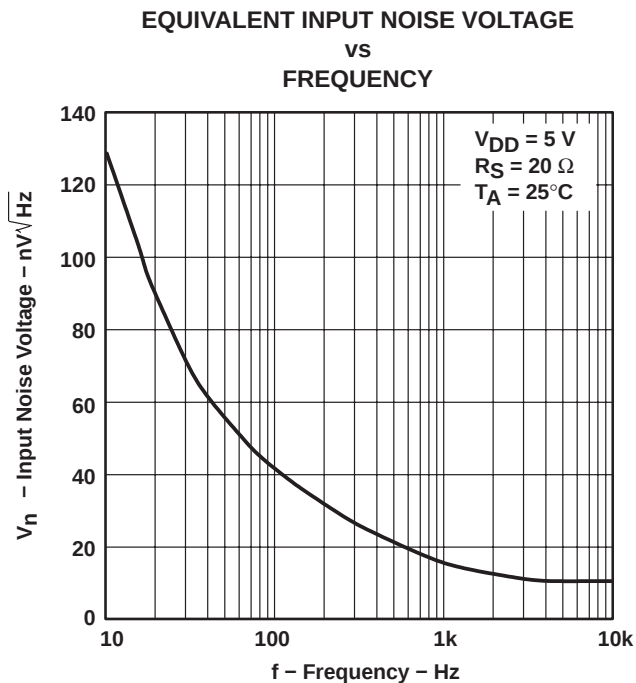
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**FAMILY OF 2.7-V HIGH-SLEW-RATE RAIL-TO-RAIL OUTPUT**  
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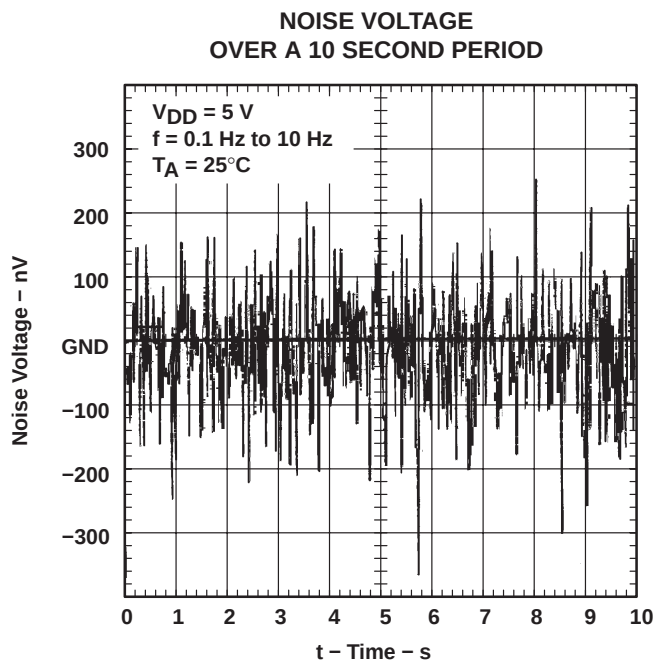
**TYPICAL CHARACTERISTICS**



**Figure 39**



**Figure 40**



**Figure 41**

# TLV277x, TLV277xA

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### TYPICAL CHARACTERISTICS



Figure 42



Figure 43



Figure 44



Figure 45

# TLV277x, TLV277xA

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### TYPICAL CHARACTERISTICS

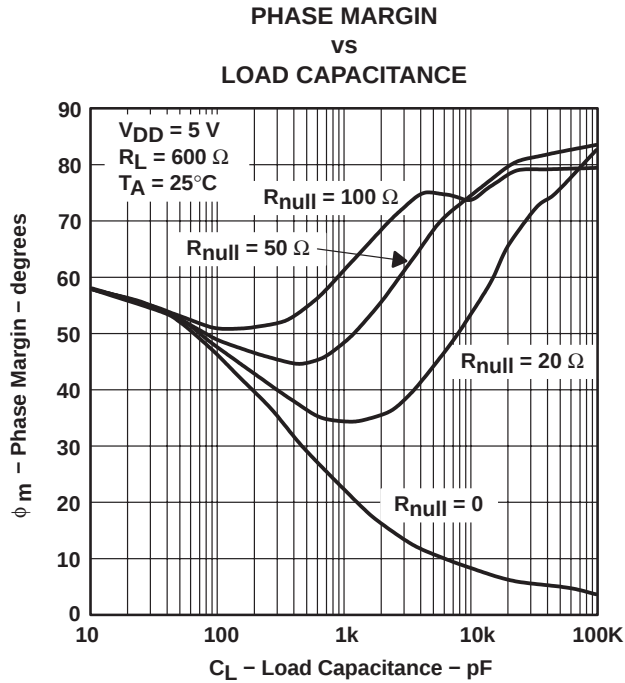


Figure 46

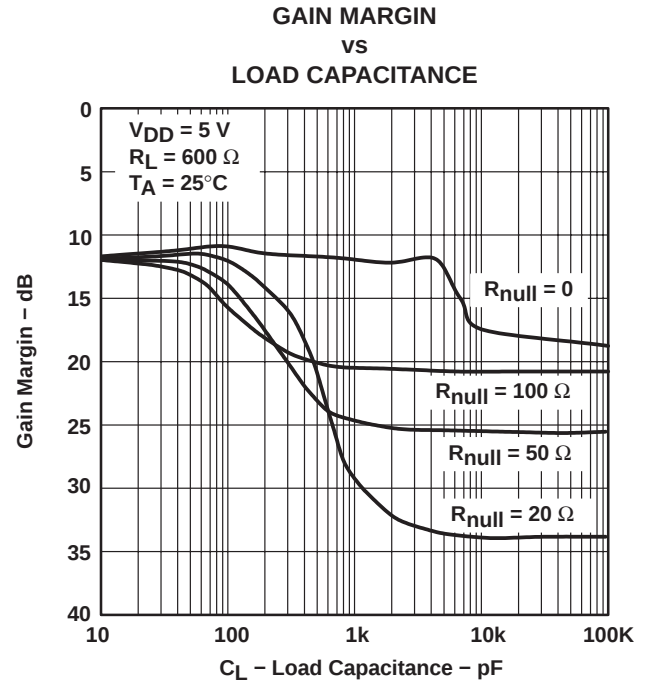


Figure 47

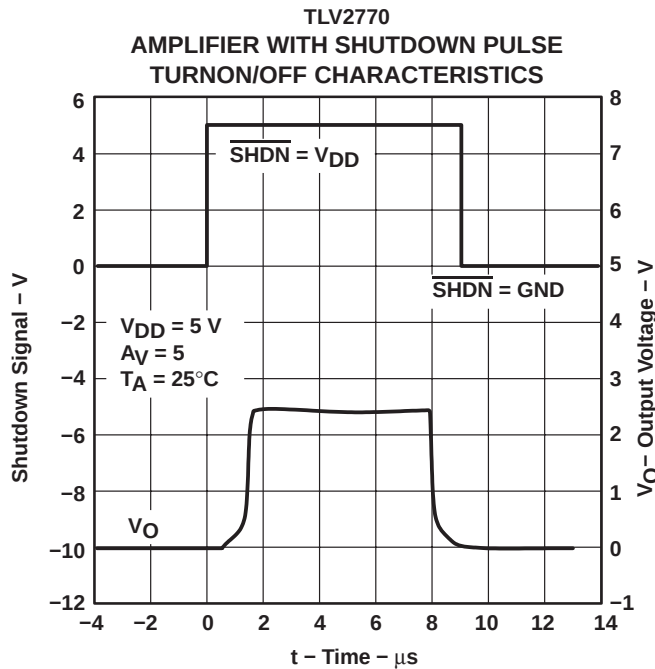


Figure 48

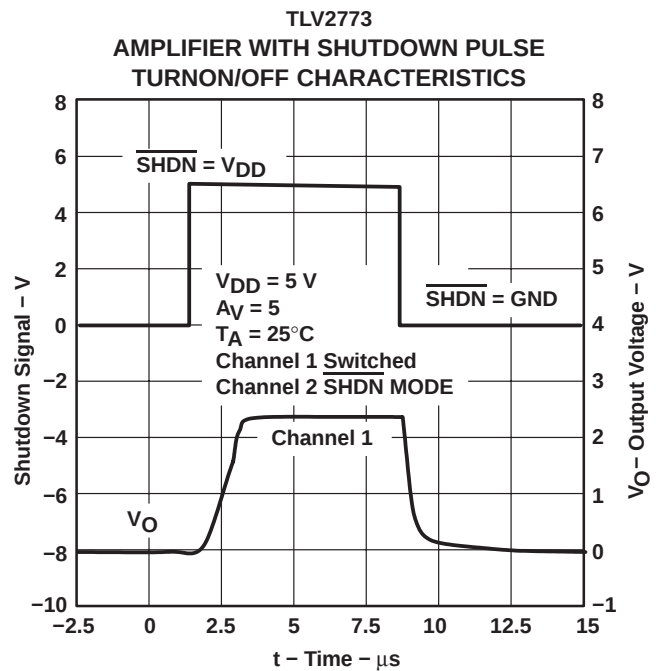


Figure 49

# TLV277x, TLV277xA

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### TYPICAL CHARACTERISTICS



Figure 50



Figure 51



Figure 52



Figure 53

# TLV277x, TLV277xA

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### TYPICAL CHARACTERISTICS



Figure 54



Figure 55



Figure 56

# TLV277x, TLV277xA

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### PARAMETER MEASUREMENT INFORMATION



Figure 57

### driving a capacitive load

When the amplifier is configured in this manner, capacitive loading directly on the output will decrease the device's phase margin leading to high frequency ringing or oscillations. Therefore, for capacitive loads of greater than 10 pF, it is recommended that a resistor be placed in series ( $R_{NULL}$ ) with the output of the amplifier, as shown in Figure 58. A minimum value of 20  $\Omega$  should work well for most applications.

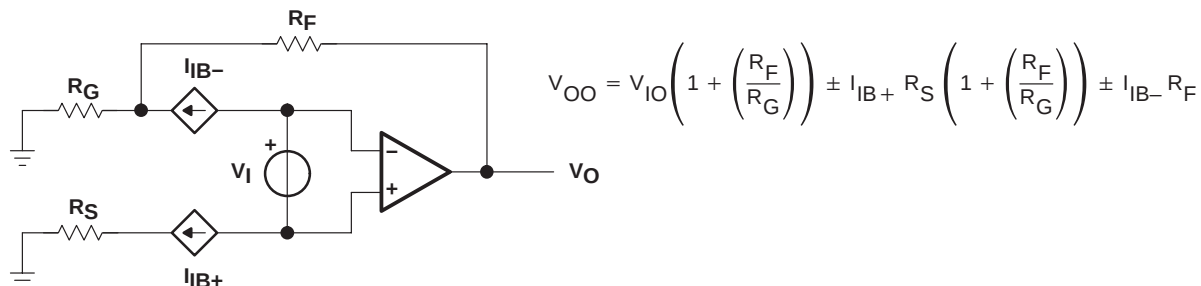


Figure 58. Driving a Capacitive Load

## APPLICATION INFORMATION

### offset voltage

The output offset voltage, ( $V_{OO}$ ) is the sum of the input offset voltage ( $V_{IO}$ ) and both input bias currents ( $I_{IB}$ ) times the corresponding gains. The following schematic and formula can be used to calculate the output offset voltage:



**Figure 59. Output Offset Voltage Model**

### general configurations

When receiving low-level signals, limiting the bandwidth of the incoming signals into the system is often required. The simplest way to accomplish this is to place an RC filter at the noninverting terminal of the amplifier (see Figure 60).



**Figure 60. Single-Pole Low-Pass Filter**

If even more attenuation is needed, a multiple pole filter is required. The Sallen-Key filter can be used for this task. For best results, the amplifier should have a bandwidth that is 8 to 10 times the filter frequency bandwidth. Failure to do this can result in phase shift of the amplifier.



**Figure 61. 2-Pole Low-Pass Sallen-Key Filter**

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### APPLICATION INFORMATION

#### using the TLV2772 as an accelerometer interface

The schematic, shown in Figure 62, shows the ACH04-08-05 interfaced to the TLV1544 10-bit analog-to-digital converter (ADC).

The ACH04-08-05 is a shock sensor designed to convert mechanical acceleration into electrical signals. The sensor contains three piezoelectric sensing elements oriented to simultaneously measure acceleration in three orthogonal, linear axes (x, y, z). The operating frequency is 0.5 Hz to 5 kHz. The output is buffered with an internal JFET and has a typical output voltage of 1.80 mV/g for the x and y axis and 1.35 mV/g for the z axis.

Amplification and frequency shaping of the shock sensor output is done by the TLV2772 rail-to-rail operational amplifier. The TLV2772 is ideal for this application as it offers high input impedance, good slew rate, and excellent dc precision. The rail-to-rail output swing and high output drive are perfect for driving the analog input of the TLV1544 ADC.



Figure 62. Accelerometer Interface Schematic

The sensor signal must be amplified and frequency-shaped to provide a signal the ADC can properly convert into the digital domain. Figure 62 shows the topology used in this application for one axis of the sensor. This system is powered from a single 3-V supply. Configuring the TLV431 with a 2.2-kΩ resistor produces a reference voltage of 1.23 V. This voltage is used to bias the operational amplifier and the internal JFETs in the shock sensor.

## APPLICATION INFORMATION

### gain calculation

Since the TLV2772 is capable of rail-to-rail output using a 3-V supply,  $V_O = 0$  (min) to 3 V (max). With no signal from the sensor, nominal  $V_O =$  reference voltage = 1.23 V. Therefore, the maximum negative swing from nominal is  $0\text{ V} - 1.23\text{ V} = -1.23\text{ V}$  and the maximum positive swing is  $3\text{ V} - 1.23\text{ V} = 1.77\text{ V}$ . By modeling the shock sensor as a low impedance voltage source with output of 2.25 mV/g (max) in the x and y axis and 1.70 mV/g (max) in the z axis, the gain of the circuit is calculated by equation 1.

$$\text{Gain} = \frac{\text{Output Swing}}{\text{Sensor Signal} \times \text{Acceleration}} \quad (1)$$

To avoid saturation of the operational amplifier, the gain calculations are based on the maximum negative swing of  $-1.23\text{ V}$  and the maximum sensor output of 2.25 mV/g (x and y axis) and 1.70 mV/g (z axis).

$$\text{Gain (x, y)} = \frac{-1.23\text{ V}}{2.25\text{ mV/g} \times -50\text{ g}} = 10.9 \quad (2)$$

and

$$\text{Gain (z)} = \frac{-1.23\text{ V}}{1.70\text{ mV/g} \times -50\text{ g}} = 14.5 \quad (3)$$

By selecting  $R_3 = 10\text{ k}\Omega$  and  $R_4 = 100\text{ k}\Omega$ , in the x and y channels, a gain of 11 is realized. By selecting  $R_3 = 7.5\text{ k}\Omega$  and  $R_4 = 100\text{ k}\Omega$ , in the z channel, a gain of 14.3 is realized. The schematic shows the configuration for either the x- or y-axis.

### bandwidth calculation

To calculate the component values for the frequency shaping characteristics of the signal conditioning circuit, 1 Hz and 500 Hz are selected as the minimum required 3-dB bandwidth.

To minimize the value of the input capacitor (C1) required to set the lower cutoff frequency requires a large value resistor for R2 is required. A 1-M $\Omega$  resistor is used in this example. To set the lower cutoff frequency, the required capacitor value for C1 is:

$$C1 = \frac{1}{2\pi f_{\text{LOW}} R_2} = 0.159\text{ }\mu\text{F} \quad (4)$$

Using a value of 0.22  $\mu\text{F}$ , a more common value of capacitor, the lower cutoff frequency is 0.724 Hz.

To minimize the phase shift in the feedback loop caused by the input capacitance of the TLV2772, it is best to minimize the value of the feedback resistor R4. However, to reduce the required capacitance in the feedback loop a large value for R4 is required. Therefore, a compromise for the value of R4 must be made. In this circuit, a value of 100 k $\Omega$  has been selected. To set the upper cutoff frequency, the required capacitor value for C2 is:

$$C2 = \frac{1}{2\pi f_{\text{HIGH}} R_4} = 3.18\text{ }\mu\text{F} \quad (5)$$

Using a 2.2-nF capacitor, the upper cutoff frequency is 724 Hz.

R5 and C3 also cause the signal response to roll off. Therefore, it is beneficial to design this roll-off point to begin at the upper cutoff frequency. Assuming a value of 1 k $\Omega$  for R5, the value for C3 is calculated to be 0.22  $\mu\text{F}$ .

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### APPLICATION INFORMATION

#### circuit layout considerations

To achieve the levels of high performance of the TLV277x, follow proper printed-circuit board design techniques. A general set of guidelines is given in the following.

- **Ground planes**—It is highly recommended that a ground plane be used on the board to provide all components with a low inductive ground connection. However, in the areas of the amplifier inputs and output, the ground plane can be removed to minimize the stray capacitance.
- **Proper power supply decoupling**—Use a 6.8- $\mu$ F tantalum capacitor in parallel with a 0.1- $\mu$ F ceramic capacitor on each supply terminal. It may be possible to share the tantalum among several amplifiers depending on the application, but a 0.1- $\mu$ F ceramic capacitor should always be used on the supply terminal of every amplifier. In addition, the 0.1- $\mu$ F capacitor should be placed as close as possible to the supply terminal. As this distance increases, the inductance in the connecting trace makes the capacitor less effective. The designer should strive for distances of less than 0.1 inches between the device power terminals and the ceramic capacitors.
- **Sockets**—Sockets can be used but are not recommended. The additional lead inductance in the socket pins will often lead to stability problems. Surface-mount packages soldered directly to the printed-circuit board is the best implementation.
- **Short trace runs/compact part placements**—Optimum high performance is achieved when stray series inductance has been minimized. To realize this, the circuit layout should be made as compact as possible, thereby minimizing the length of all trace runs. Particular attention should be paid to the inverting input of the amplifier. Its length should be kept as short as possible. This will help to minimize stray capacitance at the input of the amplifier.
- **Surface-mount passive components**—Using surface-mount passive components is recommended for high performance amplifier circuits for several reasons. First, because of the extremely low lead inductance of surface-mount components, the problem with stray series inductance is greatly reduced. Second, the small size of surface-mount components naturally leads to a more compact layout thereby minimizing both stray inductance and capacitance. If leaded components are used, it is recommended that the lead lengths be kept as short as possible.

## APPLICATION INFORMATION

### general power dissipation considerations

For a given  $\theta_{JA}$ , the maximum power dissipation is shown in Figure 63 and is calculated by the following formula:

$$P_D = \left( \frac{T_{MAX} - T_A}{\theta_{JA}} \right)$$

Where:

$P_D$  = Maximum power dissipation of TLV277x IC (watts)

$T_{MAX}$  = Absolute maximum junction temperature (150°C)

$T_A$  = Free-ambient air temperature (°C)

$\theta_{JA} = \theta_{JC} + \theta_{CA}$

$\theta_{JC}$  = Thermal coefficient from junction to case

$\theta_{CA}$  = Thermal coefficient from case to ambient air (°C/W)



NOTE A: Results are with no air flow and using JEDEC Standard Low-K test PCB.

**Figure 63. Maximum Power Dissipation vs Free-Air Temperature**

# TLV277x, TLV277xA

## FAMILY OF 2.7-V HIGH-SLEW-RATE RAIL-TO-RAIL OUTPUT OPERATIONAL AMPLIFIERS WITH SHUTDOWN

SLOS209G – JANUARY 1998 – REVISED FEBRUARY 2004

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### APPLICATION INFORMATION

#### shutdown function

Three members of the TLV277x family (TLV2770/3/5) have a shutdown terminal for conserving battery life in portable applications. When the shutdown terminal is tied low, the supply current is reduced to 0.8  $\mu\text{A}/\text{channel}$ , the amplifier is disabled, and the outputs are placed in a high impedance mode. To enable the amplifier, the shutdown terminal can either be left floating or pulled high. When the shutdown terminal is left floating, care needs to be taken to ensure that parasitic leakage current at the shutdown terminal does not inadvertently place the operational amplifier into shutdown. The shutdown terminal threshold is always referenced to  $V_{DD}/2$ . Therefore, when operating the device with split supply voltages (e.g.  $\pm 2.5\text{ V}$ ), the shutdown terminal needs to be pulled to  $V_{DD-}$  (not GND) to disable the operational amplifier.

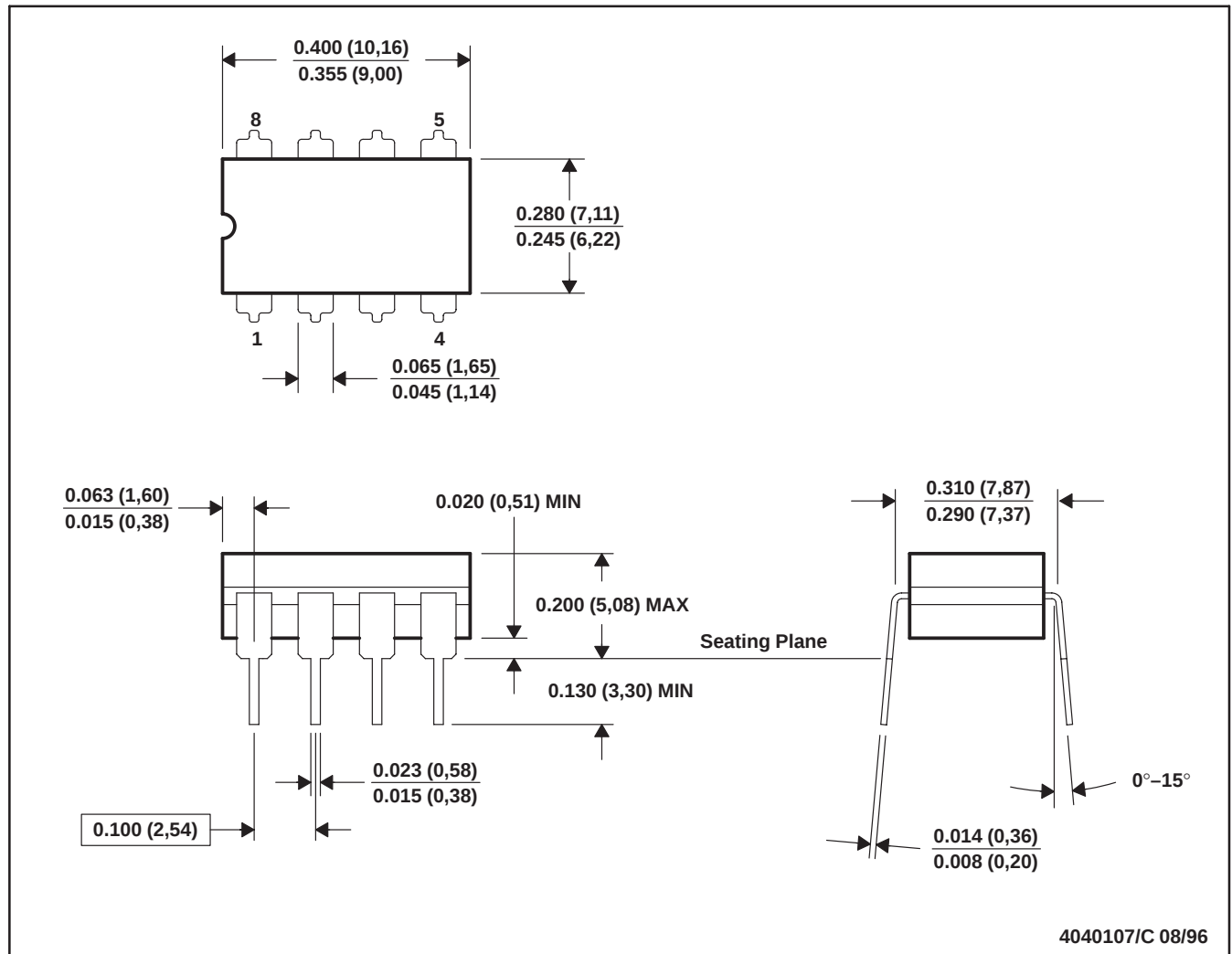
The amplifier's output with a shutdown pulse is shown in Figures 48, 49, and 50. The amplifier is powered with a single 5-V supply and configured as a noninverting configuration with a gain of 5. The amplifier turnon and turnoff times are measured from the 50% point of the shutdown pulse to the 50% point of the output waveform. The times for the single, dual, and quad are listed in the data tables. The *bump* on the rising edge of the TLV2770 output waveform is due to the start-up circuit on the bias generator. For the dual and quad (TLV2773/5), this *bump* is attributed to the bias generator's start-up circuit as well as the crosstalk between the other channel(s), which are in shutdown.

Figures 55 and 56 show the amplifier's forward and reverse isolation in shutdown. The operational amplifier is powered by  $\pm 1.35\text{-V}$  supplies and configured as a voltage follower ( $A_V = 1$ ). The isolation performance is plotted across frequency for both 0.1  $V_{PP}$  and 2.7  $V_{PP}$  input signals. During normal operation, the amplifier would not be able to handle a 2.7- $V_{PP}$  input signal with a supply voltage of  $\pm 1.35\text{ V}$  since it exceeds the common-mode input voltage range ( $V_{ICR}$ ). However, this curve illustrates that the amplifier remains in shutdown even under a worst case scenario.



## JG (R-GDIP-T8)

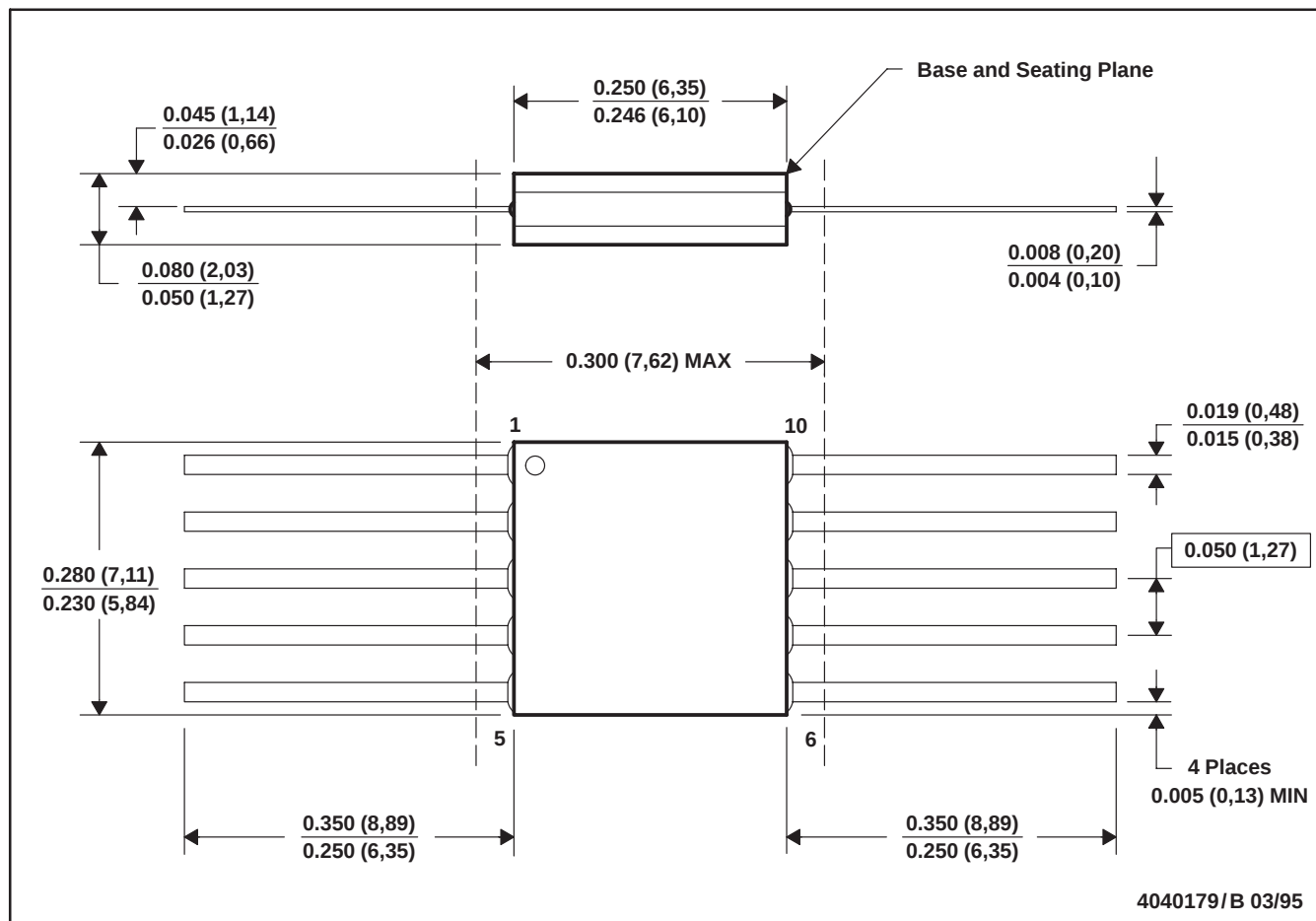
## CERAMIC DUAL-IN-LINE



- 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

## U (S-GDFP-F10)

## CERAMIC DUAL FLATPACK

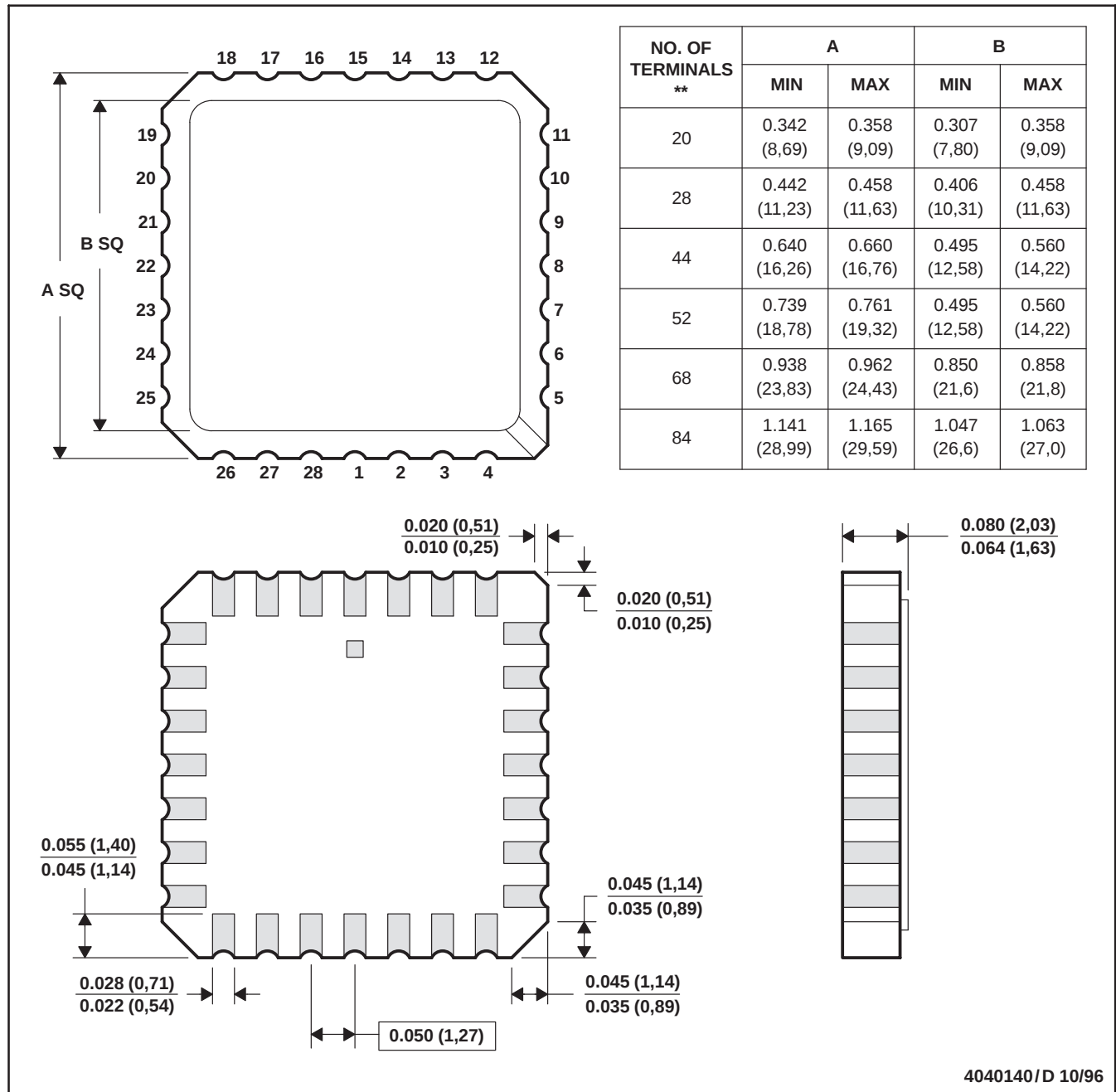


- NOTES: A. All linear dimensions are in inches (millimeters).  
 B. This drawing is subject to change without notice.  
 C. This package can be hermetically sealed with a ceramic lid using glass frit.  
 D. Index point is provided on cap for terminal identification only.  
 E. Falls within MIL STD 1835 GDFP1-F10 and JEDEC MO-092AA

FK (S-CQCC-N\*\*)

LEADLESS CERAMIC CHIP CARRIER

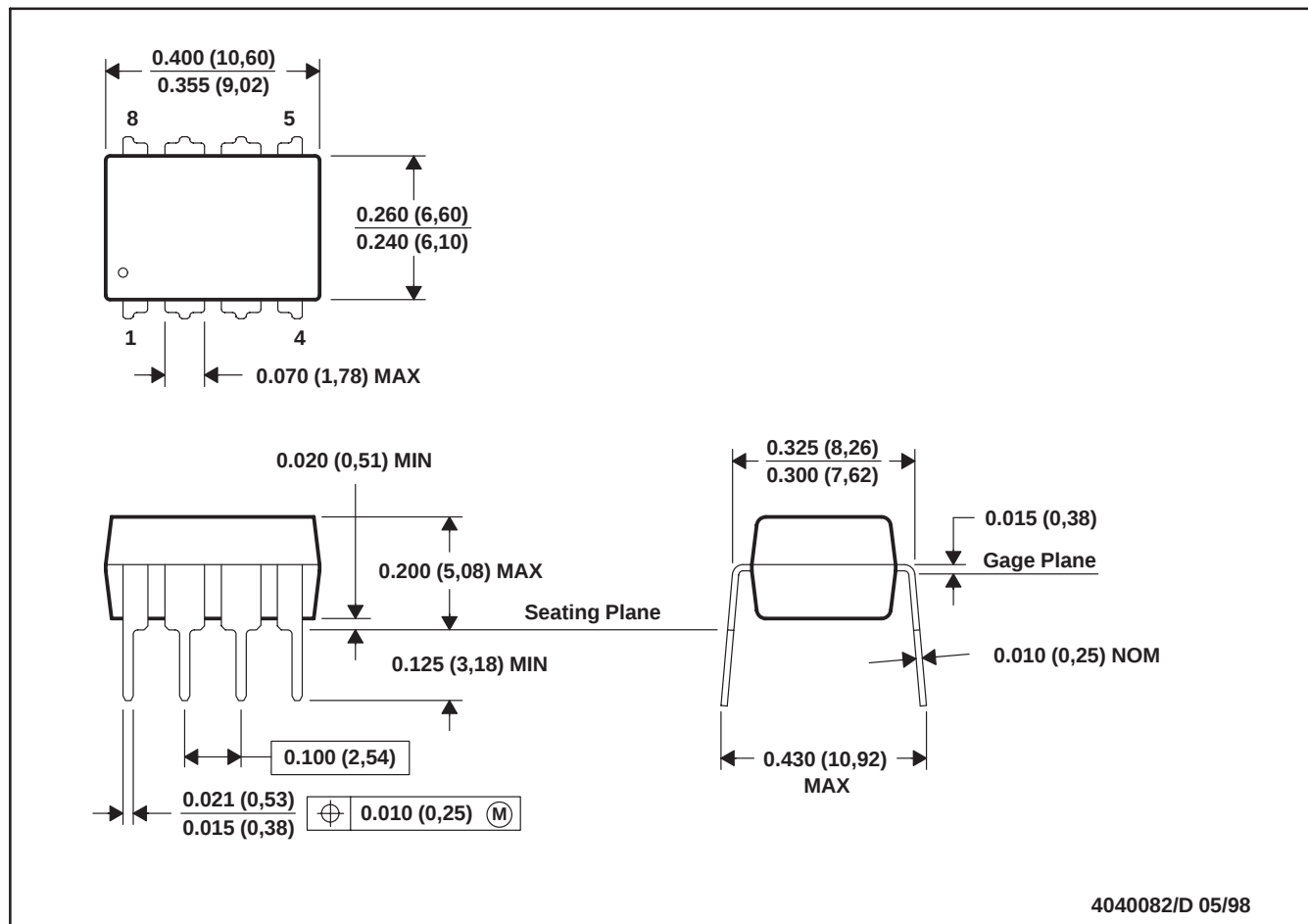
28 TERMINAL SHOWN



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

## P (R-PDIP-T8)

## PLASTIC DUAL-IN-LINE



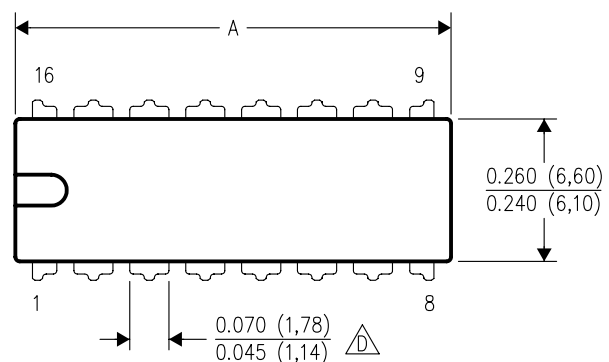
- NOTES: A. All linear dimensions are in inches (millimeters).  
 B. This drawing is subject to change without notice.  
 C. Falls within JEDEC MS-001

For the latest package information, go to [http://www.ti.com/sc/docs/package/pkg\\_info.htm](http://www.ti.com/sc/docs/package/pkg_info.htm)

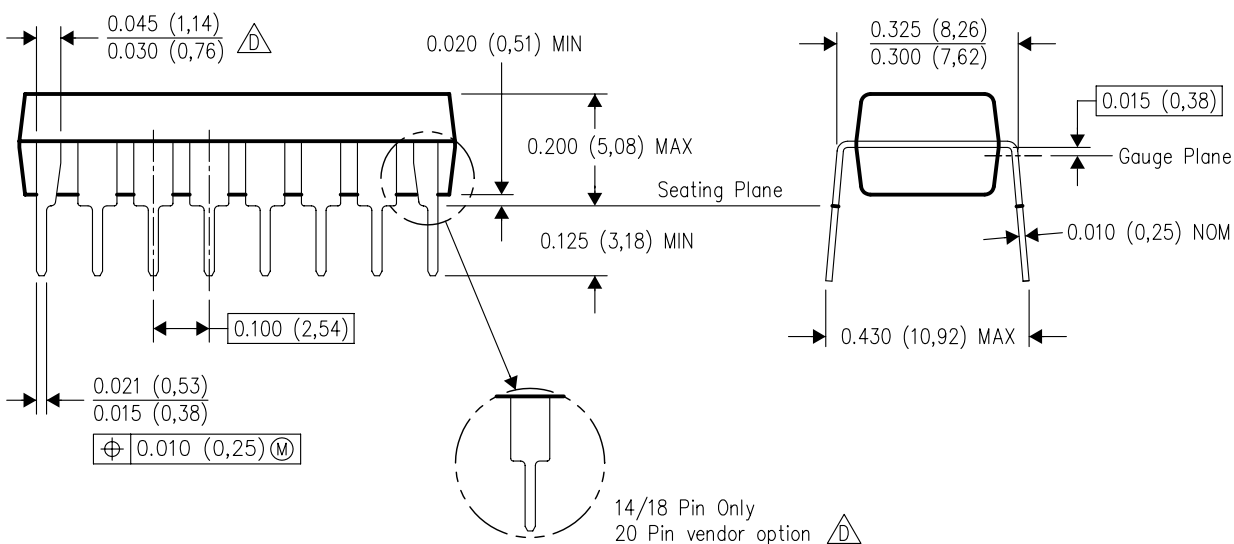
N (R-PDIP-T\*\*)

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               |



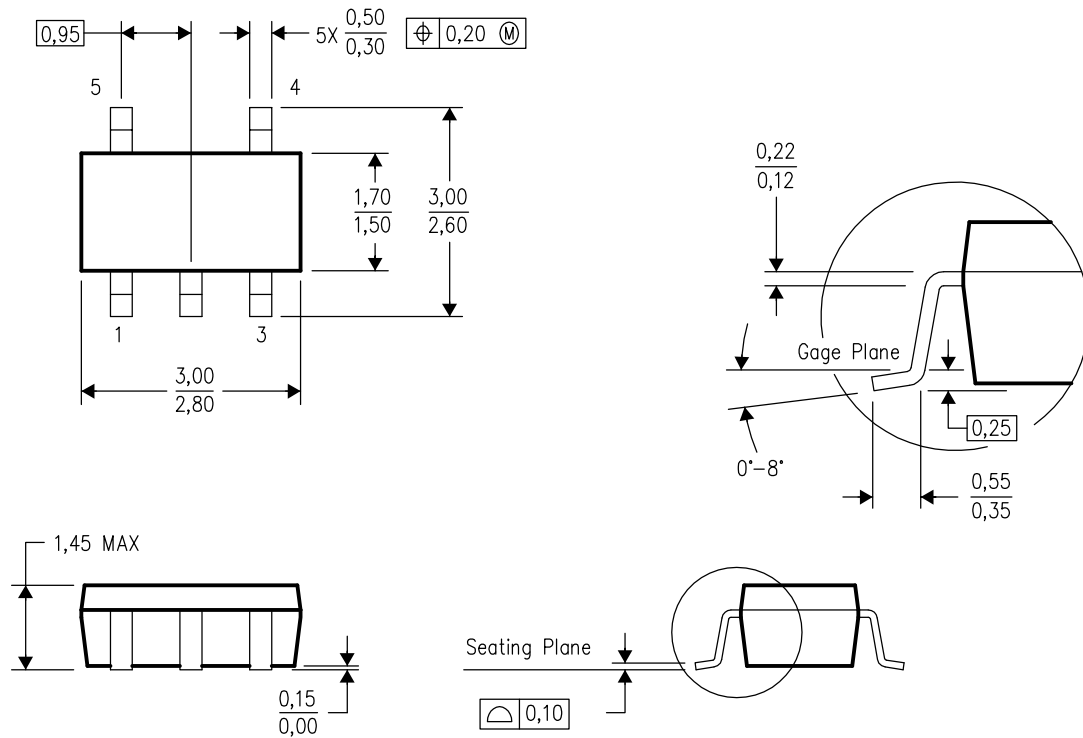
4040049/E 12/2002

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.

## DBV (R-PDSO-G5)

## PLASTIC SMALL-OUTLINE PACKAGE

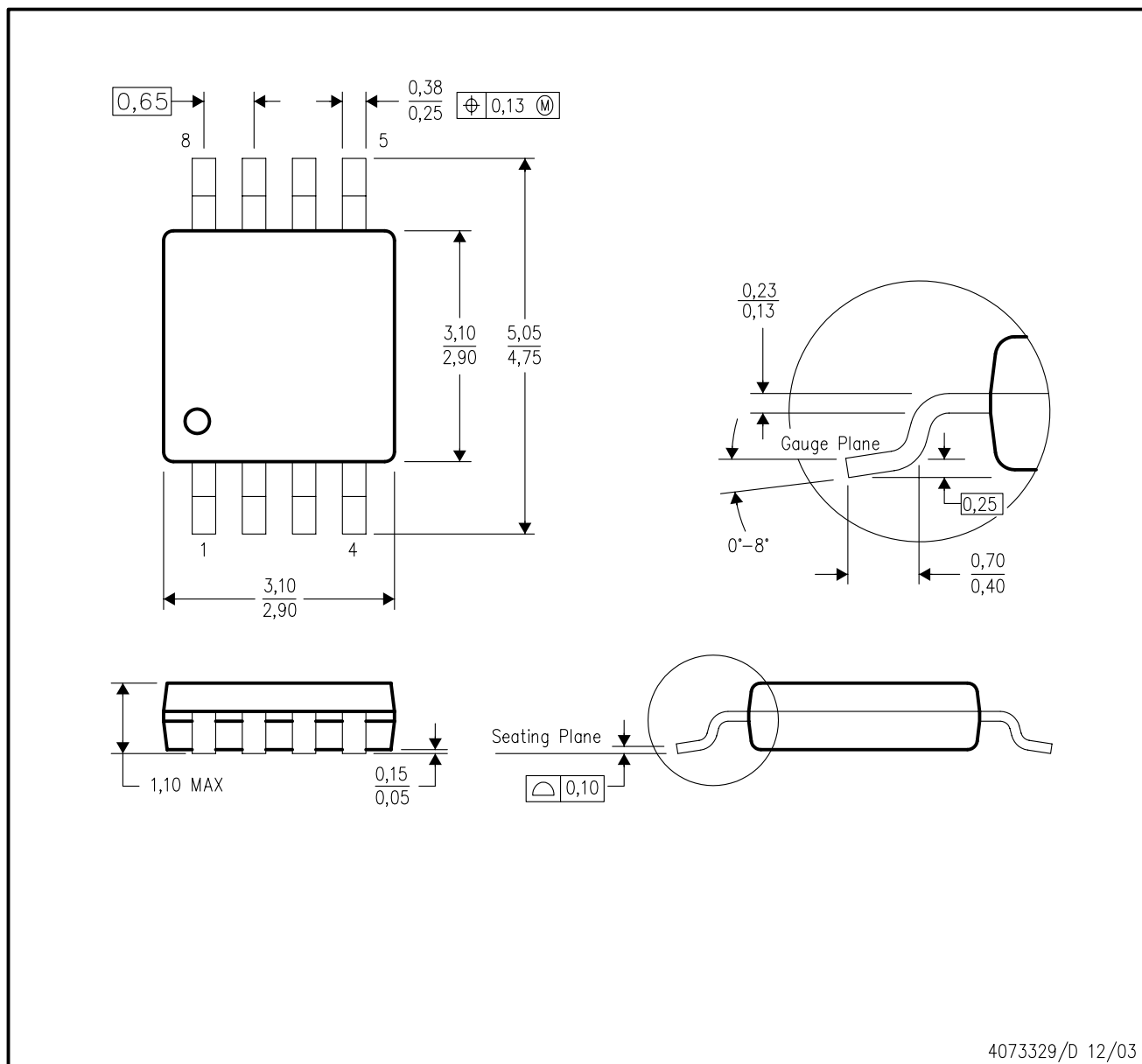


4073253-4/H 10/2003

- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Body dimensions do not include mold flash or protrusion.
  - D. Falls within JEDEC MO-178 Variation AA.

## DGK (S-PDSO-G8)

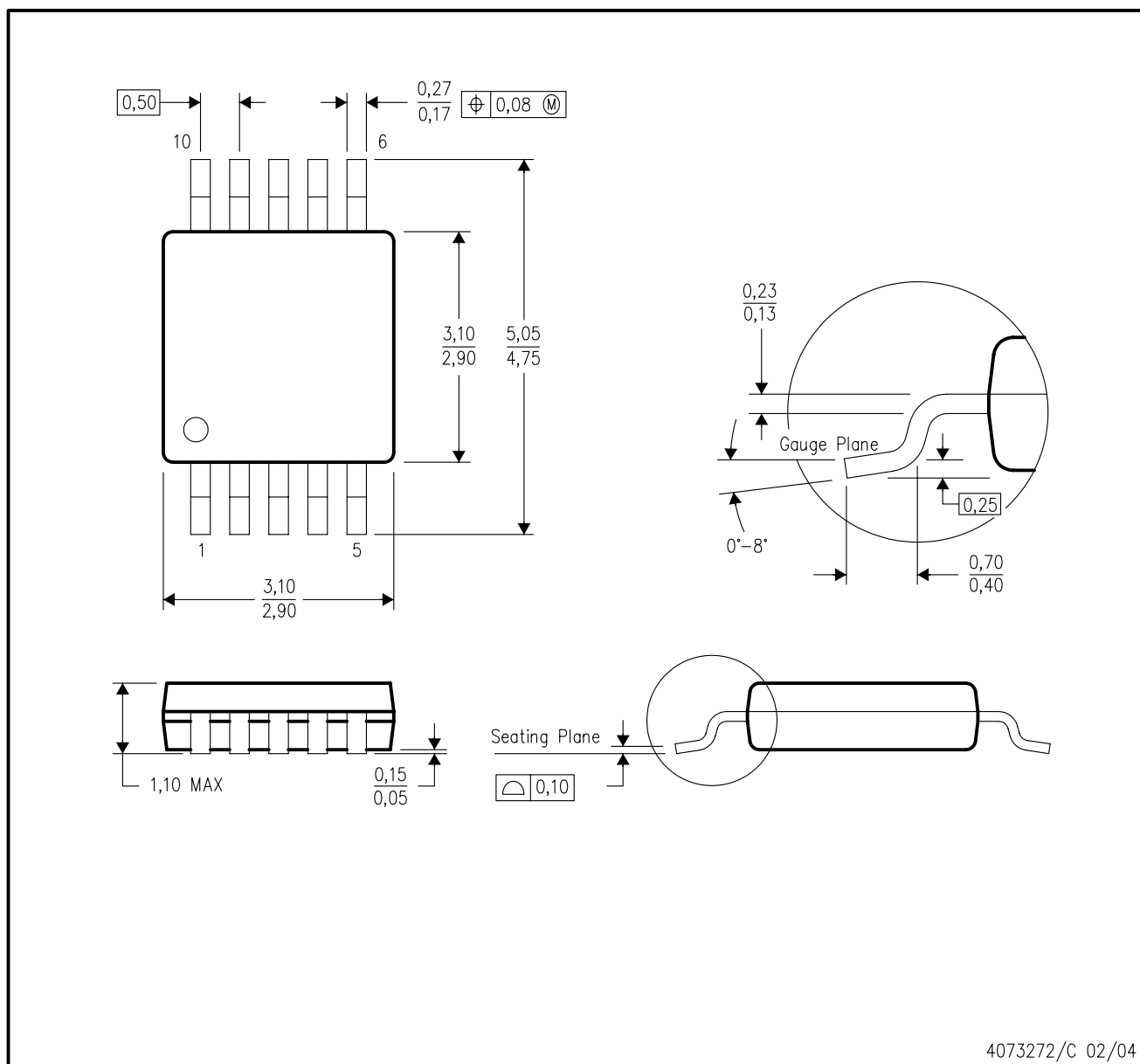
## PLASTIC SMALL-OUTLINE PACKAGE



- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Body dimensions do not include mold flash or protrusion.
  - D. Falls within JEDEC MO-187 variation AA.

## DGS (S-PDSO-G10)

## PLASTIC SMALL-OUTLINE PACKAGE

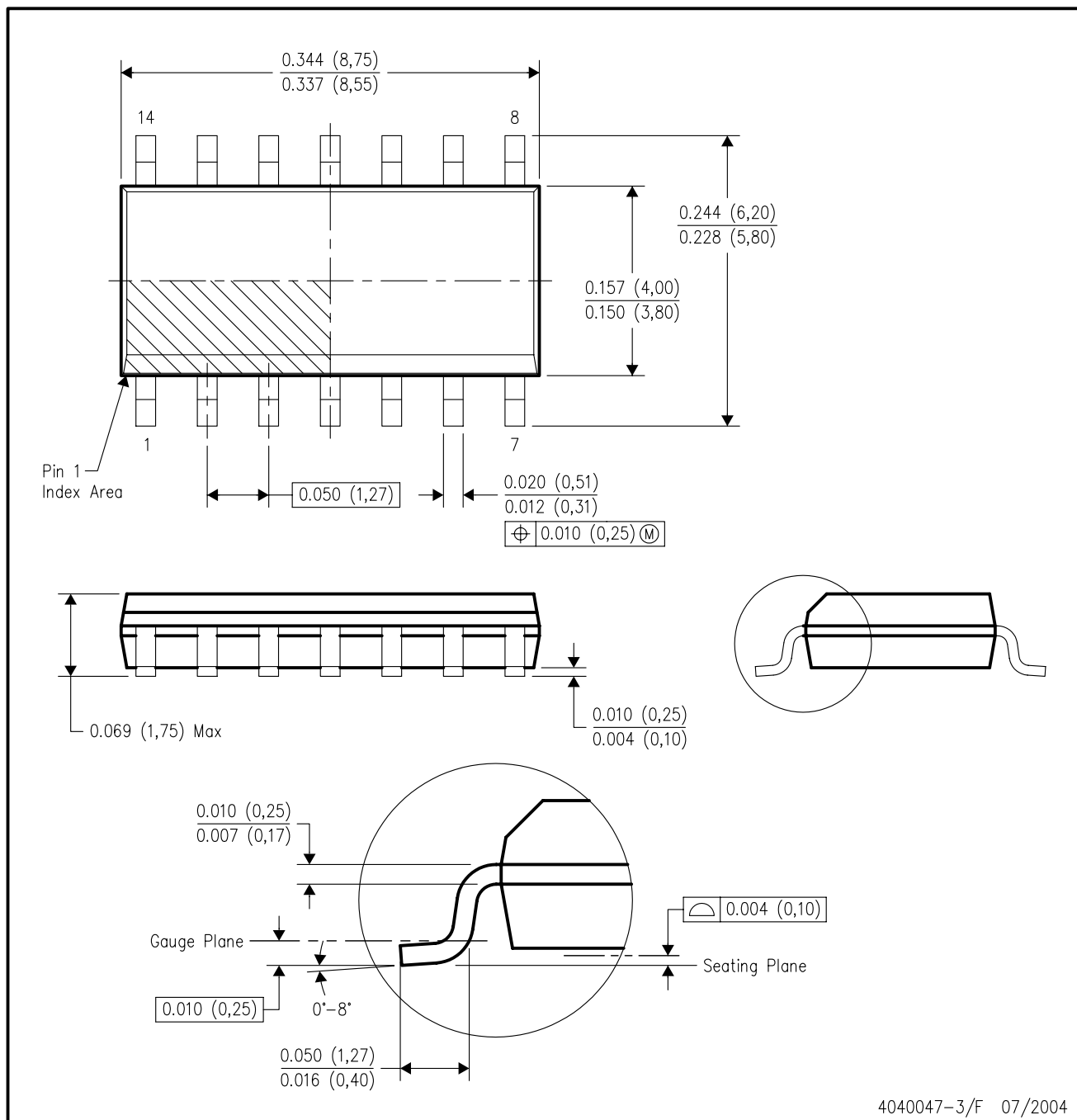


4073272/C 02/04

- NOTES:
- All linear dimensions are in millimeters.
  - This drawing is subject to change without notice.
  - Body dimensions do not include mold flash or protrusion.
  - Falls within JEDEC MO-187 variation BA.

## D (R-PDSO-G14)

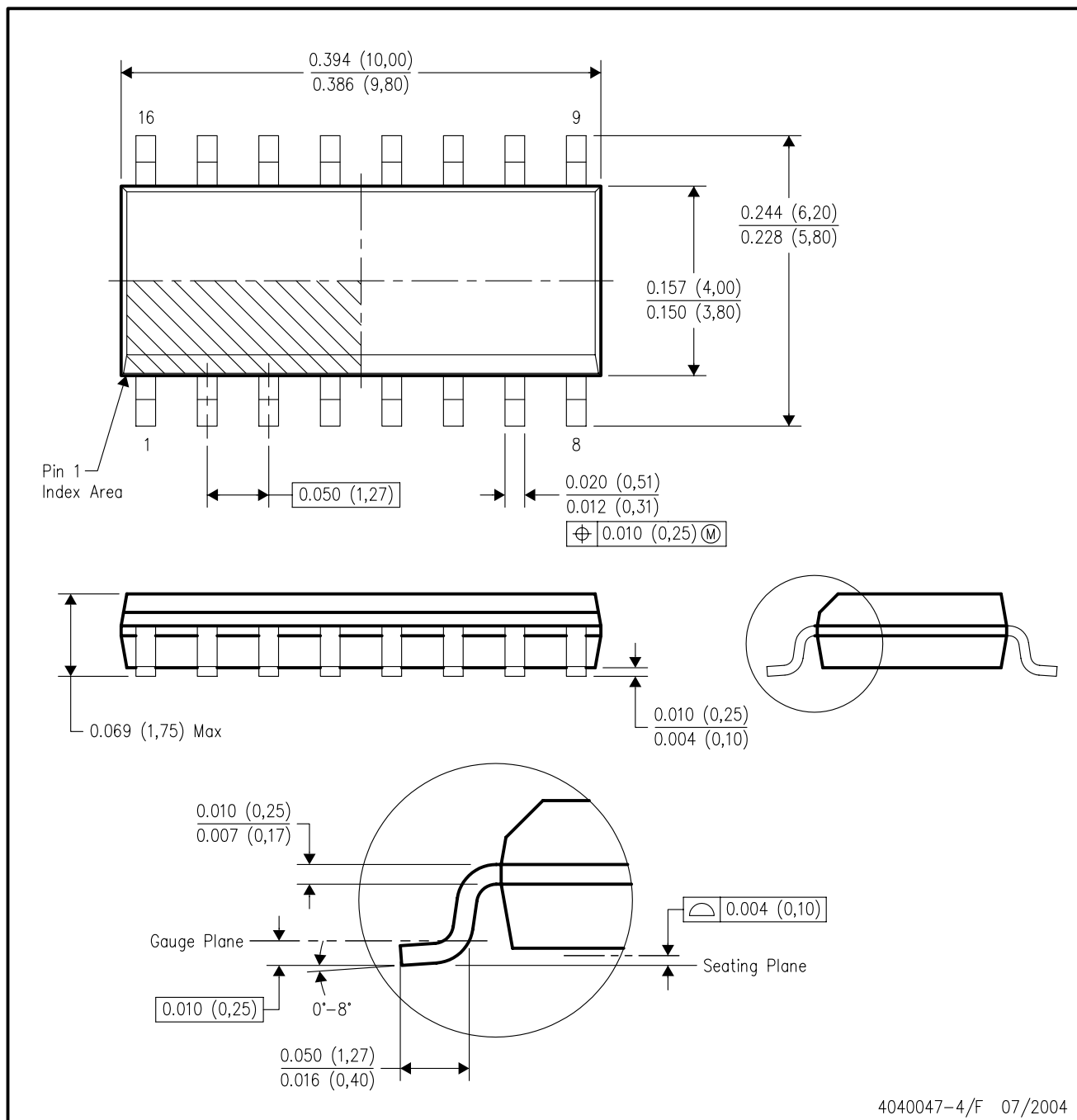
## PLASTIC SMALL-OUTLINE PACKAGE



- NOTES:
- All linear dimensions are in inches (millimeters).
  - This drawing is subject to change without notice.
  - Body dimensions do not include mold flash or protrusion not to exceed 0.006 (0,15).
  - Falls within JEDEC MS-012 variation AB.

## D (R-PDSO-G16)

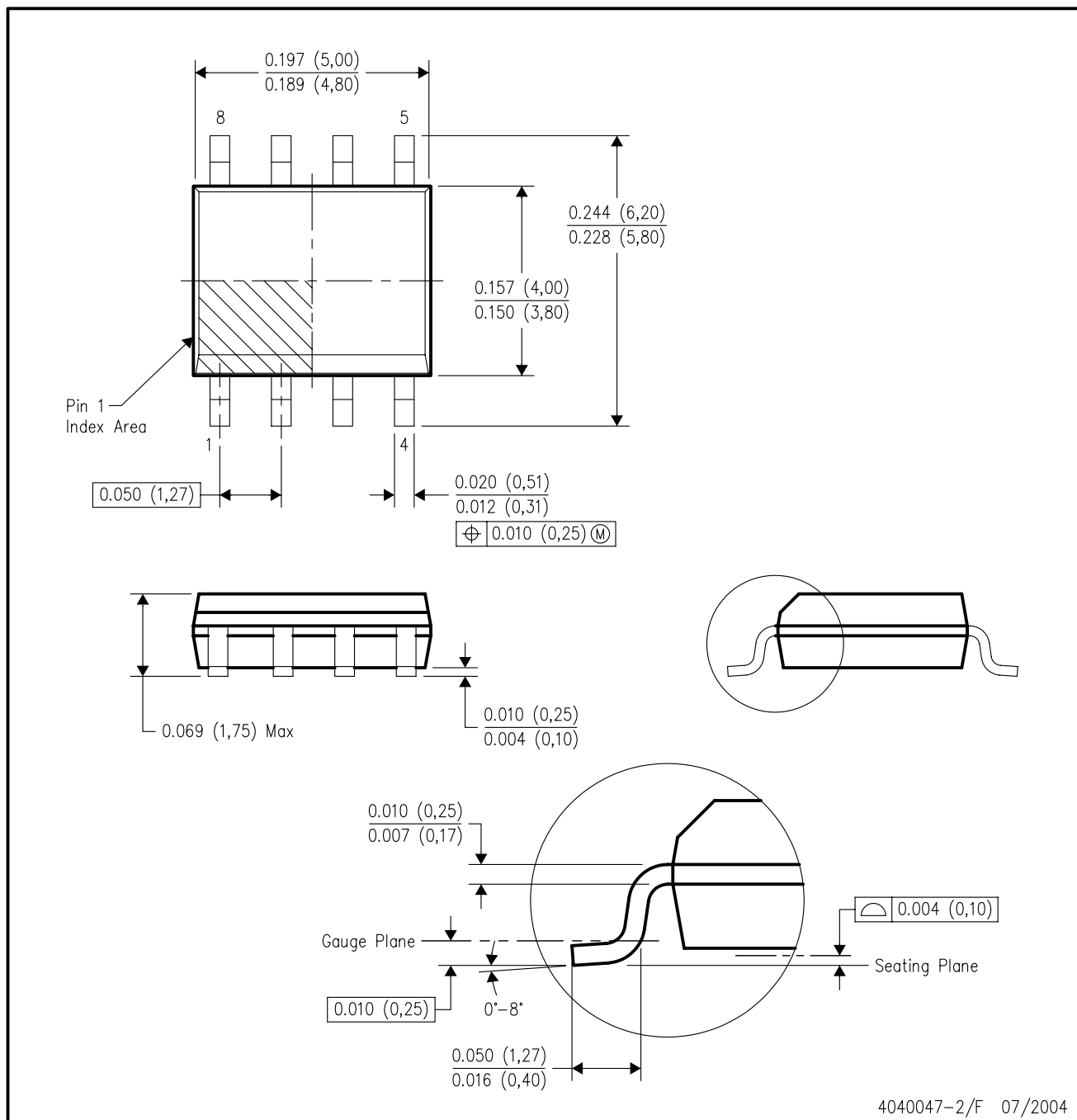
## PLASTIC SMALL-OUTLINE PACKAGE



4040047-4/F 07/2004

## D (R-PDSO-G8)

## PLASTIC SMALL-OUTLINE PACKAGE

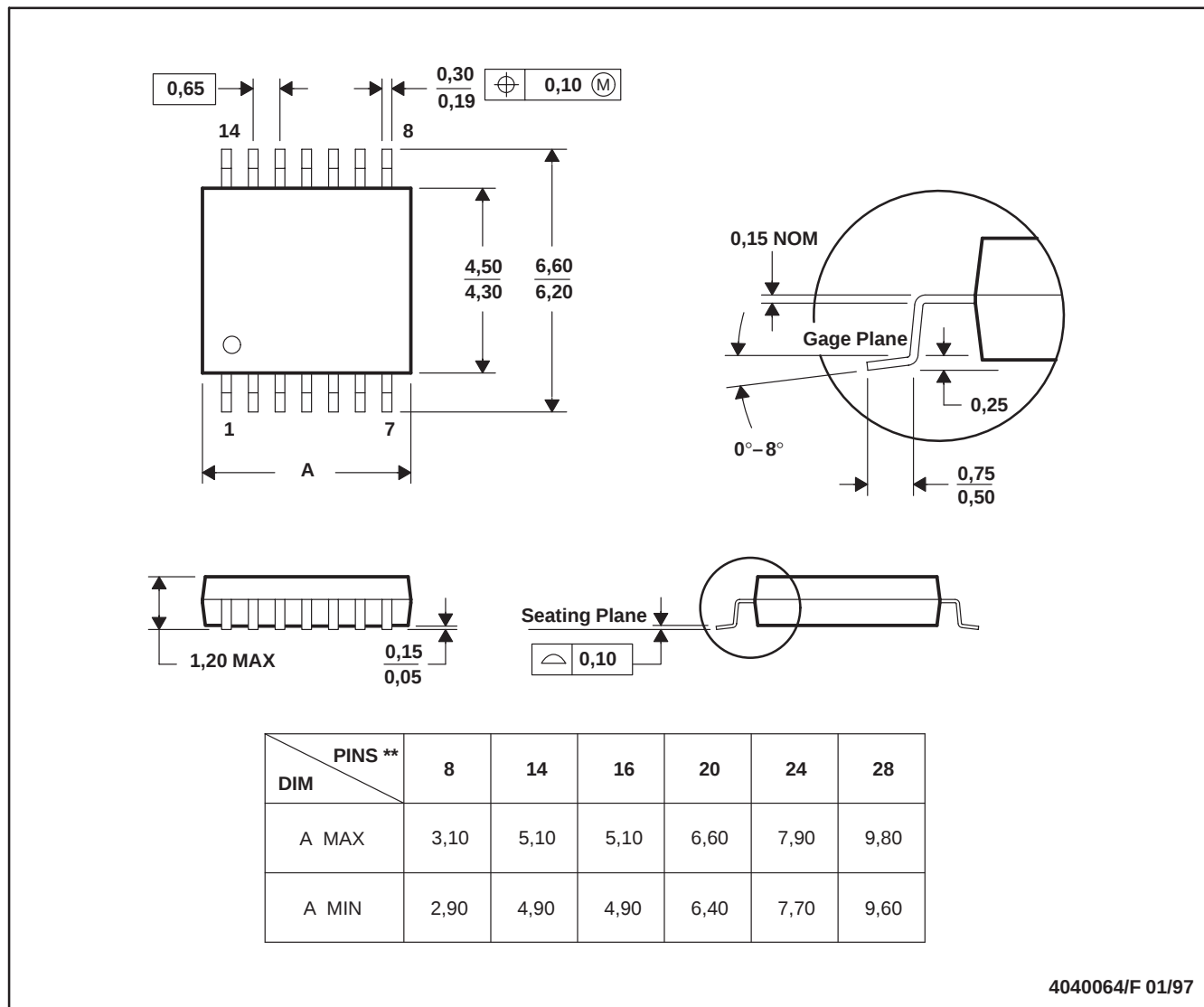


- NOTES:
- All linear dimensions are in inches (millimeters).
  - This drawing is subject to change without notice.
  - Body dimensions do not include mold flash or protrusion not to exceed 0.006 (0,15).
  - Falls within JEDEC MS-012 variation AA.

## PW (R-PDSO-G\*\*)

## PLASTIC SMALL-OUTLINE PACKAGE

14 PINS SHOWN



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

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